

Liquid evolution beneath Shatsky Rise oceanic plateau – experimental and thermodynamic simulations of the magma differentiation

A. Husen (1), R. Almeev (2), J. H. Natland (3), F. Holtz (2), J. Koepke (2), and K. Mengel (4)

(1) NTH Graduate School GeoFluxes, Leibniz University of Hannover, Institute of Mineralogy, Hannover, Germany (a.husen@mineralogie.uni-hannover.de, 0511 762 3045), (2) Leibniz University of Hannover, Institute of Mineralogy, Hannover, Germany, (3) Rosenstiel School of Marine and Atmospheric Science, University of Miami, USA, (4) Institute of Disposal Research, Clausthal University of Technology, Germany

IODP Expedition 324 recovered samples from Shatsky Rise oceanic plateau ranging from picritic basalts (15.6 wt% MgO) to more differentiated tholeiitic basalts (4.9 wt% MgO). Preliminary results of petrographic and geothermobarometric investigations provide evidence that Shatsky Rise basaltic magmas are reminiscent of typical EPR MORBs evolved along *dry* (0.2-0.6 wt% H₂O) low pressure Ol-Pl-Cpx cotectics [1]. The glass compositions and the H₂O concentrations were used to simulate conditions of multiple saturation of basaltic melts [2]. Our calculations demonstrate that the basaltic melts could have been last equilibrated with Ol-Pl-Cpx association at 1110 to 1170°C in the range of pressures between 1 atm to 300 MPa.

We present the results of an experimental study of three tholeiitic Shatsky Rise compositions from different evolutionary stages. Synthetic analogues to naturally quenched glasses (AH5: 6.7 wt% MgO, AH3: 8.2 wt% MgO, AH6: 8.9 wt% MgO) were chosen as starting materials. The experiments were conducted in an internally heated pressure vessel (IHPV) at the Institute of Mineralogy in Hannover using C-Pt double capsules. Carbon-lined capsules allowed us to maintain the conditions assumed to be prevailing in natural system: (1) redox conditions were controlled by CCO buffer which is below QFM (QFM-1 to QFM-3); (2) water activity was low (<1000 ppm in most runs). Three capsules with different composition were run simultaneously at 100, 200, 400 and 700 MPa between 1150°C and 1225°C during 2-3 days. The run products were analyzed by electron microprobe. The Kd values between olivine, clinopyroxene and basaltic liquid were evident for achievement of equilibrium conditions in most runs (Ol: 0.28-0.31, Cpx: 0.23-0.28). In some "failed" experiments (especially at low pressures) the CCO buffer caused extremely reducing conditions, which led to precipitation of pure Fe⁰. This was attributed to be the result of a missing fluid which was possibly escaped through holes in the outer Pt capsule. Preliminary data on H₂O concentration in the experimental glasses gave maximum H₂O contents of 0.2 wt%. The natural phase assemblage was reproduced in all three starting materials. Contrasting differentiation trends were observed due to changes of the order of crystallization, which was governed by the pressure and bulk composition.

New experimental data are in agreement with results of our thermodynamic calculations and support the idea of magma evolution along low pressure cotectics (< 200 MPa). At 700 and 400 MPa, the earlier Cpx stabilization drives liquid lines of descent (LLD) off the trend defined by Shatsky Rise basaltic glasses. In contrast, 100 and 200 MPa Ol-Pl-Cpx saturated experimental glasses are developing along the natural LLD.

Experimental Ol+Pl+Cpx saturated glasses produced at different pressures were used to evaluate the accuracy of the method [2] and COMAGMAT program [3] utilized in our modeling. Although the results of the calculations demonstrate some systematic deviations from experimental data, they are almost two times better than the precision of geothermobarometers used in COMAGMAT model (50 MPa and 10°C).

Experiments with H₂O-CO₂ fluid are in progress to test the effect of small amounts of H₂O (up to 1 wt%) on mineral cotectics.

References:

1. Sager et al., (2010) Expedition 324 Scientists Preliminary Report
2. Almeev et al., (2008) Journal of Petrology, 49(1), 25-45.
3. Ariskin and Barmina (2004) Geochemistry International, 42(1) S1-S157