AN ABSTRACT OF THE THESIS OF

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The Eyjafjöll Volcanic System, in southern Iceland, is a member of the Southeastern Volcanic Zone (SEVZ), a segment of the Mid-Atlantic Ridge. The SEVZ is a well-exposed (subaerial) propagating rift, analogous to the volcano-tectonic structures that accommodate the growth of ocean floor spreading ridge segments. Eyjafjöll represents 780 Ka of volcanic activity, composed of alkaline and subalkaline (transitional) lavas and hyaloclastites ranging in composition from picrites to rhyodacites. Gaps in age data suggest ice ages occurring at the same general time as evidence from other systems within Iceland suggest: 160 and 400 Ma. These were most likely periods of colder climates during which hyaloclastites dominate the section.

Experimentally derived models of simple closed-system fractional crystallization at the NNO and QFM buffers (1 atm, no water) show trends which are quite similar to most of the observed compositional variation in Eyjafjöll. Major differences between the real data and the modeled data can be explained by conditions of higher pressure and water content. Minor differences can be explained by magma mixing among melts at different states of evolution and/or addition (accumulation) of varying amounts of the following phases as phenocrysts: olivine, clinopyroxene, plagioclase, titanomagnetite, and apatite. Magma mixing is implicated by mineral zoning and textures, along with whole rock major element analyses. It is possible this mixing occurs between segregated portions of single magma chambers (as the magma supply rate is so small). Mineral separation and later entrapment is demonstrated by the existence of cumulates, the high frequency of phenocrysts in most of the samples, and major element data. Rare high

pressure crystallization, as high as perhaps 10 Kbar, is inferred from high Ti:Al ratios in clinopyroxene and CaO trends of the real data that suggest high pressure early clinopyroxene fractionation.

High $^3He/^4He$ ratios (18-19 x atmospheric) suggest that source material is undepleted and hotspot derived. This is corroborated by the uniformly light rare earth enriched patterns of the rare earth element data. Similarity of helium values for both alkalic and tholeiitic material within the Eyjaföll system suggests crustal assimilation is not the process which creates the alkalinity of this region. The pressure of primary melt segregation is inferred from MgO and FeO contents of the parent composition to be approximately 12-15 Kbar (36 to 45 km depth) from a spinel lherzolite source composition. Degree of melting is probably small, around 3%. The depth is corraborated by geophysical evidence which shows a crustal thickness below Eyjafjöll of 15 km and by the geothermal gradient which suggests intersection with the mantle solidus occurring somewhere between 30 to 50 km depth. The high pressure of melting combined with the small % of melt is the cause for the alkalinity of the system.

Eyjafjöll lies 30 km behind the tip of the propagating rift (SEVZ), and has a low magma supply and rapid cooling rate. These thermal conditions have evolved over time, however. In the earliest history of the system compositions were limited to basaltic material with little compositional evidence for fractional crystallization. In more recent times, however, compositions have become more varied, with flows representing nearly every level of crystal fractionation, from 0 to 75%. This suggests a decrease in cooling rate and/or increase in magma supply during the growth of the Eyjafjöll system and the consequent formation of more stable magma chambers. There is also evidence (alkalic character and little fractionation) that in its earliest history, Eyjafjöll was most likely at the tip of the propagator. With this in mind, a southward propagation rate for the SEVZ has been estimated at 0.8 ± 0.3 cm/yr.