

DIVERSE INTRUSIVE AND VOLCANIC ROCKS IN THE AXIS OF THE ABANDONED SNAEFELLSNES RIFT: VI_IDALSFJALL, NORTH CENTRAL ICELAND

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INTRODUCTION

The Skagi area is located in north-central Iceland and lies near the axis of the Snaefellsnes rift, the most recently abandoned ridge segment formed by the interaction of the Mid-Atlantic ridge and the Iceland hotspot (Gudmundsson *et al*, 1993). The northwestern tip of Vi_idalsfjall, in the southwest Skagi area, was previously mapped as a silicic intrusion (Annells, 1968). However, that study ignored other distinct units. The purpose of this study was to map a portion of northern Vi_idalsfjall, describe new units, and to identify relative age relationships among the units. The results of this investigation will provide information on how the ridge evolved over time as the rift progressed toward abandonment.

Methods

Reconnaissance mapping and examination of aerial photographs initially established the field area of Vi_idalsfjall. GPS surveying was also employed to help establish, record, and transfer unit positions to a 1:20,000 map. This information, in combination with detailed field mapping, was used to create a geologic map of the study area (Fig.1). Field mapping consisted of defining units, constraining unit boundaries, and establishing contacts and relationships among units.

Over fifty samples were collected from the different units. These samples were brought back to the Colorado College and billets were prepared for thin sections, which were used in

a petrographic study. Fifteen samples, whose selection was based on location and unit occurrence, were prepared for XRF and ICP-MS analysis at ACT Lab in Tucson, AZ. The geochemical data were analyzed using the 2003 Ig-Pet program. Through the use of this software different geochemical plots were constructed, including harker diagrams, spider plots, tectonic plots, and discrimination diagrams.

Petrography and Stratigraphy

Five units were mapped in the field area. Units were defined in the field based primarily on texture, phenocrysts, field location, and stratigraphic relationships

The five units include a 400-meter thick series of basalt flows with a few well-exposed

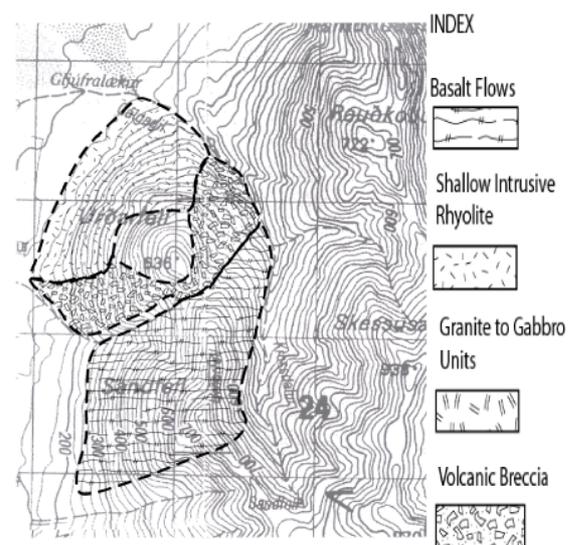


Figure 1: Field map with units and boundaries.

individual flows up to 2 meters thick. These flows are similar to the dominant basalt type of the Skagi zone: iron-rich tholeiite (Sigurdsson *et al.*, 1978). There is some variation among the basalt flows; there is an occurrence of olivine phenocrysts with reaction rims while others have only a groundmass consisting of clinopyroxene and minor opaques (<5%). The basalt unit extends outside of the study area and other flows have been mapped and described by Annells, 1968.

A shallow rhyolite intrusion is the most extensive unit. This unit was previously mapped as the silicic intrusion. This unit, which occurs in the northeast section of the field area, has two distinct appearances in outcrop: 1) large weathered exposures are present in situ, but the majority of the unit has been broken up and is represented by large scree slopes along the hillsides; and 2) the unit forms resistant walls and columnar-like structures. This unit's mineral constituents are approximately: orthoclase (65%), plagioclase feldspar (17%), quartz (15%), and hornblende (3%). There are trace amounts of oxides present, both pyrite and magnetite, and trace amounts of zircon. These modal abundances combine both phenocryst and groundmass mineralogy.

A fine- to medium-grained granite appears to cut the rhyolite and is in sharp intrusive contact with a medium- to coarse-grained gabbro, represented by both a typical and cumulate form. The combined thickness of the granite and both gabbros is 15m.

The difference between the typical and cumulate gabbro is apparent in both the mineralogy and grain size of the gabbro. The typical gabbro is finer grained and tends to have more quartz (5%) and hornblende (uralite, 20%), and less clinopyroxene (15%) than the cumulate gabbro. The cumulate gabbro has coarser grains of opaque phenocrysts (magnetite) and plagioclase laths. The cumulate gabbro also has a greater percentage of mafic minerals (55%) than the typical gabbro (50%).

These two intrusive units are exposed in a narrow EW-trending shear zone. The shear zone was identified by a fault plane located

between the granite and upper-most unit, a volcanic breccia. Two suites of samples, traversing from the granite to the gabbro, were collected. In the field a coarsening of grain size, an increase of mafic minerals, and a change in color from light gray, to black and white, identified the transition from granite to gabbro. The modal mineralogy of the granite and gabbro section changes from one unit to the next. The quartz percentage decreases from the granite (30%) to the gabbro (2-5%). The percent of potassium feldspar in the granite is 50% and does not occur in the gabbro. The plagioclase increases in the gabbro (43%), from the granite (5-10%). Both clinopyroxene (5%) and hornblende (2-3%) occur in the granite, and increase in the gabbro (clinopyroxene 25%, hornblende 15%, and orthopyroxene 5%). There is a relatively large amount of magnetite, identified by red alteration along the edges to hematite, in both of the gabbros (10%) along with secondary chlorite and serpentine. There are trace amounts of opaque minerals, zircon, apatite, and calcite as a secondary mineral in the granite.

Field relations between the intrusive units and the volcanic breccia are unclear. The volcanic breccia is an amalgamation of different basaltic and other volcanic and intrusive rocks. It is found throughout the study area, (see Rider, this volume).

Geochemistry

Fifteen samples were analyzed by XRF and ICP-MS (Fig.2) and correspond with the units described above. Four flows from the basalt unit were analyzed. The basalts, (47.4-54.1 wt.% SiO₂), are somewhat evolved (6.7-3.0 wt.% MgO) tholeiites (12.5-15.7 wt.% Fe₂O₃). One flow plots as basaltic andesite and another flow is extremely silicified. These flows all show slight LREE-enrichment with no Eu anomaly (Fig.3). On spider plots the basalts match OIB and EMORB well but have negative Sr anomalies (Fig.4).

The intrusive rhyolite (75 wt.% SiO₂) shows LREE-enrichment with a small negative Eu anomaly. The granite varies in SiO₂ from 72.2 to 57.5 wt.% as it approaches the gabbro contact. The REE pattern of the granite is very

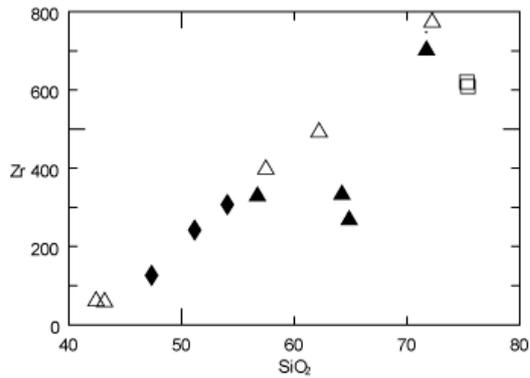


Figure 2: Harker diagram, of Zr vs. SiO₂, classification of units: Duplicate samples of the granite to gabbro suite are represented by open and in-filled triangles. The rhyolite is represented by squares and basalts are represented by diamonds.

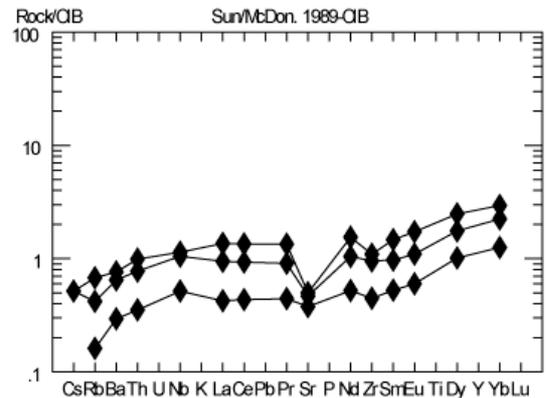


Figure 4: Rock/OIB diagram with basalt data. The basalts match well with OIB but have a negative Sr anomaly, indicating plagioclase fractionation.

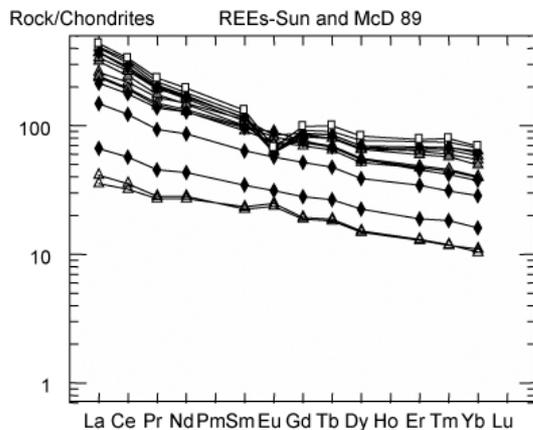


Figure 3: REE data for all samples. Duplicate samples of the granite to gabbro suite are represented by open and in-filled triangles. The intrusive rhyolite is represented by squares and basalts are represented by diamonds.

similar to that of the intrusive rhyolite. The gabbro (42-43 wt.% SiO₂) shows nearly flat REE in one sample and slight LREE-enrichment in the other with a slight positive Eu anomaly in the two most mafic samples.

INTERPRETATION

The basalts of the study area are typical iron-rich tholeiites (*Sigurdsson et al, 1978*) found within the Skagi area. They match OIB and EMORB well and have negative Sr anomalies, suggestive of plagioclase fractionation. The enriched profile suggests these basalts came from a hotspot or mantle plume rather than a shallow, depleted asthenosphere reservoir, more typical of MORB geochemistry. The

flows all have relatively low Ni (<75 ppm) and Cr levels (some undetectable, others <117 ppm).

Overall the basalts in this study came from a slightly enriched source, suggesting that as the ridge evolved the magmatism shifted to an enriched mafic material. The mineralogical distinction between the gabbros and the basalts, being a lack of olivine within the gabbros, suggest that the gabbros and basalts were not from the same melt.

Some notable characteristics of the gabbro are: the low SiO₂, high Fe, and the high V contents and the only Eu anomaly occurs in the cumulate rocks. The contrasting geochemical data of the two end samples of the gabbro, to that of the other samples in the suite sets, suggest these rocks may represent a cumulate. The SiO₂ content (42-43 wt.%) of these samples are unlike any basalt samples in Iceland. These rocks have high iron (18.3 and 18.7 wt.%) and extreme vanadium contents of 775 and 730 ppm (Fig.5). In general these two samples are distinct from the other basalt data collected from the study area and the other KECK studies of Iceland. The high Fe and V data and the positive Eu anomaly suggest that the gabbros may have formed by the accumulation of magnetite and plagioclase.

However, the low MgO and Ni are indicative of an earlier fractionation of olivine, most likely prior to the intrusion. The Cr levels are below detection limit which implies these gabbros were not cumulates from pyroxene or

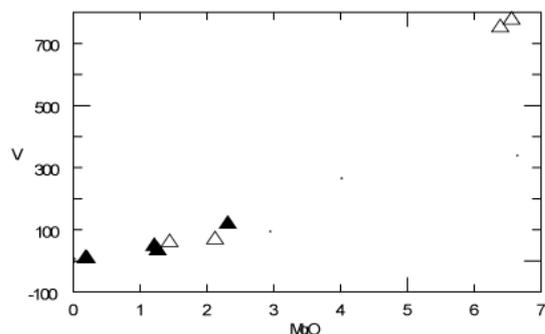


Figure 5: A Fenner diagram with V vs. MgO separates the cumulate gabbro and shows that the Fe-Ti oxide is important in this solid concentrate. The duplicate samples are both shown: in-filled and open triangles each represent a different suite. The two triangles on the top right of the diagram are the most mafic samples of the suites.

olivine and probably not primary melts (Fig.6).

The critical feature of the shallow intrusive rhyolite is its parallel REE pattern with that of the granite and the typical gabbro. This implies either 1) a common source among the intrusive units; or 2) fractionation from the gabbro to the rhyolite, although the lack of exposed intermediate units argues against fractionation.

The continual geochemical variation between the gabbro and the granite as the granite approaches the gabbro may represent assimilation or mixing of silicic with mafic material, although there is no clear field evidence for this process.

The granite yielded an Ar/Ar plateau age of 7.03 +/- 0.07 Ma (2-sigma error). This age is younger than the regional basalts of this area, and is younger than a basalt extruded from the volcanic breccia (see Rider, this volume). □

The basalts may represent the end of the rift magmatism. A way to test the apparent change of the plume signature in the region would be to determine the geochemical data of more voluminous flows of OIB, MORB, or EMORB.

A possible model for magmatic evolution is the Skagi area would be to hypothesize that the thick pile of basalt flows reflects a mid-ocean ridge at its most active time. As the ridge began to progress toward abandonment, any shallow mantle reservoir shut off and the

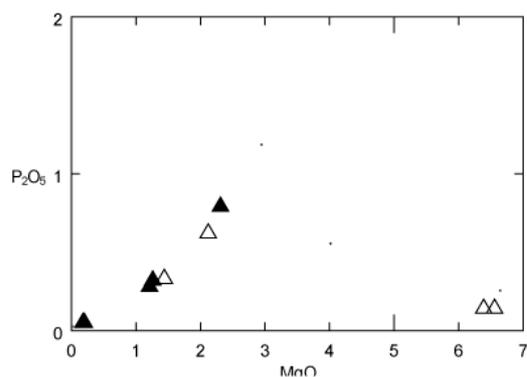


Figure 6: A Fenner diagram with P₂O₅ vs. MgO shows where apatite joins the fractionation assemblage. The duplicate sample sets are both shown: in-filled and open triangles and square each represent a different suite. The two triangles on the bottom right of the diagram are the most mafic samples of the suites.

mantle plume signature becomes apparent in the enriched basalt flows of this study. Remelting of crustal basalts might generate silicic melts with the same REE patterns as the basalts.

One way to test this model would be to identify older, thicker piles of basalt flows nearby and to determine if they show a more ORB-like geochemistry. That might represent a time when the rift was very active and would support the above hypothesis of evolution to a more enriched, plume-like source as the ridge was abandoned.

The geochemical and petrological date of this study suggests that the ridge appears to have become more silicic as it progressed towards abandonment.

REFERENCES CITED

- Annells, R.N., 1968. A geological investigation of a Tertiary intrusive center in the Vididalur-Vatnsdalur area, northern Iceland. St. Andrews, Scotland University of St. Andrew, Masters thesis pp 28-36.
- Gudmundsson, A., Bergerat, F., Angelier, J. Off-rift and rift-zone palaeostresses in Northwest Iceland. Nordic Volcanological Institute, Geosciences Building, University of Iceland, Reykjavik, Iceland, 1993.
- Sigurdsson, J. -G., Schilling, P.S. Meyer, 1978. Skagi and Langjokull Volcanic Zones in Iceland: 1. Petrology and Structure. Journal of Geophysical Research, vol.83, No. B8, pp.3971-3981.