Solid Earth
Discussions

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Interactive comment on "A database of plagioclase crystal preferred orientations (CPO) and microstructures – implications for CPO origin, strength, symmetry and seismic anisotropy" *by* T. Satsukawa et al.

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We are grateful to Dr Prior for his review and comments.

Required Changes:

Title. The title should make clear that this relates to plagioclase fabrics in gabbroic rocks. There are many other plagioclase bearing rocks that are not part of this study. Just add "in gabbroic rocks" or "in gabbros" before the hyphen in the title. Our reply: We agree. The title will be changed to : "A data base of plagioclase crystal preferred ori-

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Interactive Discussion

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entations (CPO) and microstructures - implications for CPO origin, strength, symmetry and seismic anisotropy in gabbroic rocks".

Plagioclase compositions. Unless I am being blind I cannot find any data on the plagioclase compositions. As Marshall and McLaren (1977 * 2) point out the shortest burgers vector changes as a function of space group (order-disorder) and therefore composition is a primary control upon plastic deformation. The data must exist for plagioclase composition(s) for all of these samples and should be included in table 2. Where plag is zoned that should be recorded and where there are porphyroclasts and recrystallized grains the compositions should be reported separately. Our reply: The plagioclase in our mafic samples is rarely below An50; in most cases, it is close to An70-80. The plagioclase diffraction patterns are well indexed by Channel 5 regardless of the chosen reference file from An40 to An100 (Ildefonse personal communication). We used the file for An 70-90 (bytownite) by default when the An

Other suggestions:

Temperatures: If there are constraints on T of deformation in plastically deformed samples why not include these in one of the tables. Our reply: We don't have good constraints on the T for the studied samples.

Reference frames. You can do more to make the reference frames of pole figures clearer. Add a pictogram to each one that distinguishes whether the sample is one with a foliation/lineation ref frame and shows the orientations of these or a drill core ref frame. I would rotate all core ref frame sample images so that core axis is vertical. Our reply: We agree. We will add a pictogram as suggested, and will rotate the core samples in a unique reference frame.

J and pfJ values are a function of sample size. For comparison why not normalise all data sets to the same number of grains (choose a random set of n grains: e.g see Holness et al 2012). Our reply: The values of J and pfJ presented in our paper are normalized using the standard method of quantitative texture analysis (e.g. Bunge,

1982) so that a uniform distribution has a value of one for both parameters and they are squares of density function of the ODF and PF respectively, and hence can be considered as a probabilities. The use of J-index in Figure 10 to compare P- and S-wave anisotropy of olivine and plagioclase CPOs is an application of a standard method. J and pfJ depend on the CPO, sample symmetry and crystal symmetry, for plagioclase we use a triclinic sample symmetry. The CPO depend on the number of measurements for EBSD data as illustrated in our figure 4, but this dependence is non-linear and does not obey the 1/n law used in many EBSD papers, because any normalization has to take into account the number of grains, texture strength, texture entropy, crystal and sample symmetry. It would be unwise to normalize the values from U-stage data for olivine with orthorhombic crystal symmetry and 100 measurements per sample, to compare with plagioclase measurements with triclinic crystal symmetry and several thousands measurements per sample, without a serious study of the normalization procedure. Although the reviewer's remark is well intentioned, we feel this to be beyond the scope of this paper. In fact this is a complex subject, where a formal statistical analysis has recently be made and it will be the subject of another publication.

It is not clear to me whether the elastic properties calculated for each sample relate just to the plagioclase component or to all phases (or more confusingly to just plag in old manual data and all phases in newer auto data?). Also - I think ipg is a good way of comparing lots of data and helps in defining fabric types, but is not the ideal input data for calculating elastic properties- particularly if recrystallized grains and porphyroclasts have very different sizes. Our reply: Elastic properties have been calculated for plagioclase only. It is said in the text; we will try to make it clearer. We agree with Dr Prior's comment about avoiding to use 1ppg (we believe that this is what Dr Prior meant by "lpg") data to calculate seismic properties. As a matter of fact, as stated in the paper (end of section 3.1), we used gridded data whenever available to calculate seismic velocities and anisotropy.

Supplementary comments (annotated manuscript):

p. 1195, line 1-3: need to be more specific – this is certainly true of gabbros and maybe other igneous precursors. Felsphar also detrital and metamorphic – does not necessarily apply to those. Our reply: We will modify the sentence to : "Similar to a number of typically "crustal" phases (e.g., quartz, K-feldspars, phyllosilicates), the CPOs in plagioclase may have multiple origins. In plagioclase-rich gabbroic rocks, origins of CPOs vary from mineral fabric typically formed by magmatic processes to crystallographic orientations resulting from crystal-plastic processes."

p. 1195, line 12: Marshall and McLaren 2 papers in 1977 Our reply: We will add a reference to "Marshall, D. B. and McLaren, A. C.: Deformation mechanisms in experimentally deformed plagioclase feldspars, Phys. Chem. Miner., 1, 351-370, 1977."

p. 1195, line 12: "On the other hand, the crystallographic planes..." need to explain that this relates to the shapes of plagioclase in melt – normal to (010) tends to be short. Our reply: We will add the following sentence: "This relates to the shape of plagioclase grains in a magma, with the normal to (011) that tends to be short.

p. 1195, line 20: "... and S waves are polarized parallel to the foliation..." Certain composition very elastically anisotropic see Brown et al 2006 and other papers from Ross Angel. Our reply: Brown's paper is for Albite; Hence it is not relevant to this study. This will be more obvious once we have added the An contents of plagioclase in our samples in the table (see above)

p. 1196, line3: "... regardless its crystal symmetry." You should note that there have been some difficulties with EBSD on plag (PriorWheeler, 1999; Jiang et al., 2000; Prior, Mariani and Wheeler from EBSD book, 2009). Problems largely overcome now. Our reply: We will add the following text, after "... regardless of its crystal symmetry" : "Problems to indexing albite have been reported (Prior and Wheeler, 1979; Jiang et al., 2000). For plagioclase with high anorthite contents ($\geq$ An50) as measured herein, we did not encountered difficulties indexing the diffraction patterns. The structure reference file usually used is that of bytownite (developed in Montpellier), which gives

excellent results."

p. 1198, line10: "Randle and Engler (2000)" poor reference for this as it's way out of date. EBSD book 2009 is good. Our reply: Fair enough! We will replace this reference by the suggested one. "Engler, O., Randle, V., 2009. Introduction to texture analysis : macrotexture, microtexture, and orientation mapping. 2nd Edition. CRC Press Taylor Francis Group, Boca Raton, FL, USA."

p. 1201, line17: "plagioclase: Aleksandrov et al., 1974; clinopyroxene: Collins and Brown, 1998" are these the fully triclinic tensors or the monoclinic approximation, Brown et al. (2006) is the triclinic data. Our reply: The elastic constant tensor from Aleksandrov et al. 1974 is a monoclinic approximation. The only available triclinic tensor is indeed that of Brown et al, but for the calcic plagioclase (albite) end-member, hence not relevant to our study.

p. 1202, line19: "Figs. 2 and 3, and Supplement Figs. 1 to 7" It is confusing to have reference frame flipping in figures. I suggest all core samples presented with drill core axis vertical. All samples should have a ref frame pictogram that shows foliation / lineation for non core samples and core axis for drill samples. Our reply: See the answer to this question above.

p. 1205, line 19: why not normalize all the data sets to the same sample population (e.g., see Holness et al 2012) Our reply: See the answer to this question above.

p. 1205, line 27: "dominantly weak", p.1206 line1: "relatively weak", line 2 : "no strong" I think you mean strong here. Our reply: This is indeed a bit confusing. Most of the samples have weak fabric strength. The sentence will be simplified to : "The fabric strength of samples with magmatic flow textures is slightly more variable than that of plastically deformed samples (Fig. 5a), both types of textures have dominantly weak J-indices (Fig. 5c and d)."

p. 1206, line9: Holness et al use this for magmatic olivine and I think there's some

recent stuff from john / Cheadle and their students Our reply: Holness et al (2012) use the eigenvalues to determine the fabric shape shape (i.e., the classical Flinn parameter) for a given axis, which is slightly different from what we do here, i.e. quantifying the symmetry variations between two pole figures.

Table 1: Any independent constrains upon T of plastic deform? Our reply: No, we don't have constraints on the T.

Table 2: what is the plagioclase composition in each case. In case of plastically deformed what is the composition of porphyroclasts vs recrystallised. Our reply: Whenever available, the An contents of the measured plagioclases will be documented in Table 2 (see above).

Fig. 2 (A): confusing. Need to match reference frames as much as possible Our reply: OK. See answer to the same question above.

Fig. 5 (C, D): plot on same vertical scale Our reply: OK.

Interactive comment on Solid Earth Discuss., 5, 1191, 2013.