Stability of Fe,Al-bearing bridgmanite in the lower mantle and synthesis of pure iron bridgmanite

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The physical and chemical properties of the Earth's mantle as well as its dynamics and evolution depend heavily on the phase composition of the region. The lower mantle consits predominatly of bridgmanite (perovskite-structured $(Mg,Fe)(Si,Al)O_3$), thus experimental studies of geophysical and geochemical properties are essential for undertsanding the structure and evolution of the Earth's interior.

Based on experiments in laser-heated diamond anvil cells we demonstrate that Fe,Al-bearing bridgmanite (magnesium silicate perovskite) is stable to pressures over 120 GPa and temperatures above 3000 K. Ferric iron stabilizes Fe-rich bridgmanite such that we were able to synthesize pure iron silicate perovskite at pressures between ~45 GPa and 110 GPa with the composition $(Fe^{2+}_{0.64(2)}Fe^{3+}_{0.24(2)})Si_{1.00(3)}O_3$.

Fitting the data on pure iron bridgmanite to a 3rd order equation of state gives the zero-pressure bulk modulus $K_{0,300}$=190(4) GPa and unit-cell volume V_0=178.98(6) Å^3. Such value of the bulk modulus is exceptionally low and haven't been observed for any silicate perovskites.

The crystal chemistry of ferric iron-bearing Fe-bridgmanite is also remarkable. First, all iron is located in the A-site (bicapped prism) and within the accuracy of determination of the occupancies of structural positions (better than 5%) there is no iron in the octahedra (B-site). Second, it contains a significant amount of vacancies (about 12%) at the A-site. All these data show the significance of Fe^{3+}-bearing perovskite and suggest that lower mantle can contain previously unknown phases.

These results have important implications for the global Earth dynamics and interpretation of enigmatic seismic features beyond ~2000 kilometers depth. The elastic properties of iron bridgmanite different to any known silicate perovskites, which has direct implications for the interpretation of seismic tomography data.