ORIGIN OF INTERLAYERED GABBROIC, DIORITIC AND GRANITIC ROCKS ON MOUNT DESERT ISLAND, MAINE

Robert A. Wiebe, Franklin & Marshall College, Director
Reinhard A. Wobus, Williams College
Samual Kozak, Washington & Lee University

Introduction

The igneous rocks on Mount Desert Island, Maine, represent a long-studied, classical area of New England plutonic geology (Shaler, 1889; Chapman, 1970 Gilman et al., 1988). The wide variety of rock types, excellent coastal and inland exposures, and beautiful scenary (now largely in Acadia National Park) undoubtedly all contributed to early interest in studying these rocks. C. A. Chapman and many of his students have been largely responsible for the excellent geologic map and the most accessible descriptions of the rocks (Chapman, 1970), and this publication has been revised by Gilman et al. (1988). Unfortunately, because these recent works were largely intended to be guides for park visitors, they do not provide the kind of detail or documentation necessary to establish the petrogenetic relations of the various igneous units. Until now, very little was known about the possible sources, crystallization history, and emplacement of the several plutons, about the relationships between the granitic plutons and the closely associated gabbro-diorites, or about the possible relations between the plutonic and nearby volcanic rocks of roughly comparable age. In terms of the potential for petrogenetic studies, it is surprising that the igneous rocks of Mount Desert Island have not been subjected more recently to detailed studies that integrate field, petrographic, and geochemical data.

Hogan and Sinha (1989) included the plutonic rocks of Mount Desert Island within the Coastal Maine Magmatic Province (CMMP). This province consists of more than 100 mafic and felsic plutons emplaced over a time span from the Late Silurian to the Early Carboniferous. The bimodal character of this province is well established (Chapman, 1962), and there is widespread evidence for commingling between mafic and felsic magmas (Stewart et al, 1988; Chapman and Rhodes, 1992). Gravity studies (Hodge et al., 1982) indicate that many of the granitic plutons are thin, with gently-dipping floors, and probably rest on mafic rocks similar to the interlayered diorite and gabbro that partly surround and dip beneath several of them. The plutons of the CMMP intrude a variety of metasedimentary and metavolcanic rocks in several fault-bounded, northeast-trending terranes featuring different stratigraphics and different structural and metamorphic histories (Williams and Hatcher, 1982). The ages and field relations of many of these plutons suggest that they postdate the main assembly of these lithotectonic terranes (Ludman, 1986). Hogan and Sinha (1989) suggested that some of the magmatism was related to rifting in a region of transtension along a transcurrent fault system.

Field relations on Mount Desert Island

The igneous rocks on Mount Desert Island, Maine, occur largely within Acadia National Park (Fig. 1). Three plutonic units make up the main Cadillac Mountain intruxive complex (CMIC): the Cadillac Mountain granite (CMG), a hybrid unit of gabbroic to granitic rocks (G-D), and the Somesville granite (SG) (Wiebe and Chapman, 1993). Field relations indicate that the three units have overlapping ages and that they formed during the evolution of a single composite magma chamber. The gabbro-diorite unit formed through repeated injections of basaltic magma into the CMG magma chamber (Wiebe and Chapman, 1993). These injections and the subsequent interactions between basaltic and granitic magmas may have been responsible for the large number of mafic enclaves that occur throughout the CMG. Hornblende from the G-D unit gives an Ar-Ar age of about 418 +/- 5 Ma (D. Lux, personal comm., 1993). The Southwest Harbor granite (SHG) and some of the adacent gabbroic bodies appear to be older than the CMIC. The Cranberry Island Series consists mainly of Silurian (?) bimodal tuffs and lavas that may be genetically related to the SHG or the CMIC.

The CMIC occurs in an irregular, roughly oval area about 14 by 20 km (Fig. 1). Two areas of CMG are separated by complexly interlayered gabbroic, dioritic, and granitic rocks of the hybrid G-D unit (Fig. 1). The larger eastern area of CMG is rimmed everywhere except on its western margin by a basal intrusive breccia (termed a "shatter zone" by Gilman et al., 1988). This breccia contains closely packed blocks of the adjacent country rock (e.g. Bar Harbor Formation, gabbro, and the Cranberry Island Series). The breccia appears to truncate the Southwest Harbor granite. Gravity data (Hodge et al., 1982) suggest that the larger area of CMG is a saucer-shaped mass of granite that is less than 3 km thick at its center. Gravity data also suggest that the G-D unit forms a saucer-shaped body, 2 to 3 km thick beneath this area of CMG. Field relations indicate that the smaller western area of CMG lies

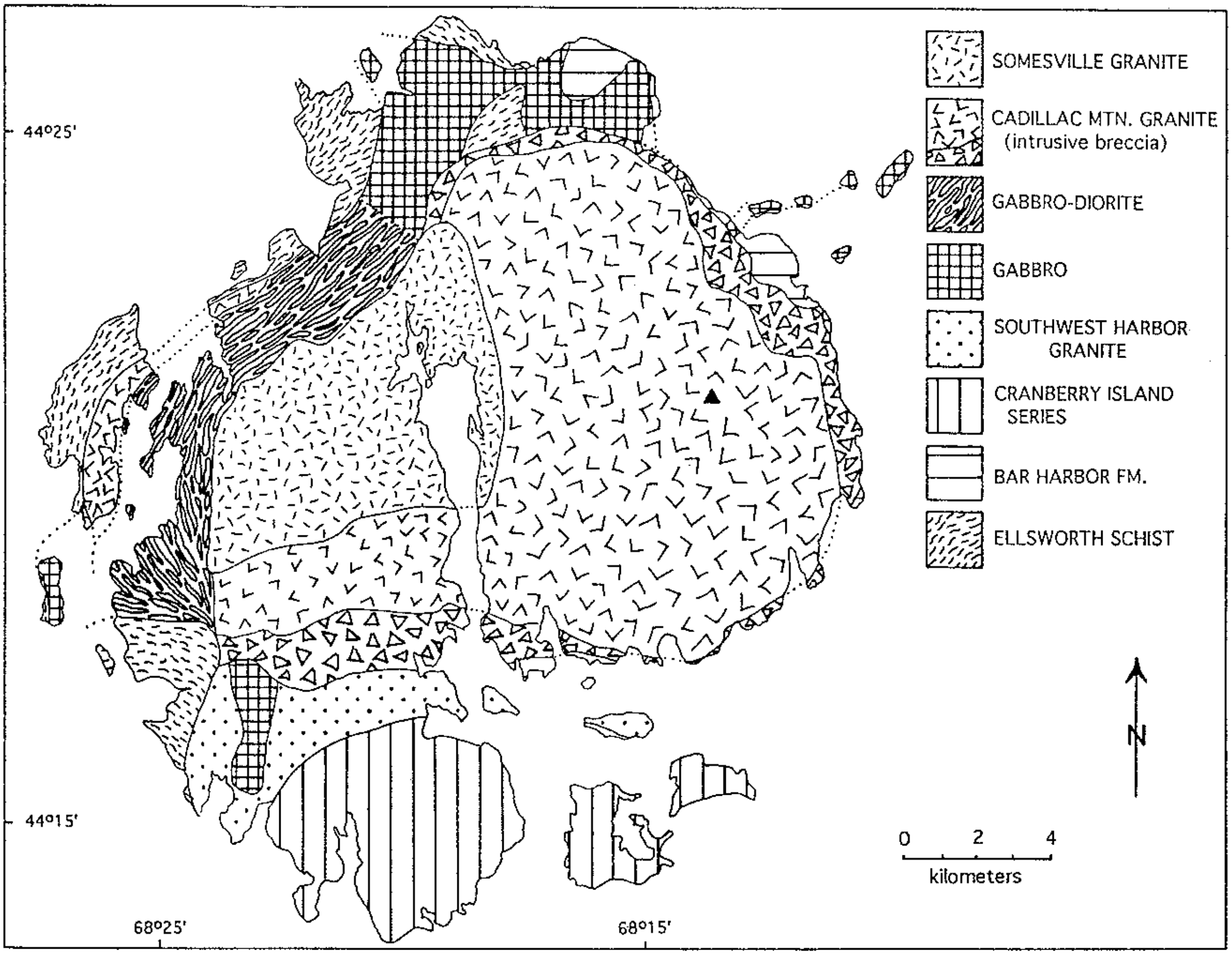

Figure 1. Geologic map of Mount Desert Island modified from maps in Chapman (1970) and Gilman et al. (1988). Solid triangle in the area of the CMG is the summit of Cadillac Mountain.

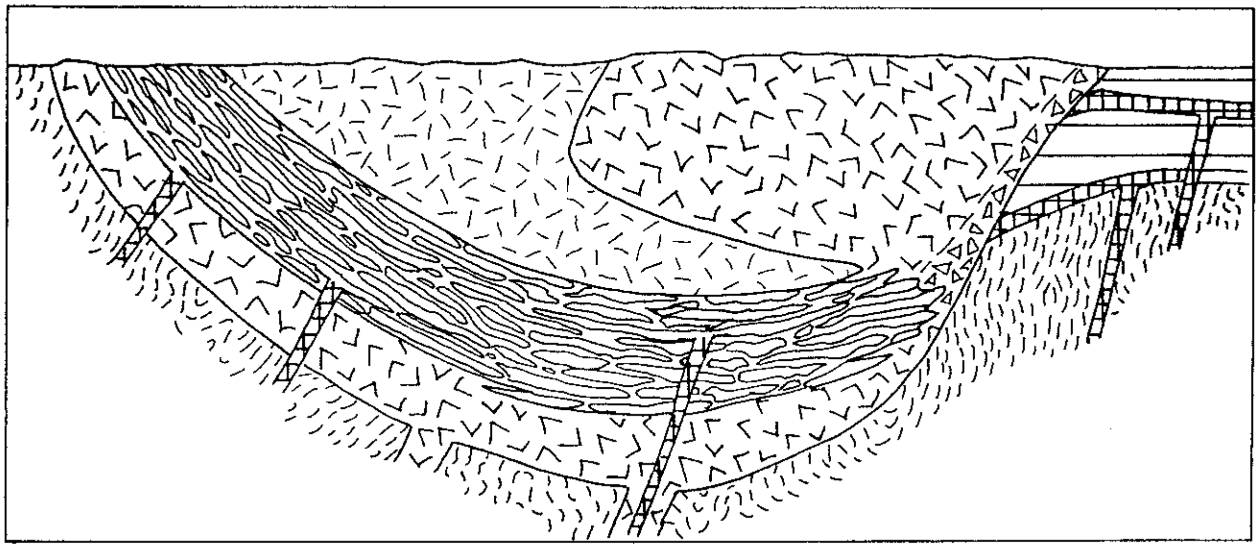

Figure 2. E-W cross-section through the CMIC, drawn about 1 km south of the summit of Cadillac Mountain. Patterns as in Figure 1.

below the G-D unit and suggest that there may be a substantial volume of CMG below the G-D unit. The 3-D shape of the Somesville granite is not well constrained, but gravity data suggest that it is thin and floored by gabbro. The initial emplacement of the CMIC appears to have been controlled by the unconformity between the Ellsworth schist and the Bar Harbor Formation. This unconformity as well as bedding in the Bar Harbor Formation also appear to have controlled the emplacement of the SHG and sill-like masses of homogeneous gabbro and diabase located to the north, east, and south of the CMIC. Steeply bounded masses of gabbro in the Ellsworth schist appear to have been feeders for the gabbroic rocks. An E-W cross-section of the CMIC is shown in Figure 2.

Student Projects

Along with four visitors (Chapman, Greene, Seaman, and Smith) our group spent four initial days in reconnaisance in order to familiarize ourselves with the range of rock types and field relations. Preliminary work and models suggested by Wiebe (Wiebe and Chapman, 1993) served as a framework that could be critically tested by our field projects. In those first days we established an informal, prioritized list of problems that we felt should be studied in order to reach a well integrated understanding of the igneous geology of Mount Desert Island. On the basis of that list students chose problems that most interested them. The end result was group of research projects that beautifully complemented each other and helped our group see ourselves as a research team instead of individuals with isolated projects. These projects also dove-tail well with ongoing work on the CMG by Wiebe and on the Cranberry Island volcanics by Seaman. Seaman is also attempting to obtain (with some support from our project) zircon ages on several of the units we are studying.

Several projects focused on different aspects of the CMIC, and all have important implications for the origin of the Cadillac Mountain Granite. **Mike Seckler** (Williams), **Liz Symchych** (Carleton), and **Fred Vanden Burgh** (Colorado) chose to work on detailed stratigraphic sections within the gabbro-diorite unit. Their projects address the nature of interactions between basaltic injections and resident silicic magma and have important implications for the subsequent evolution of the CMG. **Marnie Sturm** (Trinity) chose to study the mafic enclaves that are so widespread in the CMG. Among other things she will be able to test their possible relations to the basaltic injections. **Michelle Coombs** (Williams) and **Jonathan Holden** (Franklin & Marshall) tackled projects that attempt to understand the origin of the shatter zone which partly surrounds the CMG. Does this zone represent a major eruption or collapse of a caldera? Coombs has focused particularly on the internal structure of the zone and the granitic dikes within the zone. Because Chapman (1970) suggested that the CMG accumulated upward from the floor, Holden has been examining especially the compositional variation of the CMG in two sections upward from the shatter zone. **Kathleen Schuh** (Wooster) chose to study the Somesville granite in order to clarify its field relations with the adjacent CMG and the gabbro-diorite unit, to evaluate its possible genetic relation to the CMG, and to understand the origin of its enclaves and compositional variation.

The two remaining students focused on extremely important units that are at present very little known. **Benjamin Plummer** (Washington & Lee) is studying the Southwest Harbor granite (SHG). It will be particulaly interesting to compare the composition of this unit with the CMG which appears to have been much more extensively affected by interaction with basaltic magma. **Naomi Lubick** (Carleton) is studying sections of the Cranberry Island volcanics that are exposed on Mount Desert Island. These rocks are closely associated with the SHG. She has been collaborating closely with Sheila Seaman who is undertaking a major study of these same units on the nearby Cranberry Islands. These volcanic rocks may represent material that was ejected from magma chambers that produced the three main granitic bodies (SHG, SG, CMG) on Mount Desert Island.

Four students (Coombs, Holden, Schuh, and Symchych) are presenting posters at the NE GSA meeting in Binghamton, NY, and Lubick is presenting a poster at the North Central meeting of the GSA. We hope that much of the work we accomplish will be published in an upcoming GSA Memoir dedicated to magmatism in the Appalachians.

References

Chapman, C. A, 1962, Bays-of-Maine igneous complex: Bull. Geol. Soc. America , v. 73, p. 883-888.

Chapman, C. A., 1970, The Geology of Acadia National Park: The Chatham Press, Old Greenwich, Conn., 127 p.

Chapman, Marshall, and Rhodes, J. M., 1992, Composite layering in the Isle au Haut Igneous Complex, Maine: evidence for periodic invasion of a mafic magma into an evolving magma reservoir: Jour. Volc. and Geotherm. Res., v. 51, p, 41-60.

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

Hodge, D. S., Abbey, D. A., Harbin, M. A., Patterson, J. L., Ring, M. J., and Sweeney, J. F., 1982, Gravity studies of subsurface mass distributions of granitic rocks in Maine and New Hampshire: Amer. Jour. Sci., v. 282, p. 1289-1324.

Hogan, J. P., and Sinha, A. K., 1989, Compositional variation of plutonism in the coastal Maine magmatic province: mode of origin and tectonic setting: In: Tucker, R. D. and Marvinney, R. G. (eds.) Studies of Maine Geology: Igneous and Metamorphic Geology. Maine Geological Survey, Department of Conservation, v. 4, p. 1-33.

Ludman, A., 1986, Timing of terrane accretion in eastern and east-central Maine: Geology, v. 14, p. 411-414.

Shaler, N. S., 1889, The geology of the Island of Mount Desert, Maine: U. S. Geol. Surv., Eighth Ann. Report, 1886-87, Part 2, p. 987-1061.

Stewart, D. B., Arth, J. A., and Flohr, M. J. K., 1988, Petrogenesis of the South Penobscot Intrusive Suite, Maine: Amer. Jour. Sci., v. 288-A, p. 75-114.

Wiebe, R. A., and Chapman, M., 1993, Layered gabbro-diorite intrusions of coastal Maine: basaltic infusions into floored silicic magma chambers: Field Trip Guidebook for Northeastern United States: 1993 Boston GSA, Cheney, J. T. and Hepburn, J. C., eds. Contrib. No. 67, Dept. of Geol. and Geog., Univ. of Mass., Amherst, Mass., p. A1-A29.

Williams, H., and Hatcher, R. D., 1982, Suspect terranes and accretionary history of the Appalachian orogen: Geology, v. 10, p. 530-536.