Hybridization between Interleaved Sills of Mafic and Felsic Magmas
Pleasant Bay, Maine

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Introduction

The Pleasant Bay intrusion is located between Bar Harbor and Machias, Maine. Gravity data indicates a basin form (Biggi and Hodge, 1982) with dimensions of 12 km by 20 km and a maximum thickness of approximately 3 km. Open vugs suggest a shallow emplacement. The rock consists of 90% layered gabbro and mafic diorite that vary in grain size and texture. The other 10% can be found in the granitic pipes as silicic filter-pressed material. Bickford (1960) computed a minimum thickness of 15,000 feet of layered gabbro in the Pleasant Bay area. Within this layered gabbro are layers and lenses of medium-grained leucocratic diorite to granodiorite which contain gabbroic pillows and mafic inclusions. There also are layers and lenses of fine-grained gabbro which show chilled bottom margins (and occasionally also a chilled top margin). Basaltic dikes, prevalent in the granite surrounding the pluton, may be the source that fed the chilled replenishments.

In an area west of the central region of the Pleasant Bay intrusion, at the southwestern tip of Guard Point, there is a section where all the different rock types of the pluton are present. They can be subdivided into two macrorhythmic units with chilled gabbroic bases that grade upward to medium-grained gabbro, diorite, and highly silicic filter-pressed material. The top of each macrorhythmic unit is truncated by the chilled base of the overlying unit, a record of the infusion of basaltic magma into the magma chamber (Wiebe, 1993). The purpose of this project is to study the field relations and the petrographic and geochemical changes throughout a macrorhythmic unit in order to determine the mixing history of the Pleasant Bay intrusion.

Field Observations

At the southwestern tip of Guard Point, there is a nearly complete section of layered gabbro, beginning from the chilled gabbroic base to coarse gabbro to granodiortie and the contact with the next chill. At the chilled contact there are sunken lobes comparable to sedimentary load cast structures, as well as chilled pillows and the upward flares of granitic mush, due to turbulent interactions with the overlying mafic material. Along the edge of the bay, especially concentrated at the western edge of Guard Point, there are numerous exposures of granitic pipes. The layered gabbro continues in the second macrorhythmic unit, located across a small bay, but for the first 100 meters or so, the layering is complicated by multiple basaltic injections. Many exposures of granitic pipes are also found at the top of the second macrorhythmic unit.

Methods

Samples were taken at measured locations according to changes in mineralogy and texture seen in the hand samples in the field. In the second macrorhythmic unit, the layering was complicated by basaltic injections. As a result, the only samples used for thin sections and geochemical analyses were collected after the gradation was more homogenous. Thin sections were made from twenty-six samples altogether: fourteen from the first unit, eight from the second unit, and four from the area of granitic pipe exposures. Twenty-three of these samples, from both units, were prepared and analyzed for major and trace elements using X-ray fluorescence at the facilities at the Department of Geology and Geography at the University of Massachusetts, Amherst. Five samples from the first unit were selected for INAA analysis and were sent to the Radiation Center at Oregon State University.

Petrography

The mineralogy of the hand samples for the basaltic rocks appear fairly uniform. The most noticeable change is that the minerals become more coarse-grained up-section. In thin section, the chilled basalt is very fine-grained, and consists of mostly plagioclase, with quartz, hornblende, biotite, and opaques. The mineralogy of the basaltic pillow is similar to the mineralogy of the chill at the base of the unit. Moving up-section, another compositional change in the mineralogy shows the increasing presence of biotite.

Geochemistry

The basalts studied occurred at the base of the macrorhythmic unit and also as injected pillows. The seven basalts of the twenty-three samples analyzed for geochemistry show high magnesium and low silica. Although CaO and MgO show linear plots (Fig. 1), which would suggest a complete mixing process, many of the other MgO and SiO_2 variation diagrams are not linear. They form V-shaped patterns where the mafic rocks form a coherent cluster and the felsic rocks also form a coherent cluster, but the two types are not co-linear (Fig. 2). Figure 3 and Figure 4, show Cr vs. MgO and Ni vs. MgO. Both Ni and Cr drop in a relatively gentle and linear fashion with decreasing MgO.

Discussion

The emplacement of the Pleasant Bay pluton, whose heat remobilized the surrounding country rock to form basaltic injections, created a layering of macrorhythmic units. The area at Guard Point shows nice examples of mafic and felsic magma interaction, but limited chemical interaction. Figure 2 shows how the felsic end members of the mafic group are aimed at the mafic end members of the felsic group. This indicates that we may not be dealing with fractional crystallization, but rather, basalts being contaminated by diorites and vice versa. According to the diagrams, the mixing occurs at the end members of the mafic and felsic groups closest to each other. The ends farthest from each other were prevented from mixing because they were either chilled (basalt) or they caused the chilling (diorite). The diagrams of Cr vs. MgO and Ni vs. MgO also indicate that the basalts and gabbros are not related by fractional crystallization. Ni and Cr are so compatible that they should drop much more precipitously. Figures 3 and 4 show that the basalts are aimed directly at the composition at the mafic end of the felsic compositional group were the most efficient hybridization takes place between magmas closest to each other in composition.

References Cited

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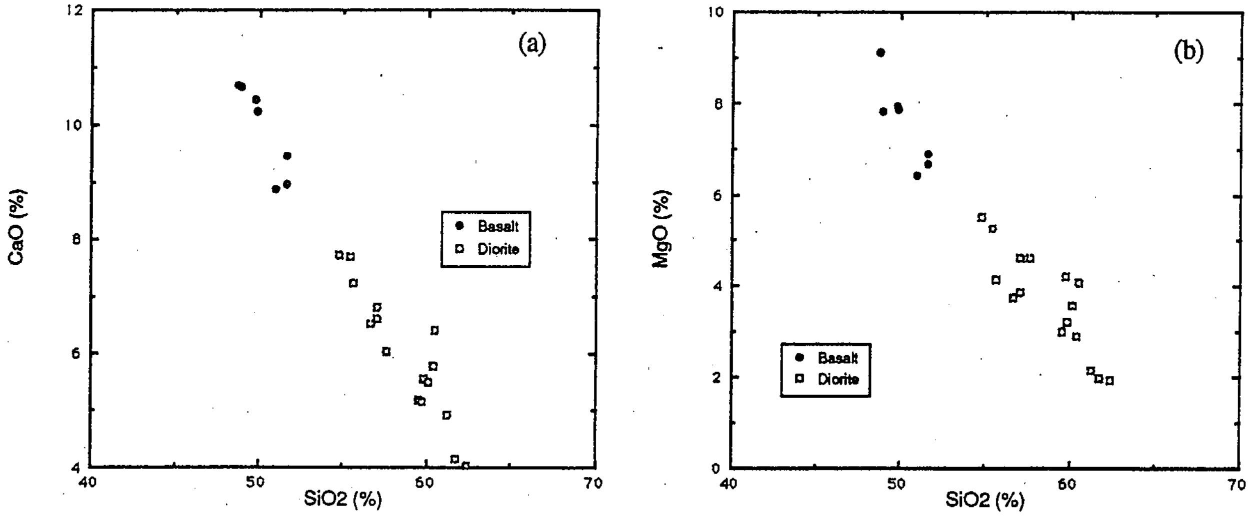

Fig. 1: Linear plots showing basalts and diorites from both macrorhythmic units: (a) CaO vs. SiO_2, (b) MgO vs. SiO_2.

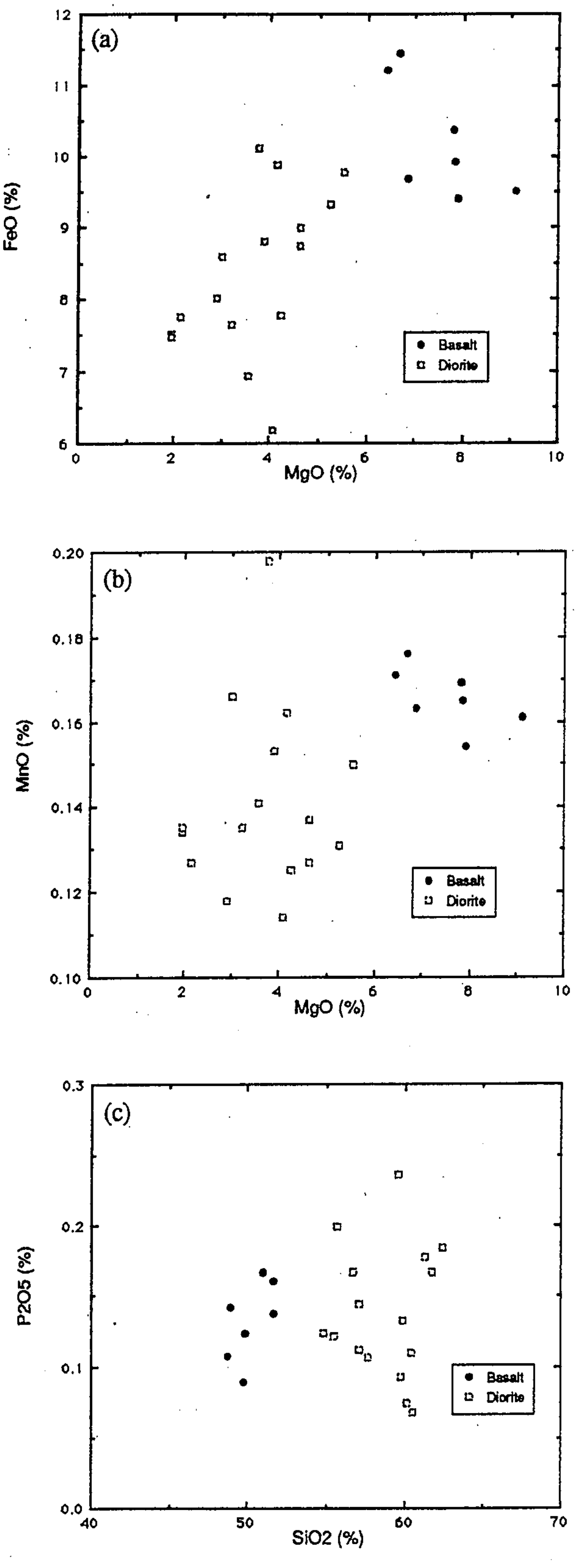

Fig. 2: Non-linear plots, some with the V-shaped pattern, showing basalts and diorites from both macrorhythmic units: (a) FeO vs. MgO (b) MnO vs. MgO (c) P_2O_5 vs. SiO_2.

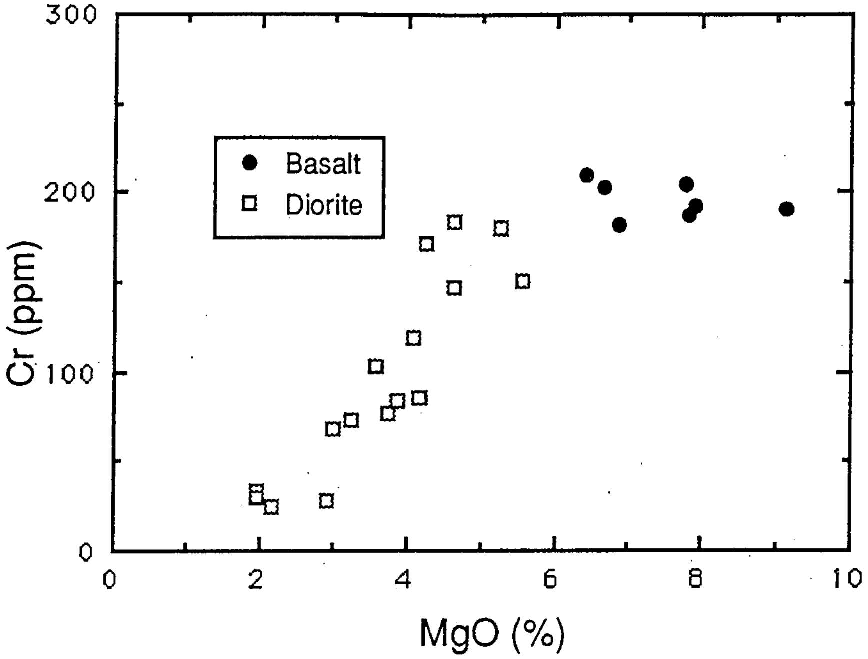

Fig. 3: Cr vs. MgO showing basalts and diorites from both macrorhythmic units.

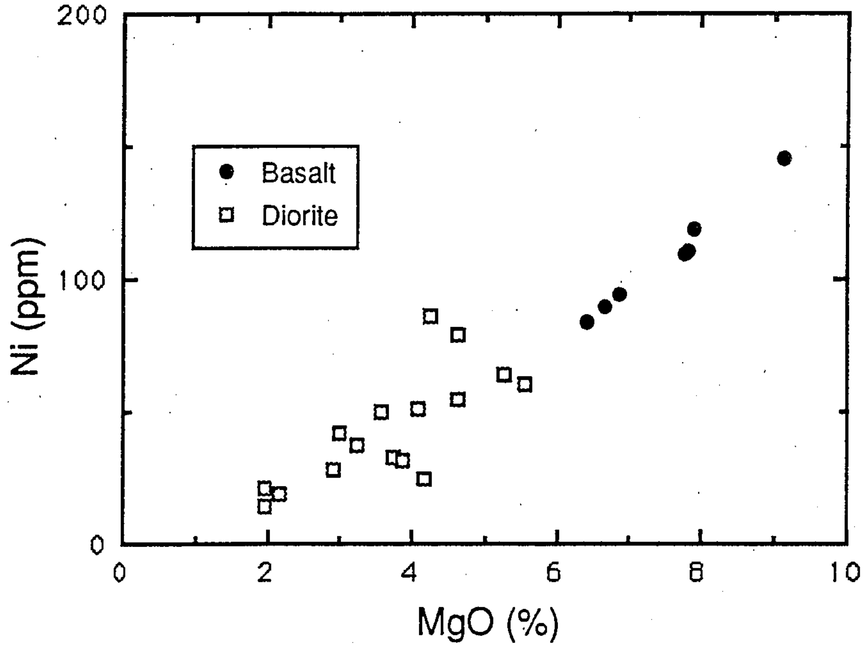

Fig. 4: Ni vs. MgO showing basalts and diorites from both macrorhythmic units.