GEOLOGY OF VINALHAVEN ISLAND, MAINE

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INTRODUCTION

This project examined the geology of Vinalhaven Island (Fig. 1). The plutonic rocks on Vinalhaven belong to the Coastal Maine Magmatic Province (Hogan and Sinha, 1989), and represent the roots of a Silurian bimodal volcanic system that apparently developed in an extensional tectonic setting, possibly in a back-arc environment. Three previous Keck projects in Maine have studied similar systems along the Maine coast (Cadillac Mountain and Gouldsboro complexes in 1993 and 1994, and Vinalhaven in 1998) and led to the publication of several papers (Wiebe et al., 1997a, 1997b; Wiebe and Adams, 1997). The Vinalhaven plutonic complex appears to be perhaps the best exposed of these bimodal intrusions. The coastal outcrops are superb and show complex commingling and mixing relations between gabbroic, dioritic and granitic rocks near the base of the intrusion. Extensive areas of large contact-metamorphosed blocks of country rock also occur iin the lower portions of the pluton. Two varieties of granite, along with tonalite, and gabbro are widely exposed and easily sampled in coastal sections, numerous quarries, and glaciated inland exposures.

To the northwest, the Vinalhaven pluton has intruded a remarkably well preserved sequence of interlayered Silurian volcanic and sedimentary rocks which have been gently folded into a basin-like structure. Even the oldest of these units on the island, the Polly Cove formation, contains felsic pyroclastic rocks which retain primary fabrics and show little evidence of regional metamorphism. It is overlain by more than 750 m of intermediate flows and breccias of the Thorofare andesite, followed by tuff-breccias and distinctive sedimentary rocks of the lower Seal Cove formation. Above this weakly deformed basaltic and rhyolitic volcanics may be cogenetic with the plutonic rocks. Large stoped blocks of the lower Seal Cove occur near the base of the pluton at the southern edge of Vinalhaven and on Greens Island to the west. All of the afore mentioned layered units have been studied by this year's Keck group for the first time, building on the work of two students in the previous Vinalhaven project on the bimodal volcanics at the top of the Silurian sequence (the Vinalhaven diabase, Perry Creek formation, and the Vinalhaven rhyolite).

STUDENT PROJECTS

The first few days were spent in getting an overview of the island geology and in giving the students an opportunity to see the variety of problems that were available. The resulting seven projects made use of that variety, focusing on plutonic, volcanic, metamophic and sedimentary rocks.

Four students undertook projects that addressed significant problems in the plutonic rocks. Two of these (Andrew Gordon and Richard Henterly) worked on different coastal sections which displayed complex interactions between resident granitic magma and episodic replenishments of basaltic magma. These projects are well integrated with four comparable studies done in the 1998 Keck project to produce detailed maps of nearly the entire base of the chamber. Henterly

concentrated on the stratigraphic variation of a major depositional unit with a gabbroic base which grades upward to hybrid and felsic rocks. His work documents both vertical and lateral compositional variation in an effort to understand the processes responsible for hybridization between mafic and felsic rocks. Gordon has documented a complex sequence of mafic replenishments that also include important stoped blocks of country rock.

Matt Manon studied a hybrid complex within the central portion of the coarse-grained Vinalhaven granite. This complex appears to have originated when late injections of basaltic magma remobilized nearly solid granite, generating heterogeneous hybrid rocks with corroded megacrysts derived from the granite in a very fine-grained intermediate to felsic matrix. Recent studies of erupted andesites on Montserrat have suggested comparable remobilization of a nearly solid pluton. This study should provide new insights into this process from the plutonic record.

Noah Westgate examined several different types of contacts (both sharp and gradational) that were produced between contemporaneous mafic and felsic magmas. Documenting the chemical exchanges and mineralogical variation that occur across these boundaries should improve our understanding of the geological processes that can take place in these dynamic settings.

Nathan Cardoos focused on the only thick package of intermediate volcanic rocks in all of coastal Maine, the Silurian Thorofare Andesite, which forms a 750-meter-thick pile of gray to reddish-brown andesite to dacite lava flows, laharic breccias, autobreccias, bedded tuff breccias, and rare airfall tuffs. On tectonic discrimination diagrams, the Thorofare andesite flows and dikes plot in the IAT (island arc tholeiite) field, suggesting that they formed before consolidation of the peri-Avalonian arc systems with the Laurentian mainland and prior to the extensional tectonic regime that produced the younger bimodal plutonic and volcanic rocks.

All five of these plutonic and volcanic studies involved careful petrographic and geochemical work. All rocks were analyzed by X-ray fluorescence at Franklin and Marshall College.

Nathan Brill's project dealt with large stoped blocks of country rock that occur within the cumulate plutonic rocks at the base of the granitic body. They include rocks which resemble the Calderwood Formation and younger, less deformed volcanic and sedimentary units along the northern margin of the Vinalhaven granite. These blocks have been strongly affected by contact metamorphism and still preserve delicate primary sedimentary and volcanic structures. Some of the metasedimentary rocks contain cordierite, andalusite and possibly hypersthene. His study relates to work by the 1998 Keck project and should provide valuable insights into the thermal history and emplacement depth of the pluton.

Lindsay Szramek focused on the Seal Cove Formation, which occurs along the northern coastline, in contact with the intruded pluton. Her careful work on the stratigraphy of this formation represents the first detailed study of these rocks and also allowed her to determine the specific sources of many stoped blocks of country rock that occur in the southern (basal) portions of the Vinalhaven intrusion.

CONCLUSIONS

The seven projects described above help to provide a solid basis for detailed understanding of the evolution of the igneous and metamorphic geology of Vinalhaven and are an important contribution to understanding the stratigraphy of coastal Maine. Over the next two years, we anticipate that several different combinations of faculty, students and visitors will write papers that can be published in national or international journals. More immediately, several students will present papers on their individual research projects at regional GSA meetings.

ACKNOWLEDGEMENTS

Approximately half of the money for supporting this project was provided by two NSF Research grants to Wiebe (EAR-0003260) and Hawkins (EAR-0003555). Several visitors to the project provided many

useful insights and much stimulation to both students and faculty. Two visitors were advisors to student participants: Dr. Rachel Beane of Bowdoin College was Lindsay Szramek's advisor, and Dr. Richard Hazlett of Pomona College helped to advise both Andrew Gordon and Noah Westgate. Dr. Mark Brandriss of Smith College helped us out especially when Bud Wobus had to be away from Vinalhaven. Dr. Kelsie Dadd of Macquarie University (Australia) studies Paleozoic volcanic rocks in eastern Australia and was particularly interested in seeing the volcanic sections on the island. Dr. Dan Lux, University of Maine, is actively doing NSF-supported research on Vinalhaven and was interested in seeing some of the plutonic rocks we were studying. Dr. Michelle Markley of Mt. Holyoke College was particularly helpful in showing us how to recognize and record some of the subtle structures in the granites. Our time on the island was greatly aided by the warmth and generosity of many of the people on Vinalhaven Island. We are especially grateful to Lucy McCarthy and John Drury for a wonderful trip to Greens Island.

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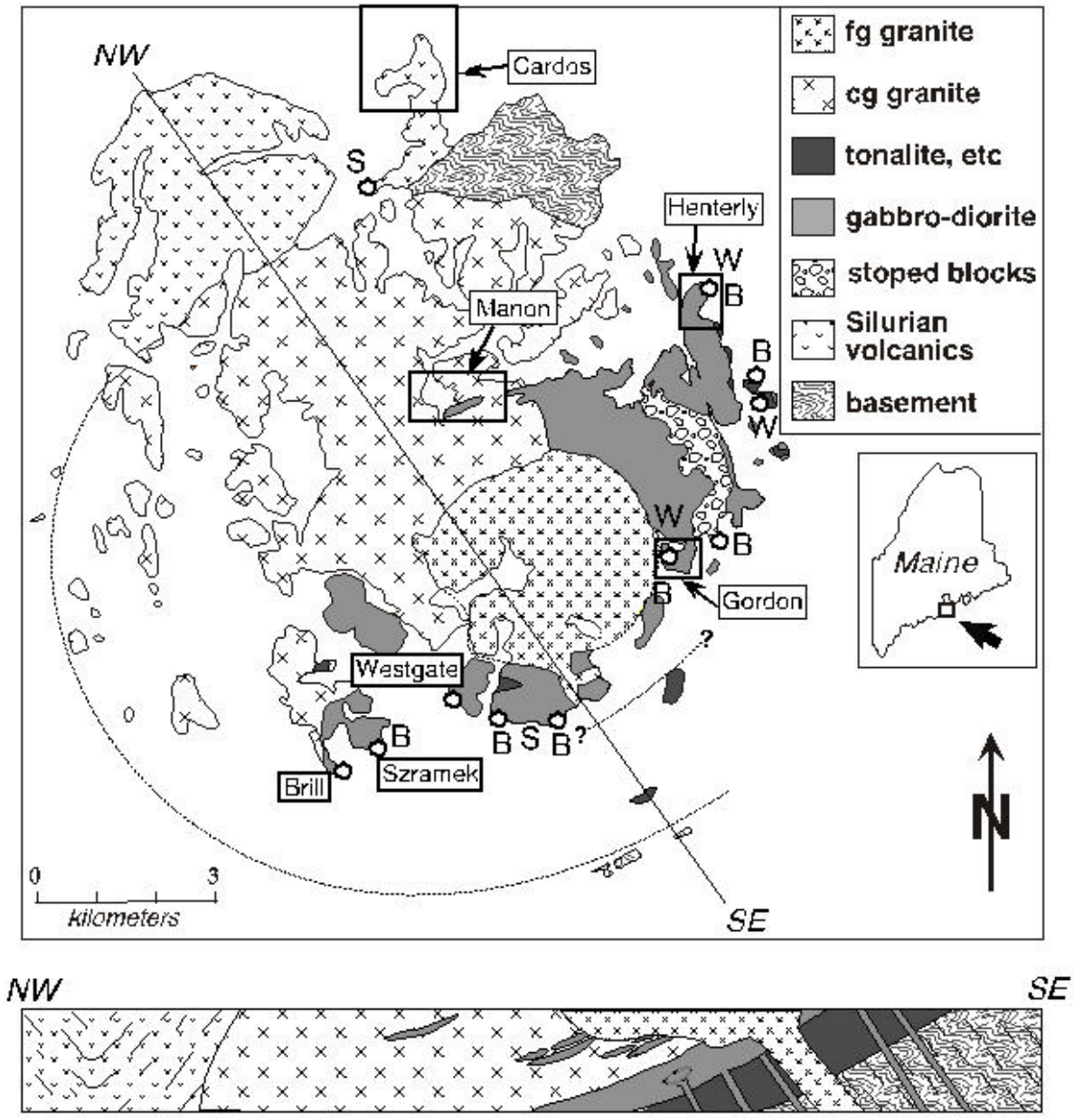

Fig. 1.Geologic map and cross-section of the Vinalhaven pluton, Penobscot Bay, Maine (modified after Gates, 2000). Locations of student projects are shown approximately. Nathan Brill, Lindsay Szramek, and Noah Westgate worked at several different locations most of which are identified by B, S, and W, respectively.