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Effect of phase transformations on microstructures in deep mantle materials

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Phase transformations induce microstructural changes in deep Earth materials, including changes in grain size and orientation distribution. The effect of phase transformations on mineral microstructures is usually studied using electron microscopy on quench products from high P/T experiments. The method allows for a precise evaluation of the microscopic mechanisms involved. It is limited, however, to samples that can be quenched to ambient conditions and allows for investigations at a single P/T point for each experiment.

In recent years, we extended the use of multigrain crystallography to samples inside diamond anvil cells under mantle P/T conditions. The method allows for monitoring the orientations of hundreds of grains and grain size variations during various physical processes, such as plastic deformation and successions of phase transformations (Rosa et al 2015, Langrand et al 2017).

Here, we will show results concerning hydrous Mg_2SiO_4 during the series of α-β-γ phase transformations up to 40 GPa and 850 °C. Such results are important to understand the descending behaviour of subducted slabs, observations of seismic anisotropy, and polarity changes for seismic waves reflected of deep Earth interfaces. The data is used to asses the effect of the transformation on grain orientation and grain sizes. In particular, we do not observe orientation relationships between the parent α-phase and the daughter β-phase phase, suggesting an incoherent growth. We also observe significant grain size reductions and only little grain growth within the newly formed phases (Rosa et al 2016).

These new results are important for understanding the mechanical behavior of subducting slabs, seismic anisotropy in the Earth's mantle, and phase transformation mechanisms in olivine. Now that it is validated, the method can also be applied to other phases that can not be studied using electron microscopy, such as perovskite and post-perovskite.

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