THE SILURIAN(?) CRANBERRY ISLAND VOLCANIC SERIES ON MT. DESERT ISLAND, MAINE.

Naomi Lubick
Department of Geology
Carleton College
Northfield, MN 55057

Introduction

This study is concerned with the petrology and geochemistry of the Cranberry Island Volcanic Series, which crops out on the Mount Desert Island and the Great and Little Cranberry Islands of eastern Maine. The geology of Mount Desert Island is dominated by the late-Silurian Cadillac Mountain intrusive complex, consisting of the Cadillac Mountain and Somesville granites and a gabbro-diorite unit. The complex was emplaced into country rock consisting of the Ellsworth Schist and the Bar Harbor formation (regularly bedded siltstones and sandstones with minor volcanics). The Cranberry Island Volcanic Series (CIVS) lies at the southern tip of the island and on the Great and Little Cranberry Islands, separated from the rocks of the Cadillac Mountain complex to the north by the Southwest Harbor Granite (SHG), a unit of probable Silurian age (Gilman and Chapman, 1988). The contacts between the CIVS and Bar Harbor formation are poor.

The CIVS is mainly a felsic, pyroclastic formation, which is older than the Cadillac Mountain complex. The areal extent of the complex is at maximum 13.5 m East-West by 6 m North-South. Gilman and Chapman (1988) divided the CIVS into three units ; only the two units that crop out on Mount Desert Island will be considered in this project (the third unit, on Great and Little Cranberry Islands to the south of Mount Desert Island, is being studied by Seaman, in preparation). The unit that will be referred to in this paper as the felsite unit has been documented as felsites, dacitic flows (Gilman and Chapman, 1988), and ash flow tuffs (Seaman, in preparation). The second unit has been referred to by Gilman and Chapman as crystal and lithic tuffs, deposited as ash falls, ash flows and possibly water-laid tuffs. This unit is evident on both Mount Desert Island and the Cranberry Islands. In addition, Seaman recognizes breccias, flow-banded rhyolites, and mafic dikes within this unit, which will be referred to as the tuff unit in this study.

The primary intent of this project is to characterize the felsite and tuff units of the CIVS on Mount Desert Island petrographically and chemically in order to assess their relationships and possibly constrain mode of emplacement.

Tectonic Background

The CIVS is part of a 250 km long volcanic terrane accreted to the North American continent prior to the Acadian Orogeny. The series can be correlated tentatively with the Castine volcanics of Pinobscot Bay and the Vinalhaven rhyolite to the southwest in the Ellsworth terrane, a so-called "tectonic province" (Seaman, in preparation). There are two different scenarios on how these terranes have been accreted: first, in a single tectonic event, i.e. the Acadian, the volcanics in the region were possibly accreted along with Avalonia to the North American continent (Zen, 1983). Second, West et al. (1992) imply that instead of several discrete tectonic events (i.e. the Tacanian, Acadian and Alleghanian), northern Appalachian orogeny was continuous throughout the Paleozoic.

Methods

Field work was carried out during June, 1993. Coastal areas provided the best access to the felsite and tuff units. Using the geologic map of Gilman and Chapman (1988) as a guide, a search was made to confirm contacts and other field characteristics. Traverses of the tuff unit outcrops below Seawall Pond and of the Bass Harbor-side (eastern) beaches on Lopaus Point documented clast occurrence. Documentation was made using a tape measure and pace-measurements, as well as estimates of clast-density. Clasts smaller than 2cm generally were not considered in estimates of average size; maximum size of a clast in each 5 meter area was also recorded.

Fifty-six samples representative of tuff and felsite were collected, of which twenty-four were chemically analyzed using X-ray fluorescence and thin-sectioned for petrographic studies. A sample from the vitrophyre on Lopaus Point is being dated by Sam Bowring (MIT), using U-Pb ages from zircons.

Field Relations

The felsite unit appears in the field as a uniform, pink, very fine to fine-grained granite. Auto-brecciated felsite was observed to the south of Kings Point in two small outcrops. The contact of the felsite unit and tuff unit to the south of Kings Point appeared as a breccia, which could in fact have been a brecciated mafic dike.

Most outcrops of the tuff unit are nonvessiculated vitrophyres and ash flows. The tuff unit contains both ash flow and air fall varieties, the latter sometimes appearing as a tuff breccia with clasts up to 1.5 meter (at Seawall Pond). Crystal clast density ranges from less than 5% to densely crystalline. The tuffs generally trend 70 to 80 degrees NE and dip steeply to the south; locally, shallow dips and chaotic

flow patterns are present. Along the Lopaus Point, over 100 meters of laminar flows are continuously bedded with occasional contorted flow patterns, and with occurrences of tension gashes. North of Seawall Point the flows trend to the northeast, projecting just north of the tuffs of Great Cranberry Island. Tuffs on the southern tip of Mt. Desert Island have been obliterated by younger aplitic granites (Devonian?).

I conducted two traverses in the tuff unit to measure clast size distribution. One was at the Seawall tuff and the second at the Lopaus Point (Figure 1). The traverse along the beach below Seawall Pond yielded immense variety in clast composition, ranging from light gray to very dark, very fine- to fine-grained light volcanics and seemingly mafic clasts. A majority of the Lopaus Point traverse crossed laminar flows without clasts; clastic zones contain pumice bombs and compacted lenses of pumice (fiamme), as well as clasts similar to those in the Seawall tuffs. There are several auto-breccias on Lopaus Point, of varying thickness, generally less than 5 m. One such breccia has lensoidal clasts that are 25 cm in length by 3 cm width; the matrix consists of smaller clasts. Clasts in both traverses were either tabular or equant (Zingg's classification, Fisher and Schminke, 1984) and angular to subangular. Clasts ranged in size from 1 mm to 1.5 m, and were on average 4 to 5 cm.

The largest clasts were deposited to the North in what Seaman has identified as the older portions of the tuff unit (personal communication). According to maximum clast sizes recorded, the largest pumice clasts and clasts present in airfall deposits indicate a distance around 5 km from the source vent [probably less, around 2 or 3 km] (Cas and Wright, 1986, p.283).

Petrography

Most tuff samples studied have flow structures; evidence of compaction is rare. Samples from the tuff unit vary in percent phenocrysts with vitrophyres having the lowest concentration (as few as 1%) and the tuff having the most (as much as 40%). Phenocrysts are mostly feldspar: Na-plagioclase (An15 in composition) and potassium feldspar (orthoclase). In the vitrophyric samples, the groundmass glass has devitrified and is now an extremely fine mixture of quartz and feldspars. Quartz phenocrysts are rare, and those in tuff unit samples are typically embayed.

Feldspars in the felsite samples are dominantly Na-plagioclase, but potassium feldspar (orthoclase) is also present. Rare quartz phenocrysts are embayed,. Micrographic quartz-feldspar intergrowths are common throughout the interior of the felsite, but are absent in samples taken nearer the contact with the tuff unit. Samples from the margin of the felsite body display an anhedral granular crystalline texture finer than samples from the center of the felsite body. This microcrystalline texture indicates a chilled margin, implying that the felsite intruded the tuff.

Geochemistry

The major-element data collected by XRF methods was graphed in order to classify the felsite and tuff units. These data show similarity between the two units and suggest that they are genetically related. The felsite and tuff units fall within the rhyolite, dacite and trachydacite fields of LeBas (1986). Content of SiO_2 ranges from 67-75 wt. %, with the felsite having distinctly higher average SiO_2 than the tuffs.

The felsites show much less chemical variation than the tuff samples. The felsites tend to show a negative trend for all major element oxides versus SiO_2, except K_2O. The scatter of the tuff unit is reasonable considering the possible inclusion of foreign clasts, mixing and sorting during emplacement. Weight % of SiO_2 decreases in the felsite samples from north to south, i.e. from the middle of the felsite body to its perimeter.

Geochemical analysis shows that the felsite and tuff are related, as most major element weight percents are very similar. The felsite intrudes the tuff, as shown by the textural relationships, and is therefore younger. Higher SiO_2 content in the felsite samples indicates it was perhaps more evolved from the parent magma than the tuff unit. Lower SiO_2 in the volcanics is consistent with their being older and less evolved. The range of SiO_2 in felsite samples could reflect fractionation within the parent magma chamber; as the edges of the intrusion crystallized, successive magma implaced would have been from a different zone of the parent magma source.

Conclusions

The felsite and tuff units of the CIVS are genetically related, and most samples are identified as rhyolites by major element chemistry. The felsite unit intrudes the tuff unit, according to micrographic textures. Using clasts as indicators, the ash flows and falls of the tuff were originally emplaced at a distance 5 to 10 km from the source vent, if not nearer.

References

Cas, R.A.F., and Wright, J.V., 1986. Volcanic Successions, Modern and Ancient: A geological approach to processes, products and successions. London, Allen and Unwin Ltd.

Fisher, R.V., and Schminke, H.-U., 1984. Pyroclastic Rocks. New York, Springer-Verlag.

Gilman, Richard A., and Chapman, Carleton A., 1988. Bedrock Geology of Mount Desert Island: A visitor's guide to the geology of Acadia National Park: Maine Geological Survey, Bulletin 38.

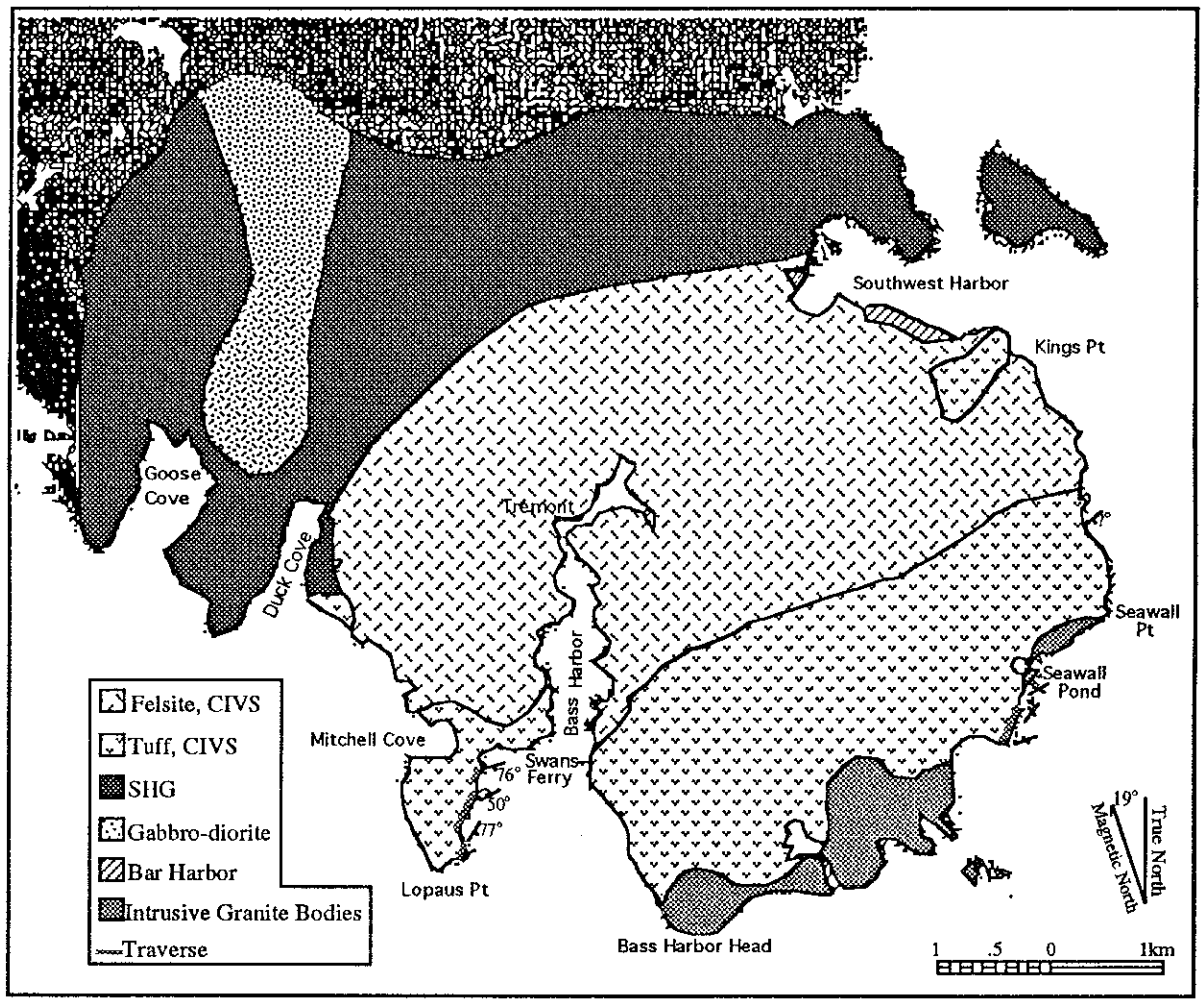
LeBas, M.J., Le Maitre,R.W., and Zanettin, B., 1986. A chemical classification of volcanic rocks based on the Total Alkali Silica [TAS] diagram: Journal of Petrology, Vol 27, p.745-750.

Seaman, Sheila, in preparation. (as well as personal communications)

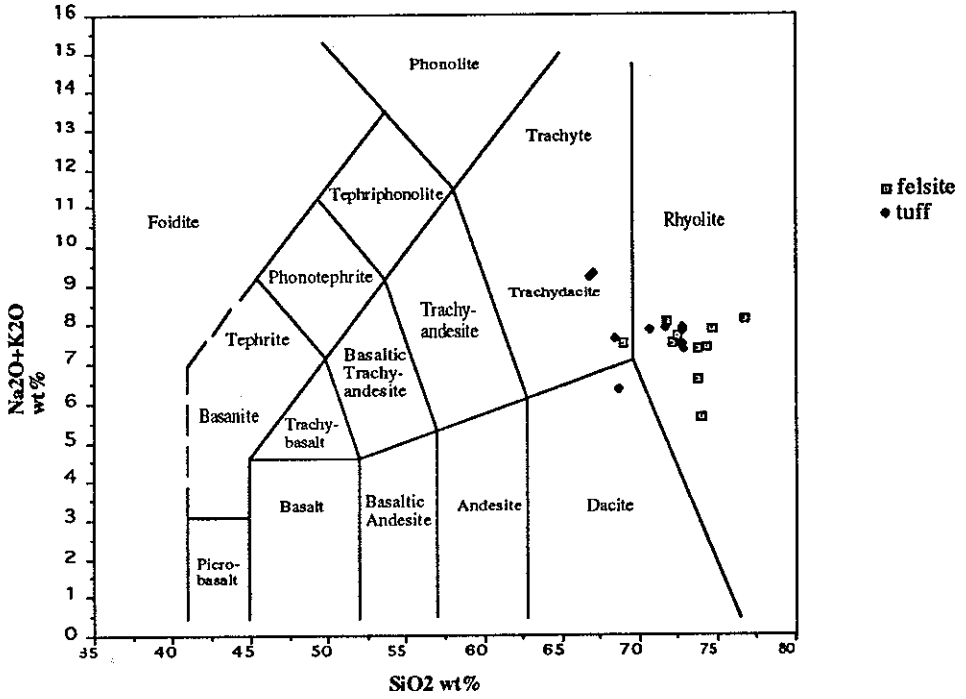
West, D.P., Jr., Ludman, Allan, and Lux, D.R., 1992. Silurian age for the Pocomoonshine Gabbro-Diorite, Southeastern Maine and its regional implications: Science, vol. 292, p.253-273.

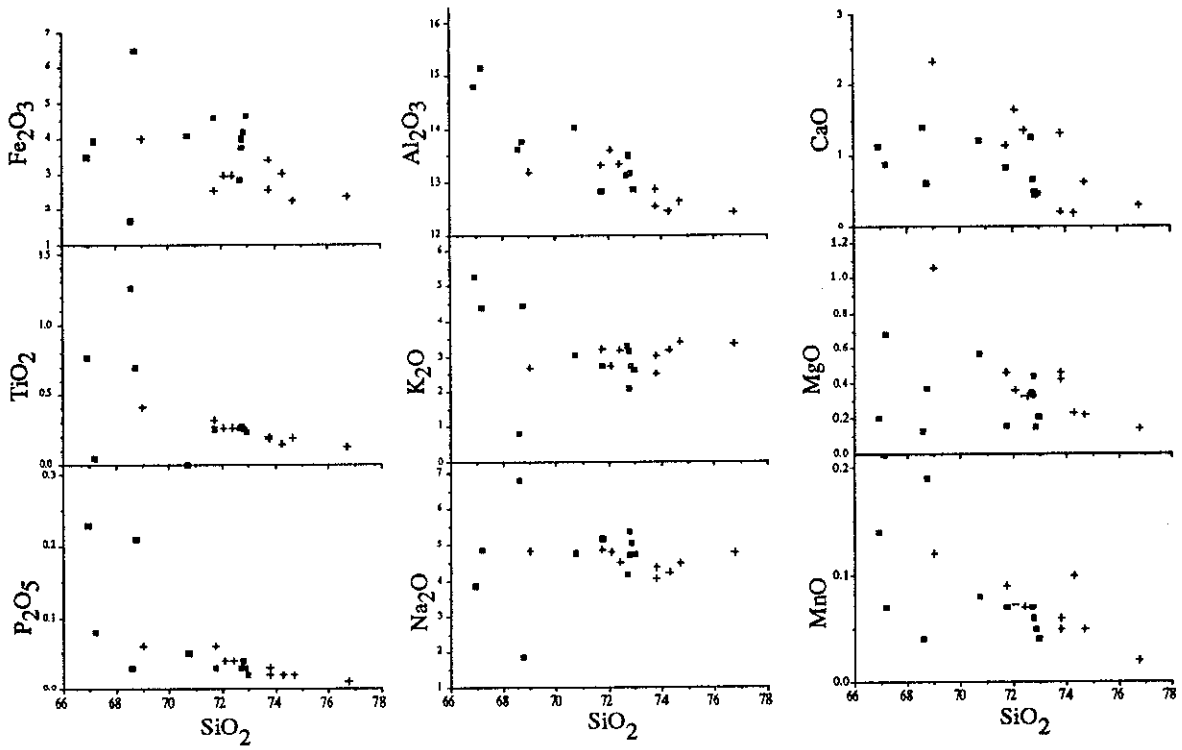
Zen, E-An, 1983, Exotic terranes in the New England Appalachians-limits, candidates, and ages: A speculative essay, *in* Hatcher, R.D., Jr., Williams, H., and Zietz, I., eds., Contributions to the Tectonics and Geophysics of Mountain Chains. Geological Society of America, Memoir 158, p.55-81.

Fig.1: The Cranberry Island Series, modified from Gilman and Chapman, 1988



Chemical Classification
after LeBas et al, 1986





SiO_2 wt. % vs. Oxides ■ tuff unit samples + felsite unit samples