Synthesis of Hydrous Olivine Under High Pressure and Temperature

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Abstract
The study of water storage in the mantle is of great importance. This is because water content can greatly change the assorted properties of the minerals present. Since Olivine comprises a major part of the mantle, it is important to understand how water can get incorporated into it. The goal of this study is to synthesize the greatest concentration of hydrogen possible in olivine. This knowledge could be applied to what we know about the mantle to further understand the role of water in mantle processes.

Starting Materials
We utilize an altered version of this equation.
2MgO + SiO2 $\rightarrow$ Mg$_2$SiO$_4$

Starting powder includes:
- 240 mg SiO$_2$
- 161.2 mg MgO
- 233.2 mg Mg(OH)$_2$
- About 10 wt% of H$_2$O

Extra MgO was added to ensure that the silica activity is low.
A sample with a mixture of forsterite and MgO also included in one experiment.

Experiments at High P/T
- Arizona 14/8 cell assembly
- Pressure: 3, 6.5 and 12 GPa
- Temperature: 1200 degrees Celsius
- Duration: 1-2 hours
- Au capsule
- BN sleeve inside capsule to impose reducing environment

Infrared Analysis
A double-polished thin section of each sample was prepared for the infrared analysis. The analysis was done at the National Synchrotron Light Source at the Brookhaven National Lab. An infrared microscope at Beamline U2A was used in order to get absorbance readings.

Results:

**Figure 1**
IR spectra for Sample 4
(3 GPa, 1200°C, 1 hour)

**Figure 2**
IR spectra for Sample 2
(6.5 GPa, 1200°C, 1 hour)

**Figure 3**
IR spectra for Sample 1
(6.5 GPa, 1200°C, 2 hours)

This sample compares the oxide mix with a forsterite based mix.

**Figure 4**
IR spectra for Sample 3
(12 GPa, 1200°C, 1 hour)

**Figure 5**
IR spectra for all samples. It can be seen that absorbance is increased as the pressure increases. This in turn means that as pressure increase, so does the water content.

**Figure 6**
Water concentration as a function of pressure.

**Figure 7**
Representative IR spectra of olivine synthesized in various oxygen fugacities. It can be seen that the absorption peak at 3600 cm$^{-1}$ becomes increasingly dominant as the environment becomes more reducing.

Conclusion & Discussion
The technique used in this research yielded water concentrations approximately 2x that of previous research such as Kolstedt et al., 1996. The technique evolved over time that, under constant temperature and pressure, olivine gets greater hydrogen concentrations when the silica activity and the oxygen fugacity are low. Thus, silica was limited and a boron nitride sleeve was used to create a highly reducing environment, which is even more reducing than iron-wüstite buffer. In order to achieve the desired results, the heating time would have to be increased so as to allow larger crystals to form. This will serve a double purpose of allowing more hydrogen to be able to get incorporated and to avoid some of the error that grain boundaries can add to the data. All together, this research shows that the technique used could be applied to achieve possibly greater concentration than have been achieved in the past.

Key References


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