Depths of partial crystallization and water contents of MORB inferred from glass compositions: phase equilibria simulations of basalts at the MAR near Ascension Island

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We present a new semi-empirical approach developed for the estimation of crystallization conditions of naturally quenched basaltic glasses from magmas erupted at mid-oceanic ridges. Data obtained as a result of phase equilibria simulations for basaltic compositions, in which the effect of pressure and of small amount of H_2O on liquid lines of descent have been modelled, indicate that MORB-magmas beneath different segments of the MAR east of Ascension island (7–11°S) have crystallized over a wide range of pressures (200 to 800 MPa). However, each segment seems to have a specific crystallization history. We report polybaric crystallization conditions (200–800 MPa) for the N-MORB magmas beneath Segments A1, A2 and A4. In contrast, nearly isobaric crystallization conditions (200–300 MPa) are obtained for the geochemically enriched MORB magmas underneath central Segment A3. The results of our modelling demonstrate almost anhydrous crystallization conditions of MORBs from the Segment A1 basaltic lavas, whereas Segment A3 MORB compositions were successfully modelled in the presence of 0.5 to 1 wt% H_2O in parental melts. These estimates are confirmed by the FTIR measurements of H_2O in basaltic glasses and melt inclusions for selected samples. Water contents determined in the parental melts are in the range 0.04 – 0.09 and 0.3–0.5 wt% H_2O for segment A1 and A3, respectively.

Our study also highlights the general problem of the evaluating the effects of H_2O on liquidus temperatures of silicates. There are significant differences in predicting liquidus depression of olivine and plagioclase utilizing different empirical or thermodynamic models [1–3]. Therefore high quality experimental data are needed to calibrate the effects of water on liquidus temperatures of the main solid phases crystallizing in MORB systems.

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Fractionation history recorded in phenocrysts: LA-ICPMS study of clinopyroxenes from Klyuchevskoy and Bezymianny volcanoes, Kamchatka

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We present results of detailed examination of trace element contents in high-Ca pyroxenes (Cpx) from high-magnesia (HMB) to high-alumina (HAB) basalts of Klyuchevskoy and basaltic andesites to andesites of Bezymianny volcanoes. These two volcanoes represent a suite of genetically linked calc-alkaline rocks where magma differentiation processes were attributed to (1) prolonged ascent-driven decompressional crystallization (7–20 kbar) of parental HMB magmas in the magmatic channel of Klyuchevskoy volcano, and (2) essentially isobaric crystallization (4–7 kbar) of HAB in magmatic chamber of Bezymianny volcano. Trace element abundances in Cpx demonstrate systematic variation with major element composition and two particular features have been reported. All Cpx phenocrysts have similar chondrite normalized patterns with a parallel arrangement for all moderate to high incompatible elements. Cpx from Bezymianny and Klyuchevskoy share the same evolutionary trends supporting the ideas on a common geochemical history of the basaltic to andesitic melts from which they have been crystallized. Another important finding is that some elements (Ti, V, Sr, Eu, Sc) exhibit compositional change from enrichment to depletion observed in moderate to more evolved Cpx. Such behaviour is best explained by stabilization of magnetite (Ti, V) and plagioclase (Sr, Eu) in the liquidus association resulting in precipitation of Cpx depleted in respect of these elements. According to our data only Cpx from HABs, basaltic andesites and two-pyroxene andesites show trace element regularities consistent with simultaneous crystallization of plagioclase and magnetite. We conclude that phenocrysts chemistry combining with major and trace element systematics observed in volcanic lavas support the crystallization relations between HAB-magmas, typical of Klyuchevskoy, and andesitic magmas of Bezymianny.