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Numerical, predictive and experimental study on elastic wave propagation in crystalline rocks

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Summary

Calculating anisotropy and better understanding this physical effect is one of the main challenges in geophysics, whether in the size of the field or micro scale. one of the very common methods of calculating seismic anisotropy is to take into account the bulk properties of the material, in a micro-scale, this is based on the average value of Crystallographic preferred orientation measurements by using, for example, Scanning Electron Microscopy to operate - Electron backscatter diffraction method.

In this study, we demonstrate a predictive, numerical and experimental study to present the advantages and disadvantages of such a method. As we know there many different sources of anisotropy in the rock from macro-scale to microscale and the averaging value calculation method does not provide any information about them and also the role of the dynamic effect of the other microstructures in the material.

Our experimental results on metamorphic and igneous rocks showed the strong effects of shape preferred orientation and crystallographic preferred orientation in seismic anisotropy. During seismic experiments, P- and S-wave propagated through the material in three principal directions simultaneously and confining pressure and temperature applied from ambient condition to 600MPa and 600°C.

These questions and motives are an open area of investigation. Therefore, several groups are working on similar topics. Within this project, we decided to build our dynamic wave propagation toolbox. Meanwhile, we investigate and calculate anisotropy experimentally to verify and develop our model in COMSOL Multiphysics. This model is also capable of adopting different material phases. Meaning that recently we plan to develop this tool to be able to incorporate the effects of fluid saturation, existence of fractures, deformed pores and voids cases.

References:

Almqvist B. G. et al., 2018, Contributions of microstructure and crystallographic preferred orientation to seismic anisotropy in the lower continental crust, European Geoscience Union.

Bazargan, M., et al., 2018; Employing Finite Element Method using COMSOL multiphysics to predict seismic velocity and anisotropy: Application to lower crust and upper mantle rocks, European Geoscience Union.

Bazargan, M., et al., 2019; Experimental investigation and numerical modelling of elastic wave propagation in metamorphic rocks, IGSC

Bazargan, M., Rémi Vachon, Christoph F Hieronymus, 2019; Evolution of the statistical distribution of crystal orientations in time- and space-varying viscous flows, Geophysical Journal International, Volume 218, Issue 2, Pages 773–786

Bazargan, M., et al, 2019; Elastic wave anisotropy in amphibolites and paragneisses from the Swedish Caledonides measured at high pressures (600 MPa) and temperatures (600oC), European Geoscience Union.

Mohsen Bazargan, Hem Bahadur Motra, Bjarne Almqvist, Christoph Hieronymus, and Sandra Piazolo, Numerical and experimental investigations of elastic wave anisotropy in monomineral and polymineral rocks, EGU2020-10671, https://doi.org/10.5194/egusphere-egu2020-10671, EGU General Assembly 2020

Bazargan, M., et al, 2020, A Numerical Toolbox to Calculate the Seismic Properties of Micro-Sized Isotropic and Anisotropic Minerals, Conference Proceedings, Mineral Exploration Symposium, Sep 2020, Volume 2020, p.1 – 3, DOI: https://doi.org/10.3997/2214-4609.202089023

Rémi Vachon, Mohsen Bazargan, Christoph F Hieronymus, Erika Ronchin, Bjarne Almqvist, 2021; Crystal rotations and alignment in spatially varying magma flows: Two-dimensional examples of common subvolcanic flow geometries, Geophysical Journal International, ggab127,

Bazargan, M., et al, in review; Pressure, temperature and lithological dependence of seismic and magnetic susceptibility anisotropy in amphibolites and gneisses from the central Scandinavian Caledonides

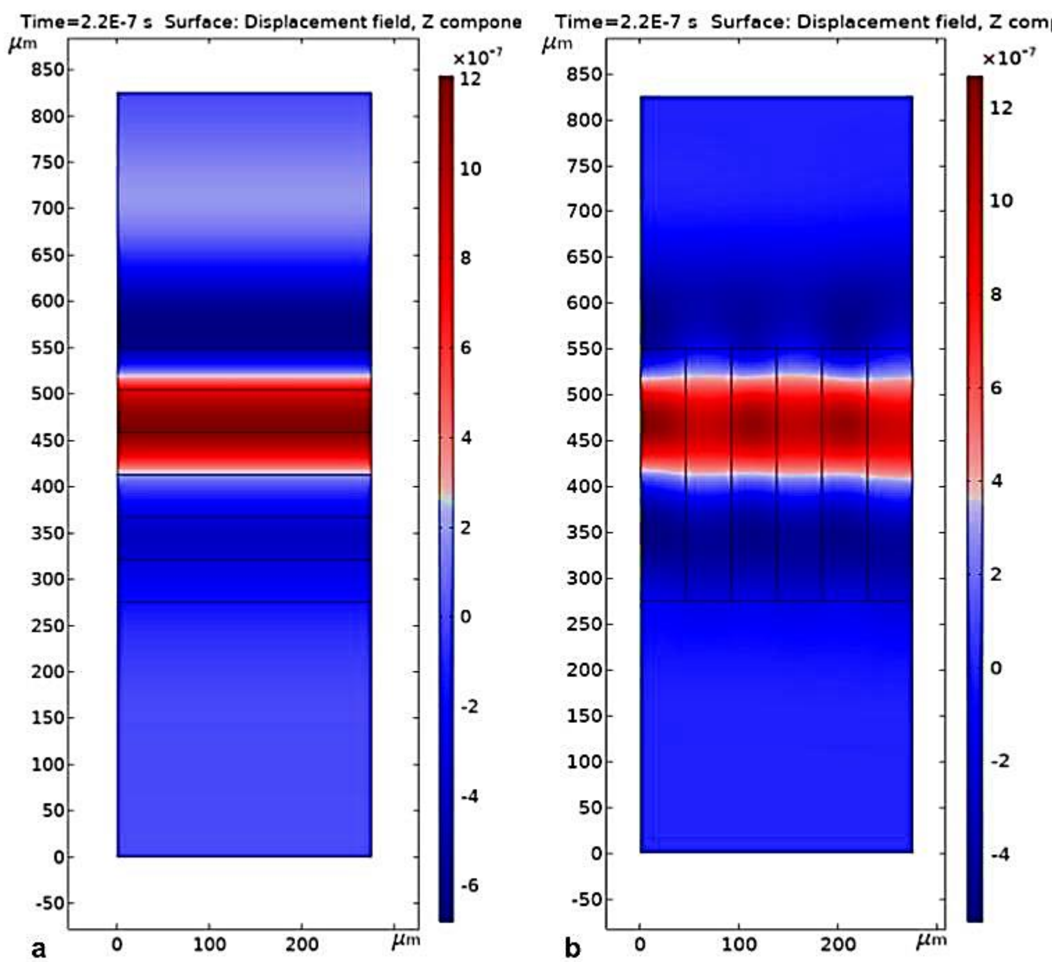

Figure 1: Compressional wave propagation in domain with a) layers perpendicular to the wave propagation direction and b) layers parallel to the wave propagation direction.