Effect of Fe content on olivine strength at high-pressure and comparison with ringwoodite

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Abstract

Terrestrial planet mantles are olivine-rich, with Fe/(Mg+Fe) ratio lower than _˜2% for Mercury and up to 25-30% for Mars, with intermediate compositions for the Earth and Venus. Experiments at 300 MPa pressure (Zhao et al., 2009, EPSL, 287, 229-240) indicate that Fe dramatically decreases olivine viscosity. Thus, the Martian upper mantle may be _˜10 times less viscous than the Earth's at the same conditions. Whether such a weakening occurs at the high pressures relevant to planetary interior is unknown. Deeper in the mantle, olivine (α) transformed into its high-pressure polymorphs wadsleyite (β) and ringwoodite (γ), the main constituents of the transition zone. Understanding the strength contrast between olivine and or phase is critical to constrain mantle convection. Here, we present the results of a series of high-temperature deformation experiments carried out in the D-DIA coupled with synchrotron radiation at pressure (P) within 1.5 – 6.5 GPa, on polycrystalline olivine specimens with various compositions along the forsterite - fayalite joint. Specimens and cell assembly were kept dry at 120C for several hours before loading into the D-DIA. Different specimens were deformed two by two in order to compare their rheology, while San Carlos olivine was used as a reference material. In a few preliminary experiments, Fe-rich γ phase rheology was compared with that of Fe-poor olivine. We will show that pressure dramatically decreases the viscosity contrast between Fe-poor olivine and Fe-rich olivine, while increasing differential stress has the opposite effect. Hence, the range of viscosities expected in planetary mantles - between the low-P high-stress regime of the subsurface and the high-P low-stress regime of the deep interior – may strongly depends on their iron contents. We will also discuss the viscosity contrast between olivine and its high-pressure polymorphs as observed in our preliminary experiments, in the framework of previously published data.

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