The Petrology of the Cadillac Mountain Granite

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Introduction

The Cadillac Mountain Granite (CMG) is surrounded on all sides, except for the western edge, by an intrusive breccia which has been termed "shatter zone" by Gilman, et al (1988). The focus of this project is to characterize the compositional variation of the CMG inward from the shatter zone and determine how it relates chemically and mineralogically to the typical CMG.

Field Observations

The transition from the granitic dikes of the shatter zone into the CMG is gradual and on the eastern edge of the contact consists of a sodic-plagioclase rich cumulate. The cumulate lies the above the contact of the shatter zone as mapped by Gilman, et al. (1988) and samples were collected along three lines of section (Fig. 1) to document the mineralogical and chemical changes from the cumulate layer inward towards typical CMG. Assuming that the contact, which dips approximately 30 degrees to the west, represents the floor of the magma chamber, the elevation of each sample from the floor of the chamber can be estimated. Thus, the chemical and compositional changes can be observed as a function of distance above the CMG chamber floor.

The typical CMG is a homogenous, massive, medium- to coarse-grained, hypersolvus granite with a CI of less than 10. Small, mafic enclaves (0.5-1.5 cm in diameter) pervade the CMG and suggest that convection was initiated by the basaltic injections that ponded on the floor of the chamber (Wiebe, 1993). These enclaves are rich in hornblende and plagioclase feldspar.

The shatter zone consists of Bar Harbor, Ellsworth schist, volcanic and basalt fragments in a granitic matrix of varying grain size and mineralogy. The size of these country rock inclusions varies greatly between the southern and eastern side of the shatter zone. The shatter has great variability in grain size and mineralogy.

The sodic-plagioclase rich cumulates above the shatter zone have biotite as a mafic mineral and grade into the more typical CMG away from the contact with the shatter zone. The cumulate rocks commonly lack the mafic enclaves that pervade the typical CMG.

Analytical Techniques

Samples were studied petrographically and analyzed for major and trace elements using X-ray fluorescence, neutron activation and inductively coupled plasma (ICP) spectrometry.

Petrography

The mineralogy of the typical CMG is dominated by equant quartz and ternary feldspar with interstitial hornblende as the major mafic mineral. Interstitial biotite is present but in lesser amounts than hornblende. Zircon, opaque minerals, and clinopyroxene are present as accessory phases. Allanite is scarce and epidote is the common alteration product.

The grantitc dikes of the shatter zone are characterized by individual grains of plagioclase feldspar and alkali feldspar with biotite as the dominant mafic mineral. Accessory phases of clinopyroxene and hornblende are present. Many samples have a fine-grained, quenched texture.

The transitional rocks between the shatter zone and the typical CMG are sodic-plagioclase rich cumulates with intersital biotite and subhedral clinopyroxene. Intersital hornblende is present as a minor mafic phase. Zircon and fayalite are common accessory phases. Alkali feldspar is usually present as individual crystals although a few perthitic feldspars are present. Allanite is scarce.

The mineralogical transition from the shatter zone to the cumulate rocks and into the typical CMG is characterized by a transition from plagioclase and alkali feldspar existing as separate phases to a ternary feldspar in the typical CMG. The other major transition is the switch from biotite as the major mafic mineral in the shatter zone and the cumulates above the shatter zone to hornblende as the major mafic in the typical CMG. Clinopyroxene and zircon are much more abundant in the lower rocks and is present only as a minor mafic phase in the typical CMG. These transitions are quite gradual with no distinct mineralogical boundaries.

Geochemistry

The geochemistry of the CMG varies with elevation above the floor of the chamber. The samples closer to the floor exhibit a large range of chemical compositions whereas the higher rocks have a more uniform composition. This scatter decreases at approximately 400 m above the chamber floor and indicates the homogenity of the typical CMG found at higher elevations. In addition to the scatter of chemical compositions at lower elevations, the lower rocks tend to be rich in Ba (Fig. 2), Sc (Fig. 3), and Zr and depleted in Rb and Be. The trend is for Ba, Zr, and Sc to decrease with increasing elevation from the floor while Rb and Sc increase with elevation. There is a small increase in potassium as silica increases (Fig. 4). The samples with higher silica content have higher potassium content and these rocks are found at further from the floor of the chamber.

Discussion

The mineralogical and chemical variations observed in the transition from the shatter zone into the CMG appear to reflect crystal accumulation. The high concentrations of Ba, Zr, and Sc suggest the accumulation of plagioclase feldspar, zircon and clinopyroxene at the base of the CMG and these phases commonly occur as concentrations of subhedral crystals. The accumulation of these crystals would concentrate a residual liquid upwards that would be depleted in these elements and enriched in incompatible elements such as Be and Rb. The mineralogy displays this trend of decreasing plagioclase, zircon and clinopyroxene at higher elevations in the CMG. These minerals are present in the upper CMG, but only as accessory phases.

The change from a plagioclase rich cumulate with few alkali feldspar grains to a ternary feldspar granite with intersital hornblende could be explained by an increase in the temperature of crystallization or a decrease in the water content of the CMG chamber. A mechanism for the temperature increase within the chamber could be the basaltic injections that ponded on the chamber floor to produce the underlying gabbro-diorite unit (Wiebe, 1993). The occurrence of these mafic enclaves throughout the CMG suggest that the basaltic injections caused intense convection within the CMG magma chamber. The lack of mafic enclaves within the cumulates of the CMG indicate that convection due to the basaltic injections began after formation of the shatter zone. A possible explanation for the reduction in the content of the magma could be degassing due to eruptions.

References

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

Wiebe, R. A., and Chapman, M. C., 1993, Layered Gabbro-Diorite Intrusions of Coastal Maine: Basaltic Infusions into Floored Silicic Magma Chambers, Fieldtrip Guidebook for the Northeastern United States: 1993 Boston GSA.

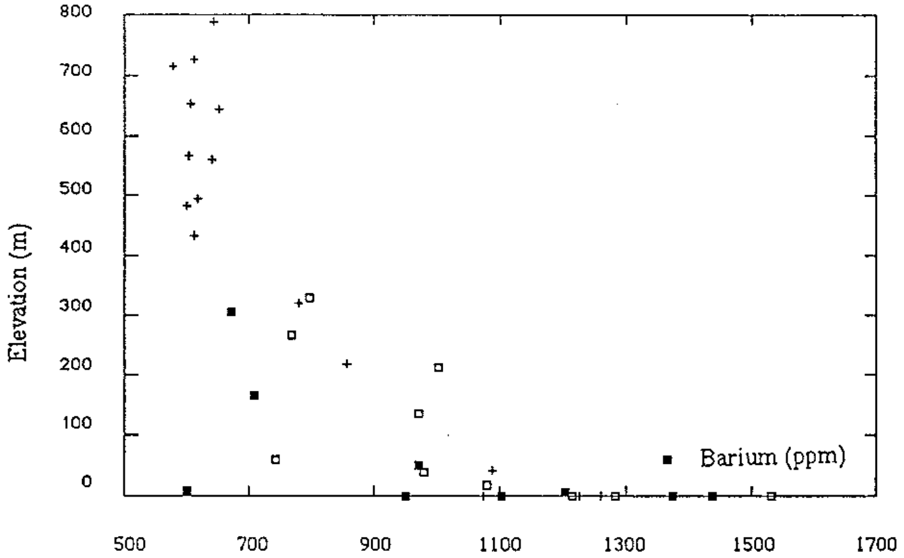

Figure 2. Barium verses Elevation above the CMG Magma Chamber Floor. Different symbols represent samples from different transects.

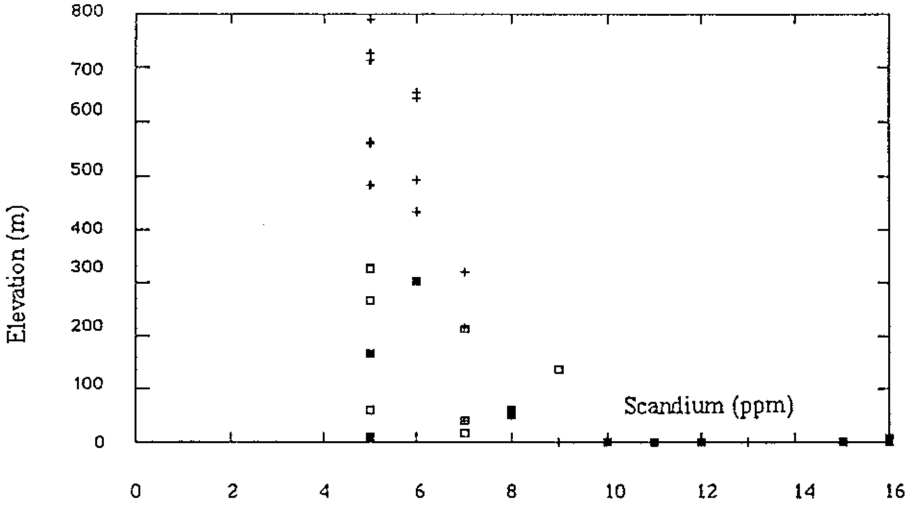

Figure 3. Scandium verses Elevation above the CMG Magma Chamber Floor

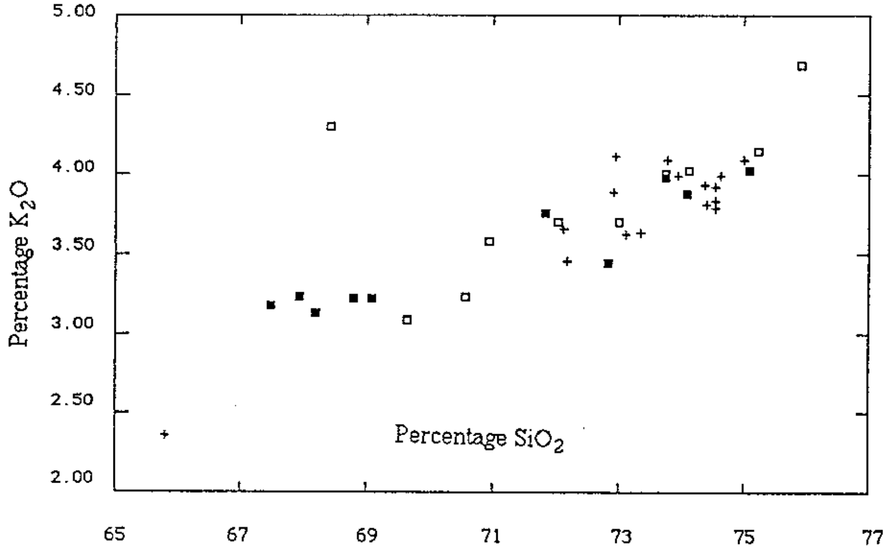

Figure 4. Weight Percent SiO_2 verses Weight Percent K_2O

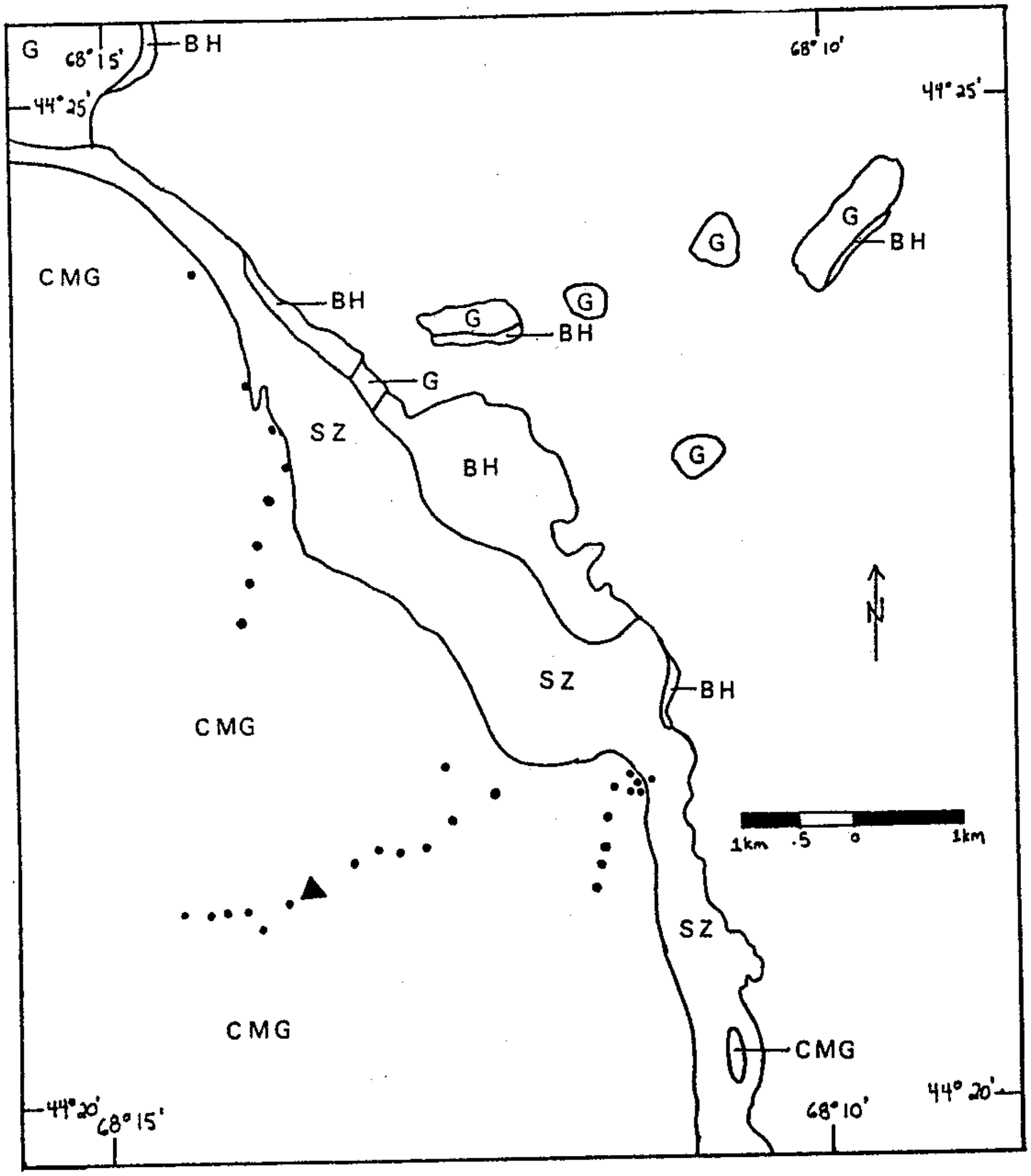

Figure 1. Map of sample locations modified from Gilman, et al. (1988). See Figure 1 in Wiebe (this volume). Rock units are Bar Harbor Formation (BH), gabbro-diorite unit (G), shatter zone (SZ), and Cadillac Mountain granite (CMG).