ESRF	**Experiment title:** Effect of Fe on olivine (α) plasticity and strength contrast with β and γ phases	**Experiment number**: ES-203
Beamline: ID06LVP	**Date of experiment**: from: 18/02/2015 to: 22/02/2015	**Date of report**: 09/09/2015
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Report:

Experiment ES203 was aimed at measuring the rheology at high pressure of polycrystalline olivine and ringwoodite with different iron contents. These rocks are relevant to earth and planetary mantle dynamics (upper mantle and transition zone). Increasing iron contents weakens olivine strength at low pressure. The goal of our experiments was two folds: i) quantify the possible weakening effect of iron on olivine high-pressure strength, and ii) compare the strength of olivine to that of its high-pressure polymorph: ringwoodite.

We carried out deformation runs with in situ stress and strain measurements on the large volume press at ID06 during ES27, in February 2014. During this first series of runs, several technical difficulties have been overcome, leading to a successful run (OLI_06, see report for ES27). Our preliminary results showed that the weakening effect of Fe is not as large at high-pressure than that reported at low pressure.

The present project ES-203 was dedicated to further investigate this effect, and to explore the rheology of olivine in the Temperature-pressure-Fe-content space. We, thus, carried out a series of experiments with several olivine compositions, i.e. Fe/Fe+Mg ratios of 0%, 10%, 70% and 100%.

Technical aspects and progress

One major change with respect to run ES27 is that the power is now brought to the vertical furnace through the vertical anvils, i.e. the anvils are now directly in contact with the furnace. This allows simplifying the deformation cell by removing the lateral metal connectors (see report for run ES27), resulting in a much stable cell at high temperature. The samples were imaged by taking a series of 12 radiographs (e;g, 0.8 mm high beam) over the whole experimental column (about 5 mm including pistons) and the images were concatenated using a Fig2D macro. The diffractions were taken using a linear detector with rotation centered on the direct beam. Recording of a diffraction image takes about one minute.

Experiments:

Given the set of anvils available, with large truncations, all experiments were carried out in the olivine stability field (α). The few attempts that has been made to reach the γ field at 50 bars oil pressure resulted in blow outs before rheological data were collected. Experiments in the γ field require anvils with smaller truncations (to reach higher pressures). The successful experiments are listed below:

Run	Load (bar)	Power (W)	Specimen Fe/Fe+Mg ratios
Rwd_017	30	165	10% and 100%
Rwd_018	30	235	10% and 100%
Rwd_019	30	235	70% and 100%
Rwd_020	30	236	0% and 100%
Rwd_021	30	235	0% and 100%
Rwd_022	40	235	0% and 70%
Rwd_024	40	235	0% and 100%

In each experiments, two samples of different compositions were stacked atop each other, which allowed comparing directly their strengths (strain rates) at given differential stress. The samples were all pressurized to the same load, heated around 800°C and 1100°C and deformed at constant strain rates. Fig. 1 shows strain results (positive in compression) for run Rwd_022. The iron free specimen (Fo100) is harder than the Fe-rich specimen (Fa70), yet by only factors ranging from 2 to 4 depending on the applied stress. The iron-rich specimen appear also more sensitive to a stress change than the iron-free specimen (Fo100). For comparison, Fa70 is several hundred times weaker than Fo100 at low pressure.

Fig. 1 – Strain results for experiment Rwd_022. The Fa70 specimen has a Fe/Fe+Mg ratio of 70% while the Fo100 specimen contains no iron. The dashed bar indicate an increase in the applied differential stress.