Solid Earth Discussions

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Comment on se-2021-3

Anonymous Referee #1

Referee comment on "Elastic anisotropies of rocks in a subduction and exhumation setting" by Michael J. Schmidtke et al., Solid Earth Discuss., https://doi.org/10.5194/se-2021-3-RC1, 2021

Review of Schmidtke et al.: Elastic anisotropies of rocks in a subduction and exhumation setting

In this paper, the authors measured the crystallographic preferred orientation of the minerals from a variety of metamorphic rocks in the Lago diCignana area, NW Alps. These data were subsequently employed to calculate the seismic velocities and velocity ratios of different rocks, including eclogite, blueschist, amphibolite, greenschist, micaschist and gneiss. The knowledge of elastic data as provided in this study is very important when we try to distinguish different rock types at depths using seismic methods. The content of the paper is appropriate for the journal, but the current version has still large room to improve. Below are my detailed comments for this paper.

Major comments

- Probably the most critical issue in the paper is the representativeness of the studied samples. As I can see, especially for the metabasic rock types, i.e., eclogite, blueschist, amphibolite and greenschist, each rock type has only one sample. Considering large variations of the deformation structure and mineral modal composition even in the same rock type, which has been frequently observed by other researchers, it is therefore difficult to reach a meaningful comparison of the elastic properties between different rock types by solely taking the few samples in this study. I suggest the authors to incorporate more elastic property data from other studies and compare them in a larger data set.

- Some single crystal elasticities that the authors used in this study may not be very suitable. I suggest the authors to choose the more appropriate ones with respect to the mineral compositions. In this sense, some substitutes that the authors used are not necessary. Below are some references to the latest single-crystal elasticities.

Chlorite: Mookherjee, M., & Mainprice, D. (2014), Unusually large shear wave anisotropy for chlorite in subduction zone settings, *Geophysical Research Letters*, *41*(5), 1506-1513, doi:10.1002/2014gl059334.

*Amphibole***:** Brown, J. M., & Abramson, E. H. (2016), Elasticity of calcium and calcium-sodium amphiboles, *Physics of the Earth and Planetary Interiors*, *261*, 161-171, doi:10.1016/j.pepi.2016.10.010.

Omphacite: Hao, M., Zhang, J. S., Pierotti, C. E., Ren, Z., & Zhang, D. (2019), Highâ□□pressure singleâ□□crystal elasticity and thermal equation of state of omphacite and their implications for the seismic properties of eclogite in the Earth's interior, *Journal of Geophysical Research: Solid Earth*, *124*(3), 2368-2377, doi:10.1029/2018jb016964.

- I think the elastic properties of rocks in this study were calculated using the single-crystal elasticities measured at the ambient condition, therefore, the effects of pressure and temperature need to be evaluated or at least discussed. This is important for different rocks that are stable at different metamorphic P-T conditions.

- The elastic properties of rocks in this study were calculated using Voigt average. However, to my knowledge, such data were mostly computed using Hill average in the literature. It is okay to use either one for the calculation, but for the purpose of comparisons especially with the data from others', it is recommended to follow the most commonly used method.

- The structure of Discussion section of the paper feels a bit strange to me. I would recommend to put "CPO development" and "Elastic anisotropies" as the secondary headings, and put "Metabasic rocks", "Metasediments" and "Gneiss" as the third heading. Besides, the content of Vp/Vs ratios, is not related to the elastic anisotropies; and it can be integrated into the Results section.

- The elastic properties data in the paper are presented in the formats of texts and tables; and they are often hard to follow, especially when comparisons are made. I think some figures would be needed to help readers catch the points.

- When discussing the elastic property data in the context of a subduction and exhumation setting, it would be great to combine them with the P-T data or path of the studied rocks. In this sense, the elastic property data can be presented in a P-T diagram with P-T path for the studied samples. A good example could be the Figure 11 in Park and Jung (2019).

Park, M., & Jung, H. (2019), Relationships between eclogite-facies mineral assemblages, deformation microstructures, and seismic properties in the Yuka terrane, North Qaidam ultrahigh-pressure metamorphic belt, NW China, *Journal of Geophysical Research: Solid Earth*, *124*(12), 13168-13191, doi:10.1029/2019jb018198.

- The authors need to give more details about the approach they used to estimate the volume proportions of different mineral phases, as well as their uncertainties if possible, because an accurate mineral percentage is critical for obtaining a reliable bulk-rock elastic property.

- The descriptions of the structures and textures of different rock types appear a bit simple. I suggest the authors to add more quantitative information such as grain size and grain shape, as well as more optical photographs to show the textures of related samples described in the text.

- The authors used F2 index to quantify the CPO strength, which is, to my knowledge, an index not as frequently used as J- and M-indices. It would be great to also provide J- or M-indices, so that a comparison with the results from other literature would be straightforward.

Minor comments

Lines 51-60. This part of content can be integrated into the Method section.

Lines 128-132. Here I think the authors mainly talked about the method of retrieval of CPO, rather than the calculation of elastic properties. It would be better move this part of content to the paragraphs above.

Fig. 1c. It is better to mark N-S-E-W directions in the stereonets.

Figs. 4-8. Please mark foliation and lineation (or x, y, z-axes) in the pole figures.

Fig. 8. Please provide labels of subfigures and use them in the text. It is hard to follow the text without a subfigure label.

Additional comments can be found in the annotated pdf file.

Please also note the supplement to this comment:
https://se.copernicus.org/preprints/se-2021-3/se-2021-3-RC1-supplement.pdf