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Partitioning of iron between lower mantle minerals

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The Mg-Fe partitioning between lower mantle minerals of perovskite and ferropericlase has been long searched but the results exhibit large inconsistency. The partitioning of iron into recently discovered post-perovskite phase has been controversial as well. This could be in part due to multiple valence and spin states of iron in the lower mantle conditions as well as heterogeneous distribution of iron in laser-heated DAC samples. Here we examined the Mg-Fe partitioning between perovskite/post-perovskite and ferropericlase based on sub-micron scale chemical analyses of recovered samples. The high-pressure phases were synthesized from $(\mathrm{Mg}_{0.9}\mathrm{Fe}_{0.1})_2\mathrm{SiO}_4$ gel at pressures between 30 and 126 GPa and temperatures around 2000 K in a laser-heated DAC. The thin section of recovered samples were obatined by Ar-ion milling using PIPS and Ion Slicer. A typical grain size was about 100-nm. The chemical analyses were made with TEM, FE-EPMA and FE-SEM. The Fe^{3+}/total Fe ratios were also determined from the ELNES spectroscopy attached with TEM. For samples thinned by the Ion Slicer, large areas were observed under the TEM. The analyses demonstrated a remarkable chemical gradient in iron content according to a temperature gradient during laser-heating. Such a spatial variation in iron content was found only in ferropericlase, whereas perovskite and post-perovskite had limited chemical variations. This results in apparently large variations in the Mg-Fe partitioning. The partitioning was therefore calculated from the Fe/Mg ratios of perovskite/post-perovskite and original bulk composition. The Fe^{3+}/total Fe ratios were obtained to be 0.1 to 0.2 for all perovskite, post-perovskite and ferropericlase, indicating the minor presence of ferric iron in our samples. Our results show that $\mathrm{K}_D(\mathrm{Fp/Pv}) = (\mathrm{X}_{Fe2+}/\mathrm{X}_{Mg})^{Fp}/(\mathrm{X}_{Fe2+}/\mathrm{X}_{Mg})^{Pv}$ is approximately constant at 4 between 30 and 105 GPa. This value is lower than those obtained at about 1500 K by

Kobayashi et al. [2005], likely due to the higher temperature in this study.