Tholeiitic vs. Calc-alkalic Differentiation and Arc Crust Evolution

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The liquid line of descent (LLD) for a representative basalt in the Izu-Bonin-Mariana (IBM) arc was investigated at 0.3 GPa in the presence of 0.49 - 2.83 wt.% H_2O, in order to constrain the creation and evolution of the arc's crust. This is of interest as differentiated continental crust may form in the intra-oceanic IBM system. The calc-alkalic trend of IBM plutonic rocks, which are likely to form the middle crust with intermediate composition, is best reproduced by the LLD of a hydrous basalt with 2.5-3.0 wt% H_2O. However, several lines of evidence suggest that IBM basalt magmas contain much smaller amounts of H_2O, leading to the conclusion that crystallization differentiation of a hydrous basalt magma could be an unlikely mechanism to form intermediate middle crust. Instead, mixing of mafic magma with crust-derived felsic magma reproduces the chemical trends and petrographic characteristics of calc-alkalic rocks reasonably well. Tholeiitic trends, on the other hand, which are often documented for rocks in intra-oceanic arcs, can form either from the anatexis of mafic lower crust or crystallization differentiation of basaltic magma in the presence of small amounts of H_2O (˜0.5 wt%). Seismic velocities of the inferred crust/mantle rocks, which are obtained based on both the present experimental results and semi-theoretical calculations, fits well with the observed seismic structure, supporting the proposed process of intermediate crust formation.