Effect of variable CO_2 on andesite-lherzolite reaction: Implications for mantle hybridization and generation of alkalic basalts

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Presence of recycled oceanic crust, a major heterogeneity in the Earth's mantle, is invoked in the source of many ocean island basalts (OIBs) [1]. However, andesitic partial melts derived from oceanic crust, upon reaction with subsolidus peridotite, produce basanites [2] but cannot form strongly alkalic lavas such as nephelinites. In this study, we evaluate whether such an andesite, with dissolved CO_2, can evolve to more Si-deficient magma due to partial reactive crystallization in subsolidus peridotite.

We performed piston-cylinder experiments at 1375 °C, 3 GPa with homogenous mixtures of 25% or 33% of an andesite and lherzolite KLB-1 with 1 to 5 wt.% CO_2 in the starting melts (0.25 to 1.62 wt.% bulk CO_2). Upon reaction, with increasing CO_2 in the reacting melt: a) modes of reacted melt, opx and garnet increased while that of olivine and cpx decreased b) the andesite evolved from basanite to nephelinite c) the residual melts, on a volatile-free basis, showed variation in SiO_2 from 44-40 wt.% and 45-43 wt.%, TiO_2 from 6-5 wt.% and 7-6 wt.%, Al_2O_3 from 14-11 wt.% and 13-10 wt.%, MgO from 13-17 wt.% and 12-17 wt.%, CaO from 8-11 wt.% and 8-11 wt.% and Mg# from 68-75 and 69-73, for 25% and 33% melt-added series, respectively and d) FeO* and Na_2O did not show significant variation.

Our results show that with increasing CO_2 in the andesite, its reaction with lherzolite yields greater degree of Si-undersaturation owing to dilution of melt SiO_2 by CO_2 and lowering of melt SiO_2 by enhanced crystallization of opx at the expense of olivine. Increased precipitation of garnet lowers Al_2O_3 in the reacted melts. Increased CaO and MgO and no significant trend of FeO* and Na_2O with greater bulk CO_2 content confirm propensity of Ca^{2+} and Mg^{2+} over Fe^{2+} and Na^+ in entering silicate melt as carbonates. Residues show more opx-enrichment with greater CO_2 in the system. We have developed a model for quantitative prediction of mineral modes in hybrid residues as a function of melt-rock ratio and dissolved CO_2 in the reacting melt. At a given MgO, the CO_2-bearing reacted melts are better match for alkalic OIBs in terms of SiO_2, Al_2O_3, CaO, Na_2O and CaO/Al_2O_3 than their volatile-free analogs.

[1] Hofmann & White (1982), *EPSL* 57, 421-436. [2] Mallik & Dasgupta (2012), *EPSL* 329-330, 97-108.

Use of uranium, thorium and carbon isotopes for thermal groundwater and travertine dating

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The use of ^{14}C dating in groundwater in some cases, is facing serious difficulties. It first of all - reducing the specific activity of 14C in groundwater due to dissolution of carbonate host rocks, overstates age, and mixing with younger water, substantially understates it. In this regard, we propose the sharing of ^{14}C and ^{234}U-^{238}U for dating. However, ^{234}U-^{238}U method now not enjoys great popularity. This is due to the need to determine a large number parameters. It should be noted difficulty in defining SSA, and respectively, α-recoil loss factor. For practical use of the ^{234}U-^{238}U method, we offer to introduce in the calculation the generalized parameter (probability of the transfer of ^{234}U into water, or "effective α-recoil loss factor") derived empirically from geological benchmarks, hydrodynamic calculations, and paleo-hydrogeological reconstructions [1]. For hydrothermal system located within mainland European Subarctic 14C age of thermal waters is 9-12 ka, 234U/238U age - 6-11 ka. Calibrated δ13C age of travertine - to 3 ka. U-Th age of travertine -- up to 1.5 ka. Assessment calculations show that when dating groundwater isotope of uranium, 10% admixture of young water (up to 100 years) reduces the age of ancient water (11 ka) by 11%. Joint dating of the groundwater and from them formed travertine possible to estimate the velocity of the groundwater in the hydrothermal system and the speed of neotectonic uplift of the area.

[1] Malov (2013) Lithol. Miner. Resour. **48**, 254-265.

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