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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 are 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.
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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.