特別講演

Arc Basalt Simulator, a simulation model for arc basalts: An attempt to understand mass balance beneath subduction zones

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アーク・バサルト・シミュレーター，島弧玄武岩のシミュレーションモデル：沈み込み帯マスバランスの理解を目指して

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和文要旨

　島弧玄武岩の成因を(1)沈み込みスラブの累進変成脱水作用－(2)スラブフルイド・マントル反応－(3)フルイド付加・マントル融解反応の３段階のモジュールを用いたマスバランス計算によってシミュレーションしたモデルを紹介する（Kimura et al., under review）．このモデルでは，島弧玄武岩の地球化学的組成多様性は，様々な温度で脱水したスラブフルイドの多様性と，スラブフルイドの付加率，さらにマントルの部分融解度で説明できる．

Overview: ABS history and concept

A numerical mass balance model of slab-dehydration, fluid-mantle reaction, and fluid-fluxed mantle melting was generated (Kimura et al., under review). The development of the model includes an earlier version of the ABS (Arc Basalt Simulator) model, which was applied to the basalts from NE-Japan and result published in (Kimura and Yoshida, 2006). An EXCEL® spreadsheet based calculator ABS ver.1 was coded and applied to understanding the origin of the K-h relationship in the NE- and SW-Japan arc basalts (Kimura and Stern, in press) and West Sunda arc basalt, Indonesia (Sendjaja et al., in press). ABS ver.1 simply assumed mixing of sediment (SED) and altered oceanic crust (AOC) for slab component and dehydration of the slab with slab-fluid Ds determined for K-free AOC (Kessel et al., 2005). Here we outline a more comprehensive model
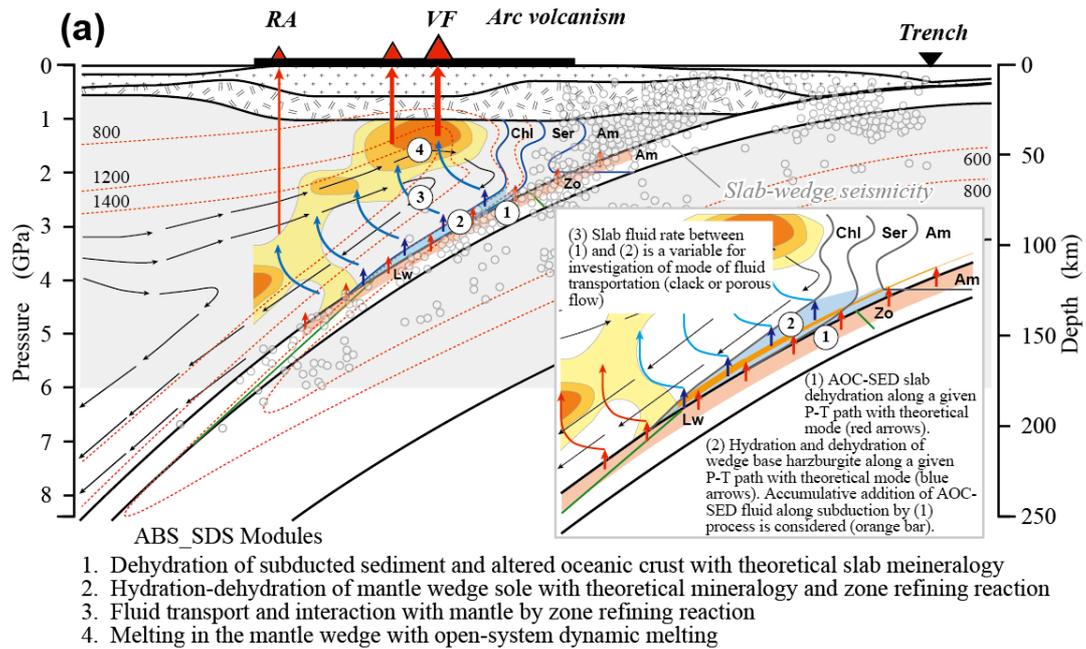
Fig. 1 Conceptual schematics of Arc Basalt Simulator (ABS ver.2) model equipped with Slab Dehydration Simulator (SDS).

including slab dehydration along the slab P-T path (Fig. 1). Prograde metamorphism of AOC and SED were simulated using Perple_X ver.7 thermodynamic model (Connolly and Kerrick, 1987; Connolly and Petrini, 2002) for modal composition of metamorphic minerals and

bound H_2O content over P-T conditions 100-1400 (°C) and 0.5-6.0 GPa (Hacker, 2008). Slab P-T trajectories were calculated with geodynamic model using temperature dependent olivine rheology (Fig. 2; van-Keken, 2003). This information was combined with
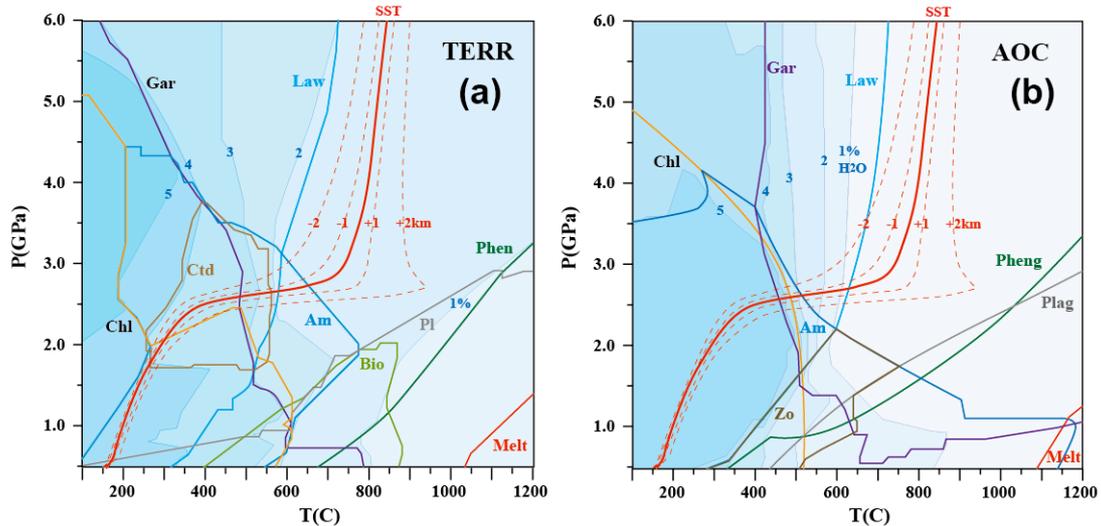

Fig. 2 Phase diagram and bound H_2O isopreth of SED and MORB calculated by Perple_X ver. 7. Perple_X ver.7 calculations provide phase boundaries, modes, mineral compositions (not used for ABS), and bound H_2O in the subducted slab. If P-T trajectory of subducted slab surface (SST) is given, equilibrium changes in slab modes and fluid dehydration from the slab can be calculated. The SST given on the panels (a)-(b) was calculated for Izu arc subduction zone. Dashed lines with +/- numbers show P-T trajectories (in km) above and below the slab surface. Mineralogic modes and H_2O content at a given P-T condition along SST are then taken into ABS ver.2 calculations.
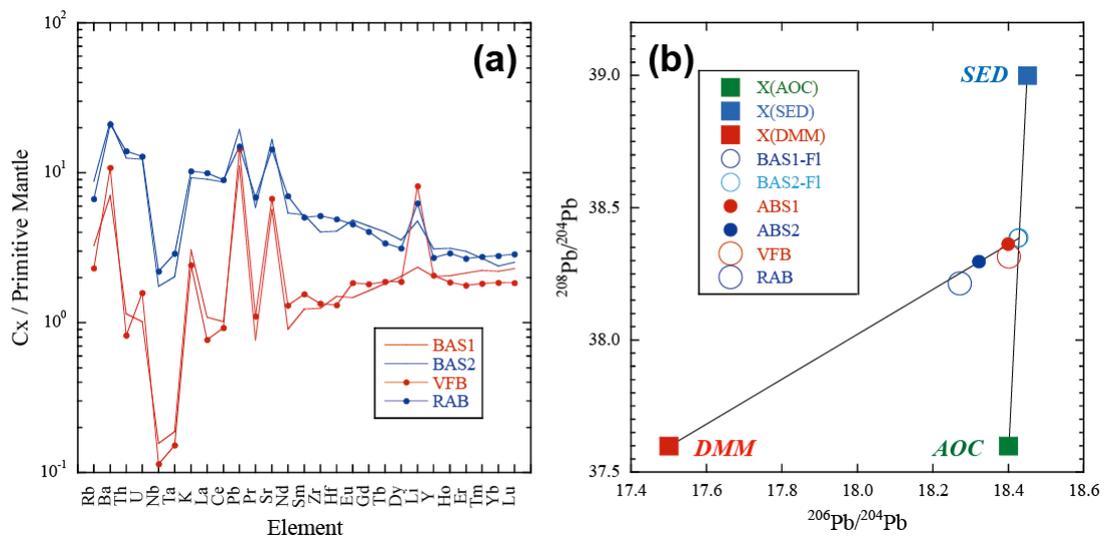
Fig. 3 Application of the ABS ver.2 to the N-Izu across arc variation. (a) trace element calculation results for volcanic front (VF) and rear arc (RA) lavas, (b) calculated results for Pb isotope variation between VF and RA.

partition coefficients between metamorphic minerals and aqueous fluid (Brenan et al., 1995; Feineman et al., 2007; Green and Adam, 2003; Kessel et al., 2005; Stalder et al., 1998) to calculate the trace element compositions of slab-derived fluid.

Model and application

Because ABS ver.2 is a forward model of the slab dehydration, fluid-mantle reaction, and fluid-fluxed melting, adjusting each parameter should be done by comparing model results to the composition of natural basalts. Graphical fitting using multi-element plots and isotope plots are used for the evaluations (Fig. 3). For application to the N-Izu basalts, we used source compositions DMM (a 3% MORB depleted DMM (Workman and Hart, 2005), AOC of Pacific Plate altered oceanic crust (Hauff et al., 2003; Kelley et al., 2003)), and SED of mixture between pelagic clay and chert sediments in the Pacific Ocean (Plank and Langmuir, 1998). With the ABS model, fitting of trace element abundance and isotope compositions were achieved (see Fig. 3). All intensive and exten-

sive parameters required are reasonable. These variables are: for VF basalt: slab dehydration 2.9 GPa-685 (℃), 3x fluid mantle reaction, 20% melting of mantle at 1 GPa with 4% fluid flux; for RA basalt: slab dehydration at 6.0 GPa-813 (℃), no mantle reaction, 1% mantle melting at 2.3 GPa with 1% fluid flux.

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