Chemical geodynamics of subduction zones: geochemical mass balance approach with Arc Basalt Simulator version 5

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A forward geochemical/petrological model created by Arc Basalt Simulator version 5 (ABS5) is used to examine the element mass balance in arc magma genesis including the dehydration of slab materials and flux melting of wedge mantle peridotite that form primary arc magmas. The inverse problem approach using the forward ABS5 model allows for estimation of intensive and extensive geophysical variables in arc magma genesis. The intensive variables are slab dehydration depth (P_{SS}) and temperature (T_{SS}) and mantle melting pressure (P_{perid}) and temperature (T_{perid}). The extensive variables are the amount of slab liquid added to the mantle ($F_{slab\ liq}$) and the degree of melting of the mantle (F_{perid}) along with the amounts of water in the slab liquid ($XH_2O_{slab\ liq}$), mantle (XH_2O_{perid}), and magma (XH_2O_{melt}). The subordinate geochemical variables are the degree of chemical reaction of the slab liquids to the solid slab (*%R*); the slab liquid fractions from igneous oceanic crust (F_{liq}(*AOC*)), sediment (F_{liq}(*SED*)), and metasomatized mantle peridotite layers (F_{liq}(*DMM*)); and the degree of depletion of the wedge mantle ($\%MORB_{ext}$). The mass balance of 26 incompatible elements, 6 major elements including H_2O, and Sr–Nd–Hf–Pb isotopes are calculated by the same scheme. Monte Carlo calculations are used to estimate the aforementioned variables by fitting the calculated magma composition to that of observed values. This paper describes the ABS5 calculation scheme and presents its application results. The geophysical variables are compared with those estimated by other methods, and the control of magma productivity and formation mechanism of the volcanic front are discussed.

Keywords: Geochemistry, Arc magmas, Role of water, Mass balance model

