Elastic Anisotropy of Ferropericlase in Earths Lower Mantle

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Ferropericlase, containing about 10-20 at.% iron, is thought to be the second most abundant mineral of the lower mantle. Knowledge of its elastic anisotropy at relevant pressures is of great importance for our understanding of the structure and dynamics of the deep Earth interior. However, the effect of iron content on the single-crystal anisotropy of (Mg,Fe)O is still unclear. Furthermore, we still do not know the way the pressure-induced spin pairing of Fe^{2+} in ferropericlase (e.g. Badro et al., 2003) affects the elastic anisotropy. We performed 60° forward Brillouin Scattering on single-crystal $(Mg_{0.9}Fe_{0.1})O$ in a diamond anvil cell to the spin transition pressure of iron. At lower pressures a methanol-ethanol-water (16:3:1) mixture was used as pressure transmitting medium, at pressures above 15 GPa we loaded neon to minimize potential effects caused by non-hydrostaticity. The sample material has been synthesized and annealed at 25 GPa and 1800 °C (Keppler et al., 2007). This allows an almost complete reduction of Fe and makes the Fe^{3+}/Fe^{2+} ratio probably more realistic for lower mantle ferropericlase. The anisotropy factor A = $(c_{11}-c_{12})/2-c_{44}$ of $(Mg_{0.9}Fe_{0.1})O$ depends linearly on pressure up to about 40 GPa. At around 20 GPa ferropericlase is elastically isotropic as theoretically predicted for pure MgO by Karki et al. (1997). By comparing our results with the available data for Mg-rich ferropericlase and pure MgO, we notice that up to 20 GPa, the anisotropy factor seems to be insensitive to iron content; however, at higher pressures, we found that the anisotropy factor of $(Mg_{0.9}Fe_{0.1})O$ is about 15 % higher than the one determined by Crowhurst et al. (2008), who performed impulsive stimulated light scattering on $(Mg_{0.94}Fe_{0.06})O$. With the onset of the spin transition of iron at around 40 GPa, the anisotropy increases more rapidly. This anomalous behaviour was not resolved by Crowhurst et al. (2008) for $(Mg_{0.94}Fe_{0.06})O$. Our results suggest that the addition of iron to MgO significantly increases its elastic anisotropy in the lowermost part of the Earth's mantle.

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