Geophysical Research Abstracts,
Vol. 11, EGU2009-1213, 2009
EGU General Assembly 2009

Eutectic propeties of primitive Earth's magma ocean

G. Lo Nigro, D. Andrault, N. Bolfan-Casanova, and J.-P. Perillat
(g.lonigro@opgc.univ-bpclermont.fr)

Eutectic properties of primitive Earth's magma ocean

G. Lo Nigro1, D. Andrault1, N. Bolfan-Casanova1 , J.-P. Perrillat2

1 LMV, Université Blaise Pascal, 5 rue Kessler, 63000 Clermont-Ferrand, France
2 ID27, European Synchrotron Radiation Facility, BP220, 38043 Grenoble, France

Abstract

It is widely accepted that the early Earth was partially molten (if not completely) due to the high energy dissipated by terrestrial accretion [1]. After core formation, subsequent cooling of the magma ocean has led to fractional crystallization of the primitive mantle. The residual liquid corresponds to what is now called the fertile mantle or pyrolite.

Melting relations of silicates have been extensively investigated using the multi-anvil press, for pressures between 3 and 25 GPa [2,3]. Using the quench technique, it has been shown that the pressure affects significantly the solidus and liquidus curves, and most probably the composition of the eutectic liquid. At higher pressures, up to 65 GPa, melting studies were performed on pyrolite starting material using the laser-heated diamond anvil cell (LH-DAC) technique [4]. However, the quench technique is not ideal to define melting criteria, and furthermore these studies were limited in pressure range of investigation. Finally, the use of pyrolite may not be relevant to study the melting eutectic temperature. At the core-mantle boundary conditions, melting temperature is documented by a single data point on (Mg,Fe)2SiO4 olivine, provided by shock wave experiments at around 130-140 GPa [5]. These previous results present large uncertainties of ~1000 K.

The aim of this study is to determine the eutectic melting temperature in the chemically simplified system composed of the two major lower mantle phases, the MgSiO3 perovskite and MgO periclase. We investigated melting in-situ using the laser-heated diamond anvil cell coupled with angle dispersive X-ray diffraction at the ID27 beamline of the ESRF [6]. Melting relations were investigated in an extended P-T range comparable to those found in the Earth's lower mantle, i.e. from 25 to 120 GPa and up to more than 5000 K.

Melting was evidenced from (a) disappearance of one of the two phases in the diffraction pattern, (b) drastic changes of the diffraction image itself, and/or (c) appearance of a broad band of diffuse X-ray scattering associated to the presence of silicate liquid. The pressure evolution of the eutectic temperature is found below the melting curve of pure MgSiO3 perovskite [7] for more than 500 K and also below the solidus curve of pyrolite [4] for 100-200 K at 60 GPa.

References

[1] B. T. Tonks, H. J. Melosh, Journal of Geophysical Research 98 5319 (1993).
[2] Litasov, K., and Ohtani, E. Physics of The Earth and Planetary Interiors, 134(1-2), 105-127, (2002).
[3] E. Ito, A. Kubo, T. Katsura et al., Phys. Earth Planet. Inter. 143-144 397 (2004).
[4] A. Zerr, R. Boehler, Nature 506–508 (1994).
[5] J. A. Akins, S. N. Luo, P. D. Asimov et al., Geophys. Res. Lett. 31 doi:10.1029/2004GL020237 (2004).

[6] Schultz et al. International Journal of High Pressure Research. 25, 1, 71-83 (2005).
[7] Zerr, A. and Boehler, R. Science, 262, 553–555 (1993).