GEOLOGY OF AN ABANDONED OCEANIC RIFT:
THE SKAGI AREA, NORTH-CENTRAL ICELAND

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GEOLOGIC SETTING
Iceland is a 103,000 km$^2$ island in the North Atlantic at about 65 °N. Iceland marks the intersection of the Mid-Atlantic Ridge with a mantle plume. Plume-ridge interaction drives high magmatic productivity, and has resulted in the genesis of anomalously thick crust under Iceland. As a result, Iceland is the only place on earth where an active mid-ocean ridge is exposed above sea level.

The Mid-Atlantic Ridge migrates westward in the plume reference frame, so over time the ridge and plume should be separated, but the ridge system has re-centered over the plume by a series of jumps (Hardarson et al., 1997). Abandoned rifts are recognized as regional synclines analogous to the syncline that has developed in response to the modern rift (Saemundsson, 1979). The last abandoned rift was the Snaefellsnes rift which was abandoned at about 7 Ma (Fig. 1).

The purpose of this project was to undertake a detailed study of a portion of the Snaefellsnes rift to characterize rift processes during the waning phases of activity, immediately prior to abandonment. We focused our study on the rocks exposed near the southern end of the Skagi Peninsula in northern Iceland (Fig. 1). Previous reconnaissance mapping of the area showed a promising diversity of igneous rocks in this area, including basalts and rhyolites, and mafic and silicic intrusions (Jóhannesson and Saemundsson, 1998). The area also offered good exposure in glacially carved valleys and slopes exposed by post-glacial mass wasting.

STUDENT PROJECTS
The field area divided neatly into three general project areas in the mountain ridges of Langadalsfjall, Vantsdalsfjall, and Víidalshfjall. After a brief introduction to the field areas, students selected projects in these areas and spent approximately three weeks mapping, describing the volcanic stratigraphy, and sampling. The student projects are briefly summarized below.

Langadalsfjall
Ashley Meganck, Whitman College, mapped and described the volcanic stratigraphy of southeastern Langadalsfjall. Because of the regional westward tilt toward the syncline axis that marks the Snaefellsnes rift, Ashley’s rocks are the lowest portion of the Langadalsfjall section. Her rocks included a
rhyolite and a plagioclase-rich andesite, that appear to have erupted from a complex, mixed magma chamber.

Kenneth Walker, Washington and Lee College, studied the volcanic stratigraphy of central Langadalsfjall. His area also included the coarse plagioclase-phyric andesite, which Neth termed the “Golf Ball Unit” (Fig. 3). In Neth’s area this anomalous unit was also associated with a welded tuff!

Marian Kramer, Smith College, worked in northwestern Langadalsfjall and, therefore, had the upper portion of the Langadalsfjall section. Marian encountered some complex relationships in the upper part of her sections, but worked them out with the assistance of her faculty sponsor, Mark Branderiss. Mark joined us for a week and made a significant contribution not only to Marian’s study, but to the project in general.

Vatnsdalsfjall

David Auerbach, Carleton College, mapped a very large area in northern Vatnsdalsfjall, including the highest peak in the project at 1038 m. Dave’s area also featured quite a bit of geologic complexity with lavas draping and filling steep paleo-topography.

Paige McLanahan, Williams College, focused on a single igneous unit. This unit is a thick tabular lens (Fig. 4) mapped as an intrusion on the Geologic Map of Iceland (Jóhannesson, and Saemundsson, 1998). Due to its ambiguous origin it was nicknamed the “inextrusion”, and was the subject of many evening discussions back at Blönduós.

Katie Ackerly, Williams College, studied the most striking geologic structure in the project area, a monocline in which lavas are tilted up to 40° west in the southern portion of the studied area in Vatnsdalsfjall (Fig. 4). Katie’s area had complex stratigraphic relationships, diverse volcanic rocks types, and was also related to the “inextrusion”.

Vi_idalsfjall

Amanda Bissell, Colorado College, mapped the northwestern tip of Vi_idalsfjall (Fig. 5) and focused on the diverse intrusive rocks exposed in this area. These rocks included a series of phaneritic intrusive rocks grading from gabbro to granite.

Deanne Rider, The College of Wooster, performed a stratigraphic study of a section dominated by volcaniclastic rocks in the central valley of northern Vi_idalsfjall (Fig. 3).
5). This sequence was unique in our project area, and appears to have been emplaced in a syn-volcanic graben.

Scott Pelletier, Pomona College, mapped and collected samples of intrusive rocks in the northeastern tip of Vi_idalsfjall (Fig. 5, shown as SP_M in Fig. 3). This was a challenging area due to rugged topography and limited exposure. In the final days of the project Scott also conducted a detailed field study of a dike in southern Langadalsfjall (SP_D in Fig. 3).

PROJECT RESULTS

The detailed results of student projects are presented in the papers that follow this project overview, but some broad scientific observations are highlighted here.

Mapping

The geology we observed in the field was more varied and exciting than we had anticipated. We documented the volcanic stratigraphy exposed in Langadalsfjall, Vantsdalsfjall, and Vi_idalsfjall. Silicic rocks were less extensive than mapped in all three ranges. The northern tip of Vi_idalsfjall (Fig. 5) was mapped as consisting of silicic intrusive rocks, but our field study revealed that <10% of the area mapped as such actually consisted of silicic intrusive rocks. What intrusive rocks were present were found to be lithologically diverse, including fine grained basalts and rhyolites, and a coarser series of that graded from gabbro to granite.

In Langadalsfjall the regional map showed a silicic unit that contoured around the upper portions of each of the peaks. Mapping revealed that this silicic unit existed only in the southern portion of the project area. In southern Langadalsfjall the unit is represented by a rhyolite, including obsidian, found only in Ashley Meganck’s area. The rhyolite is correlated to the andesitic “Golf Ball Unit” (see discussion below), found in also found in Ashley’s area, as well as the southeastern portion of Kenneth Walker’s area (Fig. 3).

The work in Vatnsdalsfjall centered on the “inextrusion”, referred to as the Hjallin lens by Annells (1968) and the student papers that follow, and the monocline in the southern project area. Based on field relations, and much heated discussion, it was concluded that the “inextrusion” was a topographically confined lava flow rather than an intrusion.

Petrology

Most students performed petrographic analysis of a representative suite of the samples they
collected in Iceland. Texturally and mineralogically, most basalts were representative of the tholeiitic lavas that dominate the Tertiary rocks of Iceland (Saemundsson, 1979). However, across the compositional spectrum there was textural and mineralogical diversity.

Compositionally, the samples analyzed are classified across the spectrum, from basalt to rhyolite. There is a composition gap between about 55 and 64 wt.% SiO₂, with only intrusive rocks of the gabbro-granite series, and the “Golf Ball Unit” falling in this gap. Several tuffs and epiclastic rocks were analyzed.

Screened for highly-altered samples, the group data set is generally quite coherent with trends on major and trace element variation diagrams consistent with evolution by fractional crystallization in the following order: olivine, plagioclase, clinopyroxene, Fe-Ti oxides, apatite, and zircon. Some basalts have trends of sharply increasing Al₂O₃ with decreasing MgO. These basalts also have abundant plagioclase phenocrysts, consistent with plagioclase accumulation. The “Golf Ball Unit” falls on a well defined mixing line between plagioclase-phyric basalts and dacites.

Analysis of trace element ratios and spider-diagrams demonstrated the enriched character of the basalts, and was consistent with a plume component in the source of these basalts.

The origin of the silicic rocks in southern Skagi area is equivocal. Some students argue for a significant role for crustal melting in the genesis of silicic magmas, while others present the argument that these magmas may be the result of extreme fractionation of a basaltic parent.

**Tectonic Interpretation**

The Snaefellsnes rift is generally depicted as passing through the project area at about the position of Vi_idalsfjall, and is described as being abandoned at about 7 Ma (e.g. Hardarson et al., 1997). We had nine samples dated by the ⁴٠Ar/³⁹Ar method at the geochronology lab in the College of Oceanography at Oregon State University. The Langadalsfjall section represents the accumulation of lavas between 8.6 and 7.1 Ma. The rocks deformed in the monocline at Vatnsdalsfjall are about 7.6 Ma, and the topographically confined lava of the “inextrusion” is 7.0 Ma. A lava in the volcaniclastic section at in Vi_idalsfjall is 8.6 Ma, but the coarse-grained intrusive series is about 7.0 Ma. These ages suggest that the final episode of magmatism in the area was at 7.0 Ma. This magmatism was dispersed across the ~30 km separating these areas, consistent with the width of the belts in the neovolcanic zones (Fig. 1).

Two petrologic characteristics may be particularly significant in understanding the character of the waning phase of the rift. First, though the Zr/Nb of basalts is low, suggesting a plume component, the extreme variability that characterizes the neovolcanic zones was not found. Hardarson and Fitton (1997) interpret this variability to reflect melting of mantle depleted by earlier high degrees of melting, which may not have occurred once the rift drifted from the plume. And second, if the rhyolites were derived by fractionation, this would be unusual for Iceland and could be a reflection of the relatively thin crust that resulted from the rift drifting off the plume.

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