The Southwest Harbor Granite:
A Petrographic and Geochemical Characterization of the Forgotten Unit on Mount Desert Island, Maine.

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Introduction

The Southwest Harbor Granite, (SWHG), lies between the Cadillac Mountain Intrusive Complex, (CMIC), and the Cranberry Island Series volcanics, (CIS), on Mount Desert Island, (MDI), Maine. The CMIC consists of 3 units: (1) the Somesville Granite, (SG),-a two feldspar biotite granite; (2) the Cadillac Mountain Granite, (CMG), a hypersolvus hornblende granite; and (3) a unit of layered Gabbro Diorite, (GD), with highly variable mineralogy, (Wiebe, 1993). The CIS has been subdivided into three distinct units: (1) the volcanic tuffs: and (2) the volcanic felsite units, and (3) the interbedded volcanic and contact metamorphosed siltstones and slates, (Gilman, et al., 1988). In contrast to the units in the CIS and CMIC, few field, petrographic or petrologic studies have been published on the SWHG, or on its relation to the CMIC. The Keck Consortium, with funds provided by the Keck Foundation provided this opportunity for nine students to study MDI's complex geology over the period of a month during the summer of 1993.

Purpose

This study focuses on the contact relations of the SWHG, and attempts to characterize it petrographically and geochemically. Comparison of data obtained in this study with data from the CMIC and CIS provided by other group members may clarify the relationship of the SWHG with the CMIC and CIS.

Contact Relations

The main body of the SWHG on MDI is an elongate body approximately 17.72 km^2 in area, trending east-west from Duck Cove on the southwest to Norwood Cove on the northeast. Additional outcrops can be found on Greening and Sutton Islands to the east of Southwest Harbor. Several inland traverses yielded only two samples. The SWHG is cut by numerous mafic dikes that have the same strike as those that cut the other granites of the CMIC. The SWHG is also cut by three rhyolitic dikes that have the same strike and flow structures as rhyolitic dikes in the tuffs of the CIS on Lapaus Point.

The SWHG is in contact with most major rock bodies on the island, as mapped by Gilman and Chapman, (1988). Its western edge is flanked by the Ellsworth Schist, (ES). To the south, the SWHG is in contact with two members of the CIS. Along the eastern coast in Southwest Harbor, the SWHG contacts the Bar Harbor Formation, (BHF). The Shatter Zone, (SZ), is a zone of intensely shattered country rock that flanks the northern border of the SWHG, lying between the SWHG and the CMG. Xenoliths of the ES and the BHF in the SWHG demonstrate that it intruded into these two units. The contact relations between the SZ and the SWHG could not be observed. The CIS volcanics contact the SWHG in Duck Cove, and two types of contacts were observed. In one type, sharp, chilled contacts suggest the emplacement of melted SWHG into cold CIS country rock. In a second type, there are diffuse margins suggesting the emplacement of magma into a still hot, plastic CIS. Outcrops of the GD overlie the SWHG in the west, and a possible feeder dike for this unit was found in Goose Cove. This dike displays a margin with two distinct chilled zones at its contact with the SWHG.

Petrography

In hand specimen, the SWHG is a fine grained, two feldspar muscovite granite containing white granophyre and fine grained mafic inclusions of questionable origin. Two kinds of inclusions are found in the SWHG. Streamlined, sinewy, light gray inclusions up to 1.5 m in length with diffuse margins are found adjacent to blocky, angular, dark gray, xenolith like masses up to .5m in length with sharp margins. These enclaves are found throughout the body, and they do not occur in any real pattern. In outcrop, the granite contains vugs from 1 to 3 centimeters in diameter and weathers to a light pink. The SWHG outcrops only on the coasts from Southwest Harbor to Norwood Cove on the east, and from Latty Cove to Duck Cove in the west. Sutton and Greening islands also contain outcrops of the SWHG.

In thin section, the SWHG varies in grain size, texture, myrmekite concentration, undulatory quartz distribution and plagioclase zoning development. There are three distinct textures apparent in the SWHG. Texture one is allotriomorphic, and contains phaneritic grains of anhedral quartz and medium, (1 to 5 millimeter in diameter), subhedral grains of plagioclase. Some albite twinning is apparent, but is rarely found within zoned crystals. There is little to no groundmass in this texture, and the existing myrmekite is interstitial, ranging from .1 to .5 millimeters in diameter. Samples characterized by this texture were collected throughout the northeastern coast, and in the southwest from Latty Cove to the western shore of Goose Cove. Modal analysis of samples bearing texture one show Quartz- 40.8%, Plag- 41.7% and K-spar- 17.5%. A second type of texture is hypidiomorphic, lacks myrmekite, and contains an anhedral to subhedral groundmass of quartz and plagioclase crystals, (1 to 5 millimeters

in diameter),with large, equant cumulophyric phenocrysts of tabular plagioclase, (5 to 10 millimeter in diameter). Twinning is common in this texture,and samples with it are found from the eastern coast of Goose Cove around to Duck Cove. The mode of samples with this texture is Quartz- 36.5%, Plag- 41.6% and K-spar- 21.8%. The third texture type has by far the most restricted distribution, found only in Goose Cove near the GD "feeder dike," and in Southwest Harbor adjacent to a rhyolitic dike. Its texture is allotriomorphic, and a radiating myrmekitic groundmass (ranging from 1 to 5 millimeters in size), makes up approximately 50-60% of the thin section. The quartz and plagioclase crystals appear to be corroded and replaced by the myrmekite, and the plagioclase crystals show little twinning. The mode of samples with this texture is similar to that of texture one: Quartz- 40.1%, Plag- 42.7% and K-spar- 17.1%. The K-feldspar in all samples is nonperthitic orthoclase. The muscovite in thin section is brown to green pleochroic due to chlorite replacement of the mica crystals, and is identified by its blue color under crossed polarizers.

Samples containing myrmekite are found in two areas: In Norwood Cove adjacent to the SZ contact, and in Goose Cove adjacent to the possible GD "feeder dike." (See Figure 1). Both plagioclase and quartz have been myrmekitized, and are found radiating from large plagioclase crystals. These vermicular patterns are found in all samples from the northeast coast, but their abundance increase from Southwest Harbor to Norwood Cove, where approximately 50% of the crystals display this pattern. Although, one sample taken in Southwest Harbor adjacent to a rhyolitic dike contains over 60% myrmekite. On the southwestern coast, the myrmekitic texture is found in samples from the Goose Cove area, near the GD "feeder dike." No other samples from the southwest coast contain myrmekite. The distribution of the undulatory quartz mimics the granophyre distribution. On the northeast coast near the SZ, within an area of .4 km^2, 85-100% of the quartz crystals display undulatory extinction. Outside this region, the amount of crystals showing undulatory extinction drops to about 10%. In Southwest Harbor, no quartz crystals display undulatory extinction. On the southwest coast, quartz showing undulatory extinction can be found localized in an area of about .2 $km.^2$, centered around the GD "feeder dike." About 60% of the quartz crystals show undulatory extinction in this region, and in samples collected outside of this area, this percentage is less than 5-10%. The abundance of plagioclase zoning is inverse to that of mermykite and of quartz showing undulatory extinction. Twinning is rare in zoned crystals, but the unzoned plagioclase crystals give an Ab_{90}-An_{10} to Ab_{100}-An_0 composition. The best examples collected of plagioclase zoning on the northeast coast are found in Southwest Harbor. The rest of the coast has poorly formed, highly altered zoned crystals. Plagioclase crystals in samples from Norwood Cove show no zoning. The plagioclase zoning on the southwest coast is very well developed throughout the region, except for the small area adjacent to the GD "feeder dike." Both the number of zoned crystals and the development of the zoning decrease in the area adjacent to the dike.

Geochemistry

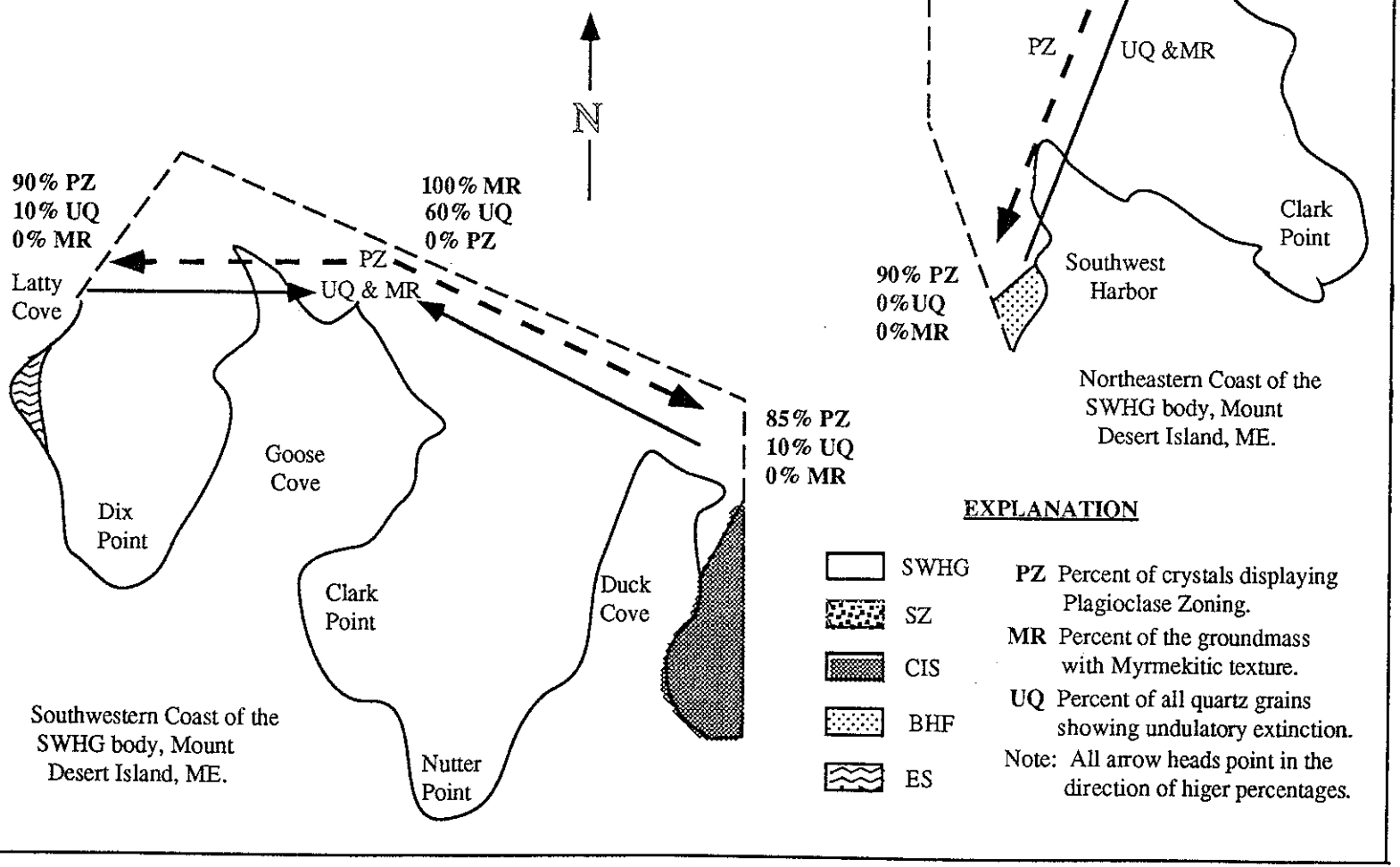
Fifteen samples selected for thin section analysis were analyzed for major and trace element geochemistry using the XRF Lab at Franklin and Marshall College in Lancaster, Pennsylvania. Thirteen of these samples were submitted for INAA analysis techniques to XRAL Laboratories to determine REE concentrations.

Major element analysis shows no discernible variation among the three textures. The samples have between 69-77% SiO_2, 4-6% Na_2O, 2-4% K_2O, and 1-4% Fe_2O_3, with less than 1% TiO_2, MnO, MgO, CaO, and P_2O_5. (See Figure 5). The high concentration of Al_2O_3 from 12 to 14% indicate a peraluminous granite. The AFM diagram after Irvine and Barger, (1971), shows all samples to be calcalkaline, have high total alkalis, and are iron and magnesium oxide poor, (Fig 2). SEM probe of plagioclase zoning will be used to determine variations in An within crystals. Figure 3 shows the geochemical patterns of the SWHG normalized to ORG after Pearce, (1984), showing K, Ba, and Th enrichment, and extremely low Yb concentrations. Trace element data indicate high concentrations of Ba and Zr relative to most types of granites described by Pearce, (1984), with moderate quantities of Sr, Ce and Y. Anomalous values indicate high Ba in one sample relative to the others, (BPP 17-A), while Zr and Sr are relatively low in BPP 54-A. The REE plot of the SWHG in Figure 4 indicates light REE enrichment and a strong negative Europium anomaly. Spider plots of the same data indicate that the samples obtained from the east coast are La, Ce, Nd, P, Hf, Sm, Ti, and Tb enriched relative to the samples from the west coast.

Discussion

The SWHG's location and contact relations indicate that it was emplaced along the unconformity between the BHF and the ES, the same unconformity that controls the emplacement of the CMIC, (Wiebe, 1993). The existence of two feldspars and vugs suggest a low pressure parental material with high water content. The myrmekitic texture concentrated in two small areas suggests that the myrmekite was formed after the emplacement of the body as a secondary feature. The negative Eu anomaly suggests derivation of the SWHG from parental material which has undergone plagioclase fractionation. Pearce, (1984), theorizes that the enrichments in K, Ba, and Th as seen in figure 3 are characteristics of both volcanic arc basalts and granites.

Figure 1: Distribution of Plagioclase Zoning, Undulatory Quartz, and Myrmekite Trends of the Southwest Harbor Granite on Mount Desert Island, Maine.



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Gilman, R. A., Chapman, C. A., Lowell, T. V., and Borns, Jr. H. W., 1988, The Geology of Mount Desert Island: Bulletin 38, Maine Geological Survey, 50pp.

Pearce, J. et al., 1984, Trace Element Discrimination Diagrams for the Tectonic Interpretation of Granitic Rocks. *Journal of Petrology*. v. 25. p 956-983.

Wiebe, R. A., 1993, The Cadillac Mountain Intrusive Complex, Mount Desert Island, Maine. Submitted to the Journal of Geology, 1993.

Figure 2: AMF Diagram of Samples Taken

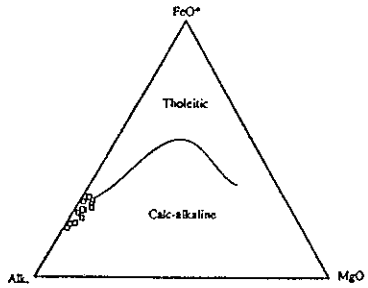

Figure 3: Geochemical Patterns Normalized to ORG after Pearce, (1984).

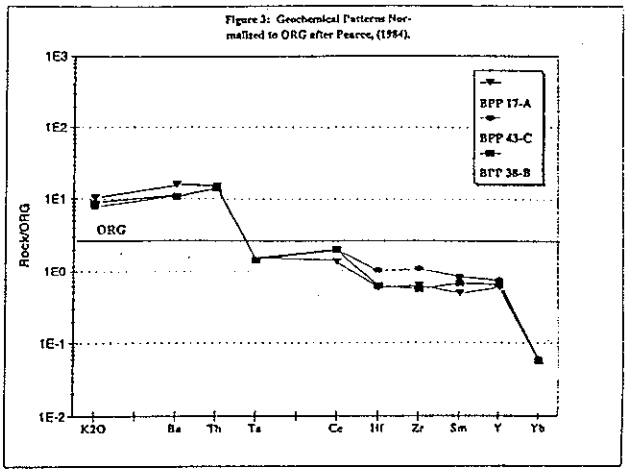

Figure 4: REE Normalized Plot Showing Light REE Enrichment and Eu Anomoly