Oxygen partitioning between magnesiowüstite and liquid Fe-rich metal at high pressure and high temperature

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Oxygen is one of the possible candidates for being a light element in the Earths core. The phase diagram of the Fe-FeO system has been investigated up to 16 GPa (e.g., Ohtani et al., EPSL, 71, 94, 1984; Kato and Ringwood, PCM, 16, 524, 1989). However, the high temperature region of this diagram is not well established because a region of liquid immiscibility exists that makes it difficult to interpret quenched samples. In this study, we are investigating the partitioning behavior of oxygen in the Fe-FeO-MgO system in order to understand oxygen solubility in molten iron at high pressures and temperatures. This work is a joint research with D. Frost and D. Rubie in Baverisches Geoinstitute.

Oxygen partitioning experiments have been conducted at 15-24 GPa and 2200-2900 deg.C with a multi-anvil apparatus installed in Baverisches Geoinstitute, Germany. The starting material was a mixture of Fe metal powder and Fe2O3 oxide powder with a composition that is 95Fe5O (weight ratio). We used MgO single crystals as sample containers. Quenched liquids consisted of O-rich blobs and dendrites in an Fe-rich matrix. During the experiment FeO from the metal liquid reacts with the MgO capsule to produce a magnesiowustite rim on the capsule wall. Chemical analyses were conducted on each of the phases, i.e., blobs and matrix and the magnesiowustite at the interface with the metallic liquid, using an electron microprobe. The fractions of the FeO-rich blobs and matrix were determined from backscattered electron images using the image analysis software Image J. We assumed the area fractions of the blobs and the matrix are proportional to their respective volume fractions. The composition of the bulk liquid metal was estimated by integrating the compositions of the blobs and the matrix metal, based on their volume fractions.

Our preliminary results indicate that the partition coefficient may increase with both increasing pressure and temperature. The pressure effect seems to be inconsistent with previous studies on oxygen partitioning between magnesiowustite and liquid Fe-Ni alloy (ONeill et al., JGR, 103, B6, 12239, 1998; Rubie et al., Nature, 2473, 2004). However, previous phase diagram studies on the Fe-FeO system have suggested that oxygen solubility in liquid iron increases with increasing pressure and the present results are consistent with these studies. The compositional difference might cause the different pressure effect. Differences might also be due to the higher oxygen fugacity employed in this study. Though more experiments at wider pressure range are required to clarify the pressure effect on oxygen solubility of molten iron, the present results might suggest that effects of pressure are different depending on the activity of FeO in molten iron and in molten Fe-Ni alloy, or that Kd varies as a function of the oxygen content of the metal.