Arc Basalt Simulator, a simulation model for arc basalts: modeling scheme and application to the IBM arc

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Basalt magmas in convergent margins have typical geochemical and isotopic signatures including elevated large ion lithophile elements (LILEs), depleted heavy rare earth elements (HREEs) and high field strength elements (HFSEs), and variously radiogenic Sr and Pb isotopes with usually un-radiogenic Nd and Hf isotopes. Origin of these characteristics have been interpreted as melting of depleted mantle (DM) peridotite by fluxing of fluids (or melts) derived from subducting oceanic plate consisting of altered oceanic crust (AOC) and sediment (SED) components. Recent experimental studies have revealed behaviors of multiple elements during slab dehydration and mantle melting. These developments enable us to generate a forward simulation model for arc basalt geochemical compositions. Arc Basalt Simulator (ABS) is an EXCEL spreadsheet based calculator including simulation ofthat predicts the partitioning of incompatible element and Sr-Nd-Pb isotopic compositions in a slab derived fluid by slab dehydration and in an arc basalt magma generated by an open system fluid-fluxed dynamic melting of a mantle peridotite. Necessary source input compositions are AOC, SED, and DM (X(AOC), X(SED), X(DM)). Variables are Mx = AOC-SED mixing rate in the slab, Ts = slab temperature, Tp = slab pressure for fluid composition, and b = fluid flux rate, F = degree of melting, f = porosity, and Xa-Pa = melting mode of DM, among which melting mode can be derived by pMELTS calculations. The fundamental modeling scheme uses Kimura & Yoshida (2006) in addition to formulations of element partition coefficients (Ds) between slab and fluid to various T (700-1200C) at different P conditions (4, 5, and 6 GPa) based on experiment by Kessel et al. (2005). Application of ABS can constrain Mx, Ts, Tp, b, and F variables by manually solving inverse problems, if all X(AOC), X(SED), X(DM), and X(Basalt) trace element and isotope compositions are given (see Kimura & Yoshida, 2006). Another application is forward modeling of geochemical variations in generated arc basalt by varying Mx, Ts, Tp, b, F, and X(AOC), X(SED), X(DM) variables. This approach reveals how much each factor affects the basalt chemistry. As an example, K-K/Nb plots of IBM basalts (GEOROC database, 2007) were examined and revealed that the observed across arc variations would reflect either different degree of slab fluid contribution and dehydration temperature, whereas along arc variation would require different slab dehydration temperature at different depths.