Geophysical Research Abstracts
Vol. 20, EGU2018-14098, 2018
EGU General Assembly 2018

Seismic anisotropy of slow-spreading oceanic crust and serpentinized mantle constrained from textures; a first evaluation on samples from IODP Expedition 357 (Atlantis Massif, Atlantic Ocean)

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Seismic tomography data suggest that slow spreading ridges appear to have weaker seismic anisotropy of crust and uppermost mantle rocks if compared to those from fast spreading ridges. Pervasive deformation, alteration and serpentinization was observed in drillcores from the sheared top of the Atlantis Massif oceanic core complex, recently sampled during IODP Expedition 357 on the slowly spreading Mid-Atlantic Ridge. Many minerals formed during that alteration (e.g. serpentine, talc, amphibole), however, have very strong seismic anisotropies. Their plastic deformation forms crystallographic preferred orientations (CPO), thus predicting strong rather than weak anisotropy.

We have analyzed CPO of fresh and altered gabbros by neutron diffraction using the SKAT texture goniometer at the Frank Laboratory for Neutron Physics, Dubna, Russia. This method allows measurements of large samples and is especially suitable for coarse-grained rocks. Synchrotron radiation was applied for finer grained talc schists and serpentinites. Measurements were performed at the high-resolution powder diffraction beamline ID22 at the European Synchrotron Radiation Facility (ESRF), Grenoble, France. Sample cylinders with a diameter of 15 mm were measured in transmission rotating the sample about 360°. Raw data from both measurement types were processed using Rietveld Texture Analysis to yield composition and quantitative information on the CPO. From this and single crystal elastic constants whole rock seismic anisotropies were computed.

Coarse-grained gabbros show no or weak CPO of plagioclase, probably due to shape alignment by magmatic processes. The composite CPO result in seismic anisotropies of about one percent. The serpentinites studied so far have surprisingly weak CPO, probably caused by lattice bending and curling of serpentine minerals. Talc-amphibole-chlorite schist, however, has a pronounced CPO and resulting high seismic anisotropy. We suppose that it is the latter rock type that might be important in defining shear zones of high seismic anisotropy. Shear zone abundance in the uppermost layer of hydrated mantle could, therefore, potentially be used as proxy for seismic anisotropy and vice versa.