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Crystallographic Preferred Orientations of Oceanic Serpentinites analyzed by Synchrotron Diffraction

Rebecca Kühn (1), Michael Stipp (2), Bernd Leiss (3), and Jan H. Behrmann (1)

(1) GEOMAR Helmholtz Centre for Ocean Research Kiel, Marine Geodynamics, Kiel, Germany (rkuehn@geomar.de), (2) Martin-Luther-Universität Halle, FG Geodynamik, Halle (Saale), Germany , (3) Geoscience Center of the Georg-August-Universität Göttingen, Department of Structural Geology and Geodynamics, Göttingen, Germany

Oceanic serpentinites comprise to a great extent the serpentine polymorphs lizardite and chrysotile. Analysis of their crystallographic preferred orientation (CPO) is challenging due to the fibrous crystal habit of chrysotile. More conventional methods such as electron backscatter or neutron diffraction are inapplicable, as the first requires polished surfaces that cannot be produced, while for the second neutrons are absorbed by the hydrogen within the serpentine crystal lattice, respectively. We therefore used hard X-ray synchrotron diffraction for unpolished sample cylinders with a diameter of up to 20 mm, which is also suitable for samples containing hydrous minerals. Measurements were conducted at the European Synchrotron Radiation Facility in Grenoble, France at beamline ID22. As beam size was limited to 1 mm, we measured several slices of the full sample cylinder to improve grain statistics.

A suite of serpentinite samples from the Atlantis Massif oceanic core complex, located on the mid-Atlantic ridge at 30°N, was studied. They were cored during International Ocean Discovery Program Expedition 357. Samples are highly altered ultramafics, containing lizardite and chrysotile, as well as magnetite and further minor minerals. The CPO and microstructures vary from weakly foliated bastite-rich to strongly foliated bastite-free mesh structures. Samples with less or no bastite clasts have intense foliations defined by the orientation of the serpentinizing microfractures. Serpentine CPO in bastite-rich samples is dominated by the bastites, while in bastite-poor samples the CPO seems to be controlled by the serpentinizing microfractures. The variations could depict differences in strain, in primary composition or fabrics inherited from the peridotite.

We show that synchrotron diffraction can be successfully used to determine the textures of oceanic serpentinites. This overcomes the severe limitations posed by more conventional methods, and opens the possibility of quantitative assessment of physical properties of hydrated oceanic Earth′s mantle. Even though the CPO in the samples originates from different microfabrics, it may lead to enhanced anisotropic physical properties.