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Characterization by Scanning Precession Electron Diffraction of bridgmanite and ferropericlase aggregates deformed at HP-HT

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The rheology of the lower mantle is of primary importance for mantle convection and hence for the dynamics and thermal evolution of the Earth. The lower mantle is mainly composed of a mixture of a high-pressure silicate, bridgmanite, with ferropericlase, an oxide which is usually considered to be weaker. It is thus very important to understand how such an assemblage deforms and in particular how stress and strain partition in between these two phases.

Recent developments in experimental rheology under extreme pressure allows now deformation experiments to be conducted under P,T conditions of the uppermost lower mantle. Using the rotational Drickamer apparatus (RDA), Girard et al. (2016) have deformed a mixture of bridgmanite and ferropericlase at 27 GPa, 2130 K and up to about 100% strain. In situ stress measurements show that bridgmanite is substantially stronger than ferropericlase suggesting that the latter largely accommodates the strain.

Here we report a transmission electron microscopy (TEM)-based microstructural characterization of these samples. Such a study is challenging because bridgmanite is very unstable once brought at ambient pressure, especially under electron irradiation, and also because TEM is usually not well adapted to characterize deformation microstructures resulting from large strains.

In this study we have acquired high-resolution orientation maps using scanning precession electron diffraction using the ASTARTM system from NanoMEGAS. Large strains are evidenced through strong intracrystalline misorientations which are analyzed and quantified to be used as a proxy of strain. We show that bridgmanite deforms along localized shear bands and that ferropericlase is indeed found to accommodate large strains (much larger than the macroscopic strain of a sample) due to profuse dislocation activity.