In situ high P-T melting and phase equilibria experiments on the Allende meteorite

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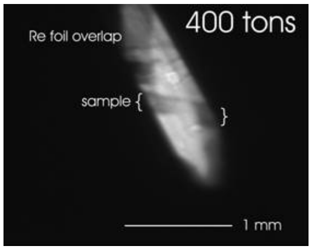
Because chondritic materials are thought to be the building blocks of terrestrial planets and planetesimals, crystallization of chondritic and peridotitic material can be used to simulate accretion and differentiation of a bulk planet. The objective of this study is to measure the liquidus phases and temperatures in situ for a number of planetary mantle analog materials at P > 20 GPa.

Experiments were conducted in the Large Volume Press at the Advanced Photon Source, Argonne National Laboratory. Phases were identified using energy-dispersive X-ray diffraction (EDXRD) with a fixed diffraction angle (2θ) of ~6° and data collection times of 60 sec. Heating runs up to 2200 °C were performed at 400, 600, and 700 tons, sampling a pressure range from 18-32 GPa.

A 3mm TEL beamline modified Fei-type assembly was used in experiments. MgO was used as the pressure standard. Temperature at the hotspot, the region of interest for analyses, was calculated using the thermal modeling program developed by [1].



Radiography image of compressed sample though the Re slits and alumina windows. Maximum pressure achieved was 19.1 GPa. The pressure standard was located immediately above the sample. The dark area in the upper left is an area where the slit in the Re foil ends.

The solidus is comparable to previous results, but the majorite liquidus temperature occurs near 2250 °C, compared to previous results of 2000 °C [2,3]. The majorite-Mg-perovskite cotectic occurs before 22 GPa, as opposed to around 25 GPa [2,3]. Although Mg-perovskite was identified as the liquidus phase above 22 GPa, the ferropericlase-out line is very steep, and may become the liquidus phase above 23 GPa. The higher liquidus temperature with the large field of melting would tend to support a shallow magma ocean model with a large zone of crystal mush.

Reference

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[3] Asahara *et al*. (2004) *Phys. Earth Planet. Int*., **143-144**, 421-432.

Fe^{3+}/Fe^{2+} of melt inclusions: Implications for melt H_2O contents

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Melt inclusions trapped by early formed phenocrysts are a unique source of information on the pre-eruptive H_2O content of magmas. However, the initial H_2O content of the trapped melt can be modified after entrapment through at least two mechanisms: dissociation caused by H_2 diffusion and diffusion of molecular H_2O.

Diffusive loss of H_2 would necessarily result in oxidation of the inclusion. The only redox variable element of sufficient abundance is Fe ($H_2O + 2FeO = H_2 + Fe_2O_3$) and complete oxidation would be expected i.e. $Fe^{3+}/\Sigma Fe = 1$ if a significant amount of H_2O had dissociated.

We present measurements of the oxidation state of melt inclusions in olivine from a komatiite of the Archaen Belingwe belt, Zimbabwe, which contains fresh olivine phenocrysts. Inclusions were rapidly homogenised and quenched to produce a glass. Samples were prepared as free standing thin sections with the inclusion exposed on both sides. Infrared spectroscopy determined the water content of the glass to be 0.18-0.26 wt%.

Fe K-edge X-ray absorption near edge structure (XANES) spectroscopy allows $Fe^{3+}/\Sigma Fe$ to be determined with micron spatial resolution from the energy of the $1s \rightarrow 3d$ pre-edge transition. Reference spectra were recorded for a synthetic mid ocean ridge basalt (MORB) composition equilibrated at 1400 ˚C and fO_2 values ranging from IW-1 ($Fe^{3+}/\Sigma Fe = 0$) to NNO+11 ($Fe^{3+}/\Sigma Fe = 1$). The $Fe^{3+}/\Sigma Fe$ values of these standards were estimated from empirical literature expressions and correlated with the XANES pre-edge centroid energies to produce a calibration curve. The average $Fe^{3+}/\Sigma Fe$ value determined for a number of homogenised MORB melt inclusions using this calibration was 0.14 ± 0.02, in excellent agreement with a literature value of 0.13 ± 0.02 determined by wet chemical analysis. The $Fe^{3+}/\Sigma Fe$ value for the komatiite melt inclusions, using the same calibration curve, was found to be 0.14 ± 0.03, indicating no significant H_2O loss via H_2 diffusion.

Loss of molecular H_2O from melt inclusions results in the formation of halos of tiny fluid inclusions and recrystallised host mineral rims around the walls of the inclusions. No such structures were observed in the samples studied and we thus interpret the measured H_2O concentrations as represntative of the trapped values.