THE ORIGIN OF THE STRJUGSSKARÐ ANDESITE, SKAGI PENINSULA, NORTH-CENTRAL ICELAND

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INTRODUCTION AND GEOLOGIC SETTING

Iceland is located in the North Atlantic Ocean between Greenland and the British Isles. Being situated on both the Mid-Atlantic Ridge and a mantle plume, Iceland has been the site of a voluminous and complex volcanic system over the past 16 million years (Trønnes, 2002). Excess magmatism driven by the mantle plume has buoyed up the Icelandic crust so that it is the only sub-aerial exposure of a mid-ocean ridge (Allen et al., 2002). Over time, the ridge moves northwestward in a mantle plume reference frame, drifting off the plume. This rift eventually becomes abandoned in favor of a new rift opening over the weaker lithosphere directly over the plume. Interaction between the plume and ridge systems has produced rocks that span the compositional spectrum from basalts to rhyolites. The origin of the intermediate rocks, andesites, is ambiguous in Iceland. They have either been formed as a result of fractional crystallization or mixing between a mafic end member and a silicic end member (Baldridge, 1973; Sigmarsson et al., 1992; Carmichael, 1964).

In 2003 participants in a Keck project studied the volcanic rocks in the Skagi area (Fig. 1) that erupted from the paleorift that existed from 15-7 Ma. They found an anomalous andesite, here named the Strjugsskarð andesite, which contained plagioclase megacrysts ranging from 1 to 3 cm in diameter. Meganck (2004) suggested that this unit may be a result of mixing of a nearby plagioclase ultraphyric basalt (PUB) and a silicic end member. Since only two samples of the Strjugsskarð andesite were analyzed in 2003, I focused on understanding the origin of this unit.

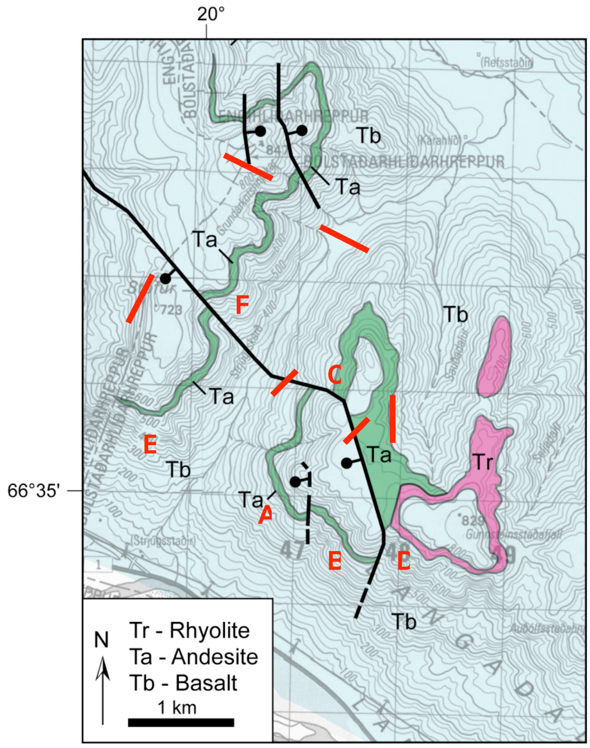

Figure 1. This shows the distribution of felsic and intermediate rocks near the Skagi Peninsula section of the extinct Snaefellsnes rift. (Figure after B. Jordan, unpublished)

METHODS

Thirty-four samples of Strjugsskarð andesite, associated tuffs, basalts and rhyolites were collected. Stratigraphic sections were measured at six field sites containing this.

Petrography and geochemical analyses (XRF, ICP-MS, and electron microprobe) were done so as to relate the rocks mineralogically and chemically. Major, minor, and trace element trends were particularly useful in developing the genetic relationships of the rocks.

FIELD DESCRIPTION

The Strjugsskarð andesite (SA) lava ranges in thickness from 31 to 84 m. The pyroclastic units related to the SA range from 2 to 25 m thick. The complete thickness of SA and associated pyroclastics thicknesses range from 39 to 87.5 m. Based on average measured thickness and estimates of the area covered by SA, its approximate volume is ~2.9 km^3. SA was divided into lithologic types according to plagioclase megacryst abundance. Normal SA (N-SA) contains 5-20% megacrysts (Fig. 2), sparsely porphyritic SA (S-SA) contains about 1-5% megacrysts, and very sparsely porphyritic SA (VS-SA) contains less than 1% megacrysts. Usually, in field sites that contained more than one lithologic unit of SA, the unit with lower phenocryst abundance was always found beneath the unit with a higher phenocryst abundance. However, some sections exhibited intermingled pods of N-SA and S-SA.

Figure 2. A typical outcrop sample of normal Strjugsskarð andesite. This photo was taken at Section E by B. Jordan.

RESULTS

Petrography & Electron Microprobe Analysis

The megacrysts of all samples show a wide range of degree of sieve texturing and the edges are usually rough and ragged, indicating disequilibrium (Fig. 3). Some megacrysts have a coarser matrix thinly surrounding the crystal, suggesting a mixing origin for these megacrysts (xenoliths/xenocrysts). Megacrysts from all samples (PUB, SA, tuff, rhyolite) showed remarkable consistency with a few differences. All megacrysts were made up of one or two larger plagioclase crystals; in many, smaller plagioclases seem to have been enveloped by the larger ones. Additionally, most megacrysts exhibit tiny, rounded prisms of a mineral that follow an internal outline of crystal growth. Electron microprobe analyses have shown that the megacrysts in both the PUB and SA have a fairly uniform composition from the core to the rim of the megacrysts of An_{82}-$_{86}$, which is a composition that is in equilibrium with basaltic magma, not andesite or dacite.

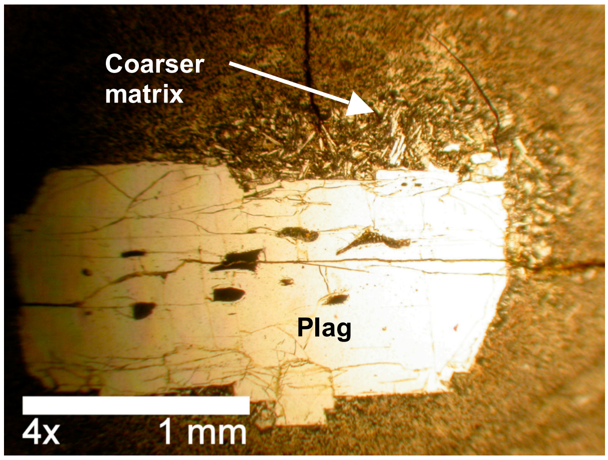

Figure 3. A plagioclase megacryst in S-SA exhibiting highly moderate sieve texture. Attached to it is a blob of coarser matrix.

Chemical Petrology

There is a broad trend relating silica content to abundance of megacrysts. In general, the lower megacryst abundance rocks have a higher silica content (dacite to rhyolite) and the higher megacryst abundance rocks have a lower silica content (andesite) (Fig. 4). Variation diagrams of major, minor and trace elements show that the Strjugsskarð andesite lies on straight line mixing trends between PUB and a silicic end member (Fig. 5). On the Zr versus SiO_2 diagram, it is clear that the

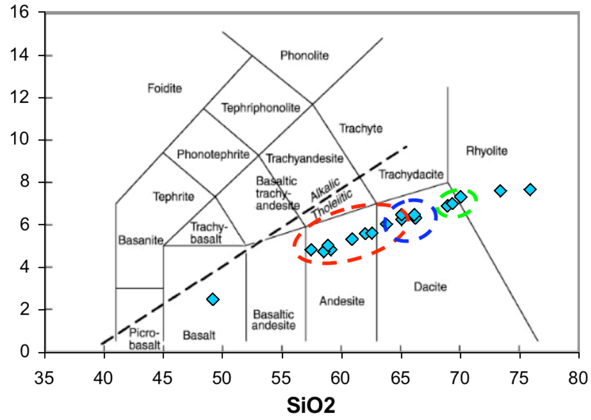

Figure 4. Total alkais vs. silica plot shows the rocks from the Skagi area collected in 2004. Blue points are rocks from this study. Red oval = N-SA, blue oval = S-SA and green oval = VS-SA).

silicic end member must be a dacite or low-silica rhyolite, since Strjugsskarð andesite only falls between PUB and a narrow range of dacites/low silica rhyolite and not between PUB and a rhyolite (Fig. 6). Based on these

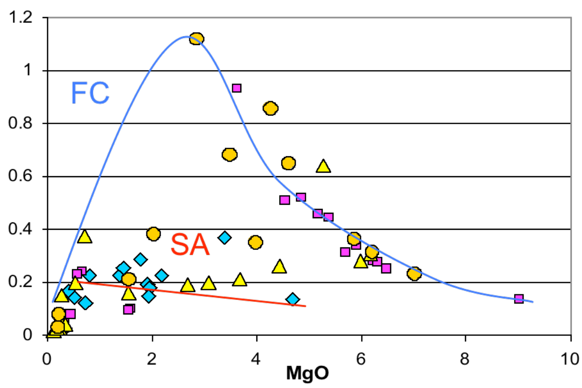

Figure 5. P_2O_5 vs. MgO shows the fractionation trend of apatite (at ~3% MgO). It is represented by the blue curve. The SA mixing trend between PUB and a silicic end member is shown by the red line. FC = fractional crystallization trend. Blue points are samples from this study. Yellow points = Lebn Schuyler's samples. Orange points = Emily (Ross) Baldwin's samples. Yellow points = Lara Kapelanczyk's samples. All samples are from the Skagi area and were collected during the summer of 2004.

results, SA was formed by mixtures of 10-60% PUB and 90-40% dacite/rhyolite. Adding more supporting evidence to the dacite end member is a REE plot with the elements normalized to MORB. The Eu anomaly is strongly negative in the rhyolite, moderately negative in the dacite and slightly positive in the PUB. Strjugsskarð andesite shows a Eu anomaly that falls between dacite and PUB; if the silicic end member were rhyolite, some Eu anomalies for the intermediates likely would be more negative than even the dacite. Above all, rhyolite cannot by the silicic end member because combining its already low Eu content with the low Eu content of PUB cannot create the higher Eu content of SA.

DISCUSSION AND CONCLUSIONS

Based on the results presented above, I propose a physical model for mixing similar to that of Meganck (2004). Figure 7 shows a cross-section of a PUB magma chamber aligned in such a way that it could both erupt in Vatnsdalsfjall and also intrude (as a propagating dike) a zoned silicic magma chamber. This magma chamber is zoned with the denser dacite on the lower half and more buoyant rhyolite in the upper half. The zoning is not meant to be construed as a strict boundary between the two silicic magmas, but as a gradation from low silica (dacite) on the bottom to high silica (rhyolite) on the top. The PUB may have intruded the zoned silicic magma chamber and mixed initially with dacite and perhaps even with some low-silica rhyolite. The low silica rhyolite erupted first, containing little to no megacrysts (such as CMA-26). It was followed by and eruption of a mingled magma, which contained dacite (low abundance N-SA and S-SA) and andesite (N-SA). Usually the N-SA overlies the S-SA, but in some areas (Section E) pods of either magma were found interfingered, suggesting complex eruption processes.

The rhyolite likely did not travel far from the volcanic vent. This idea may account for the thick unit of rhyolite and the overlying flow top layers of Strjugsskarð andesite in Section C, suggesting that this location is near the vent. The low-megacryst dacite (S-SA and VS-SA) probably traveled farther because of its lower viscosity, which would account for its position further from the proposed vent. The least viscous unit was the megacryst-rich

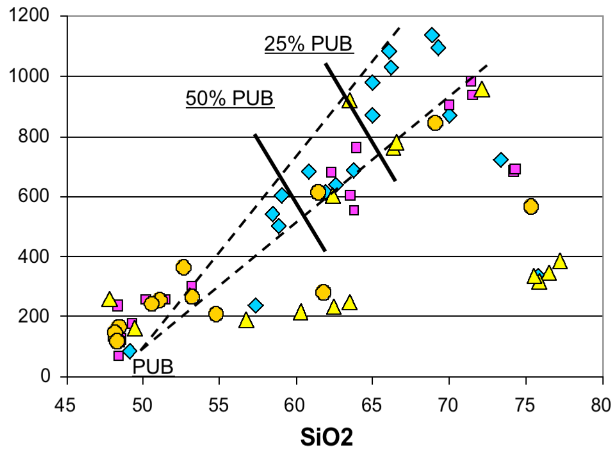

Figure 6. PUB (blue diamond at apex of "wedge") and an array of silicic end members, as shown by the dashed lines (low-silica rhyolite to dacite), likely created SA through mixing. The solid lines denote lines of equal PUB mixing percentages (50% and 25% PUB and a suitable amount of a silicic end member).

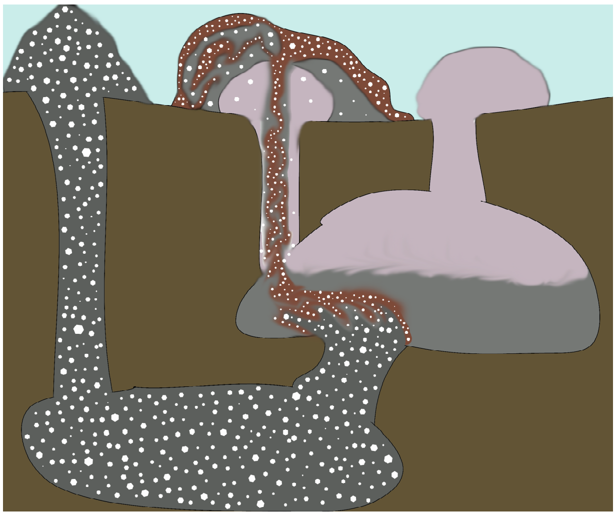

Figure 7. A schematic of the physical model of mixing that resulted in Strjugsskarð andesite. Dark gray spotted lava = PUB, medium gray lava = dacite, medium gray spotted lava = S-SA and VS-SA, red-brown spotted lava = N-SA, pink lava (with or without spots) = rhyolite. The flow to the left (PUB) represents Vatnsdalsfjall and the flows to the right represent Langadalsfjall. The rhyolite conduit on the right is a suggestion for emplacement of the rhyolite found in Section D.

Strjugsskarð andesite (N-SA), which could easily spread farther than either of its more silicic counterparts and appear on its own in outcrop. The idea of a propagating basaltic dike intruding a silicic magma chamber and triggering an eruption is not new. Blake (1984) suggested this process in the production of complicated basaltic and silicic lava emplacement during the late 15th century in the Torfajökull caldera.

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