Petrography and Geochemistry of the Arnes Central Volcano, Northwestern Iceland: The case for Fractional Crystallization in Rhyolite Petrogenesis

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Basalt is the dominant product of Icelandic volcanism. Approximately 12% of Icelandic volcanism is silicic (Sigurdsson and Sparks 1981). To further the study of Icelandic rhyolites, the 2007 KECK Iceland project explored a transitional volcanic center along the abandoned Skagi-Snaefellsnes rift in the Westfjords of northwest Iceland. Integrating mapping, petrography and geochemistry, this project seeks to constrain mechanisms of rhyolite petrogenesis in Iceland’s volcanic environment.

Fieldwork was conducted over a four-week period during the summer of 2007. Samples were collected and initially used to characterize the volcanic stratigraphy and delineate distinct units. At Amherst, thin sections were prepared for petrographic and SEM/EDS analyses. Billets were sent to Washington State University’s Geo Analytical Labs for complete geochemical analysis by XRF and ICP-MS.

Geochemical data were plotted graphically for study. The progression in Mg number across samples supported a genetic relationship among the units. Harker and Fenner variation diagrams yielded curvilinear trends consistent with fractionation. Log-Log incompatible element plots show that the incompatible elements in these lavas behave perfectly incompatibly. Incompatible trace element plots show that the ratios between incompatible elements remain the same while their concentrations increase, a trend consistent with fractional crystallization. REE diagrams and spider diagrams reveal that the rocks share similar patterns and are consistent with genetic linkages among the units in the Krossnesfjall field area. The data were next considered in the context of Iceland array data and mechanisms of rhyolite petrogenesis.

A model by Brophy (2008) was employed as a means of discriminating between partial melting of hydrothermally altered MOR gabbros and extended fractional crystallization of MORB. The comparison shows that REE versus liquid SiO2 variation in the present lavas is consistent with extended fractional crystallization of MORB under moderate pH2O conditions. Considering the results of the comparison to Brophy (Submitted March 2008) in conjunction with the co-linear variation of the Rb/Hf ratio that is inconsistent with a partial melting model of hydrothermally altered basalt crust, we conclude that the basaltic andesites through rhyolites in this study are related by fractional crystallization. The data do not preclude a more complex relationship of hybridization of silicic and basaltic magmas with subsequent fractional crystallization producing the more evolved lavas in the Krossnesfjall lava series.

These data are consistent with a model of ~65% fractionation, calculated using the Rayleigh model of fractional crystallization, from the most primitive samples present to the most evolved. Fractionating minerals are clinopyroxene, plagioclase and Ti-mgt as indicated by Sc trends, a negative Eu anomaly in dacite and rhyolite samples, and SiO2 enrichment and associated TiO2 and V trends.