The Metavolcanic Wall Rocks of the Gouldsboro Pluton: Dyer Neck and Vicinity, Maine

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Introduction:

The metavolcanic wall rocks of the Gouldsboro pluton, on Dyer Neck and vicinity in eastern Maine, are a part of the Coastal Volcanic Belt which runs from northeastern Massachusetts, along the coast of Maine, into New Brunswick. It contains primarily bimodal assemblages of lower Paleozoic volcanics. The rocks of this belt have attracted attention in recent years as they are part of a system of suspect terranes which are associated with the Appalachian Orogen. Previous studies of petrography, chemistry and stratigraphy have been made in order to suggest correlations along this belt and to constrain the tectonic setting of the accretion of these terranes. Large, well preserved sections of volcanics have been studied in Penobscot Bay (Pinnette and Osberg, 1989) and the Cranberry Islands (Seaman and others, in press) to the southwest, and the Eastport-Machias area (Gates and Moench, 1981) to the northeast. The intervening 130 kilometers, however, has received very little study, largely because later plutons of the Coastal Maine Magmatic Province have left very little of the wall rock exposed. No detailed work has been previously reported on the exposures at Dyer Neck and vicinity, but possibly correlative greenstones have been described at Flanders Bay, about 10 km to the west, by Gilman and Lash (1988).

The purpose of this study is to characterize these metavolcanic assemblages and to relate them to those studied elsewhere in the belt, in order to better understand the tectonic activity related to their emplacement.

Field Relations:

Samples of mafic and felsic metavolcanic rocks were taken and field relations noted at two primary sections, both lying on the west side of Dyer Neck, as well as at three other smaller exposures which occur as septa between the Gouldsboro granite and the rapakivi granite of Corea on Gouldsboro Neck and Dyer Neck.

The largest section occurs at Rogers Point, on the west side of Dyer Neck and extends across The Narrows to exposures on the east shore of Gouldsboro Neck, an area of approximately three square kilometers. It is the only section in the study which has been previously mapped, and it is large enough to appear on the geologic map of the State of Maine. To the west it is bounded by a fault, and consequently the exposures along the Gouldsboro Neck shoreline were heavly sheared and altered. Further from the sheared zone on the bar islands in The Narrows and in exposures on the beach at Rogers Point, some better preserved primary structures were visible in the form of discontinuous amygdular zones. The rocks have been deformed too much to reconstruct original layering, but these zones suggest a general dip to the south for the section. Further east across Rogers Point, the metabasalt is intruded by a fine to medium grained diorite. In this zone the rock has a variegated texture with hornblende-rimmed "eyes" of quartz and plagioclase which range from one to three centimeters across. Throughout the metabasalt there are epidotized blobs ranging in scale from ten to forty centimeters, and it has also been intruded by more than one generation of mafic and felsic dikes.

At the eastern end of the exposure the metabasalt is heavily brecciated over an area of several tens of meters by the intrusion of the Gouldsboro granite. The actual contact between the metabasalt and the Gouldsboro pluton is obscured by sand beaches, but there is a small exposure of polymict conglomerate between the two. This conglomerate may correlate with that described at Flanders Bay by Gilman and Lash (1988). The conglomerate at Flanders Bay was interpreted as marking the base of the Silurian Bar Harbor Formation which rests unconformably on greenstone.

About six kilometers south of Rogers Point, at Lobster Cove, is a roof pendant of metavolcanics within the Gouldsboro granite. This exposure extends for about 80 meters along the coast and dips to the south at 50°. It is composed of approximately 30 meters of basal pyroclastics containing flattened lithic fragments and fiamme, overlain by an equigranular felsic tuff, a layer of metabasalt, and capped by a felsic ash flow tuff.

Thin septa of felsic metavolcanics were also found at the contact between the Gouldsboro granite and the rapakivi granite of Corea at Shark Cove and Long Mill Cove on Gouldsboro Neck as well as at the same contact on the east side of Dyer Neck.

Petrography:

Thin sections were made of twenty-eight of the less altered samples for the purpose of petrographic analysis; however, thin section quality was still hampered by alteration, particularly in the metabasalts. Petrography revealed an amphibolite metamorphic grade for these sections, although the metabasalts in the Flanders Bay and Spectacle Island sections to the west and southwest were only of greenschist facies (Gilman and Lash, 1988).

The felsic volcanics from Lobster Cove are characterized by a recrystallized suhedral equant quartz groundmass with tabular biotite and plagioclase (An 25-40) aligned and concentrated in bands corresponding to drawn-out fiamme. Minor hornblende is also present in most sections. The metabasalt from the top of this package was less altered than the sections from Rogers Point and showed some clearer structure. It contained hornblende, plagioclase and some biotite with a weak metamorphic foliation in the tabular groundmass. Some plagioclase is clustered in bundles of larger grains that appear to be remnants of an original texture, with the foliation bent around them.

The Rogers Point locality yielded only altered metabasalt with plagioclase altered significantly to clays. However, it was possible to see a weak metamorphic fabric. These rocks are consistently composed of hornblende with lesser amounts of plagioclase and some quartz, the latter particularly filling amygdules or fractures. One section shows particularly well the original amygdular texture, which has been deformed to give ellipsoidal cross sections. The petrography of these sections is very similar to that of the reference basalts sampled from along U.S. Route 1, west of West Gouldsboro, in the area previously studied by Gilman and Lash (1988), with the primary difference being less alteration in those samples.

The diorite from Rogers Point retains some original structure although the groundmass contains thoroughly recrystallized quartz. The mafic minerals consist of optically continous clumps of chlorite, divided by significant quartz and plagioclase inclusions.

Geochemistry:

Fourteen of the least altered samples were prepared for geochemical analysis; they were chosen to provide an even representation of the study area. Four samples were sent to Oregon State University for INAA analysis, and all were analyzed for major element oxides by XRF at the University of Massachusetts. Trace element XRF analysis was performed on all fourteen at Franklin and Marshall College.

When plotted on a Total Alkalis vs. Silica diagram along with samples from the other studies previously cited along the Coastal Volcanic Belt, my samples fell along the same calc-alkaline trend with a strong bimodal distribution. Excluding the three samples that plotted in the andesite field (a diorite sample and two amygdaloidal basalt samples with late quartz filling fractures and amygdules) all samples fell in the basalt or the rhyolite field with a silica gap from about 52 to 72 percent. (Figure 1)

When plotted on a Ti-Zr-Y Pearce and Cann discriminant diagram, trace element data show the basalts falling in both the Calc-Alkaline Basalt and the Mid Ocean Ridge Basalt fields. (Figure 2) When the mafic samples are plotted on a spider diagram normalized to MORB, enrichments in LIL elements (Sr, K, Rb, Ba, and Th) are clear, while relative depletion in the "primitive" elements Sc, Cr and Ni possibly indicates prior fractionation of mafic phases. (Figure 3) A separate plot of the felsic samples normalized to MORB reveals the expected enrichment in LIL elements and depletions in Sc, Cr and Ni, as well as depletions in P and Ti indicating apatite and ilmenite fractionation, respectively. (Figure 4) Limited REE data on four samples shows a relatively flat profile with only minor fractionation between LREE's and HREE's. REE enrichment is about twenty times chondrite for the mafic samples. The felsic tuff is somewhat more fractionated, with LREE's as high as 100 times chondrite.

Discussion:

The nature and timing of the collision of Avalonia and North America during the Acadian orogeny is complex and forms the subject of much debate among geologists. A current theory propounded by West and others (1992) involves the closing of an ocean represented by the Fredericton Trough in which west dipping subduction was occuring under the North American plate while east dipping subduction was occuring under Avalonia. (Bradley, 1983) While Bradley suggests that the chemistry of these rocks supported an island arc magmatic setting, the overwhelming bimodal character of volcanism and magmatism seems more consistent with a model involving extensional tectonics. Several authors in Smellie (1995) suggest that such extensional regimes may be common at consuming plate margins.

The data presented here, especially the bimodal distribution of the rocks along the calc-alkaline trend, support the notion of a rifting environment related to subduction beneath Avalonia. The trace element data show that the basalts are somewhat contaminated by the lighter elements and that the felsic units are significantly more evolved. A rift induced upwelling of basaltic magma possibly provided the heat source to melt the crust producing the felsic volcanics and contaminating the basalts.

References:

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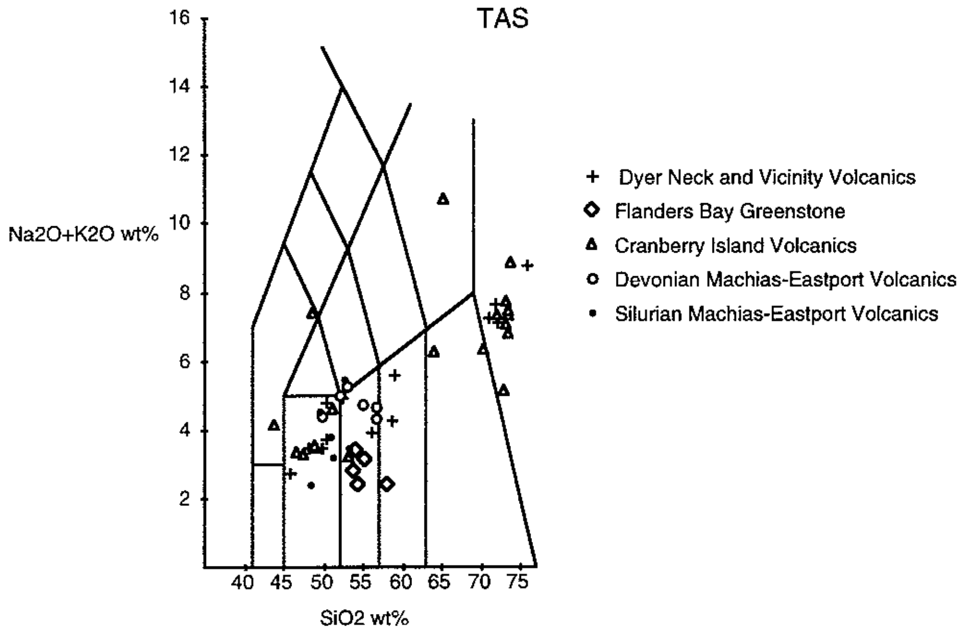

Figure 1: Total Alkalis vs. Silica plot showing bimodal distribution of volcanics in the Coastal Volcanics Belt

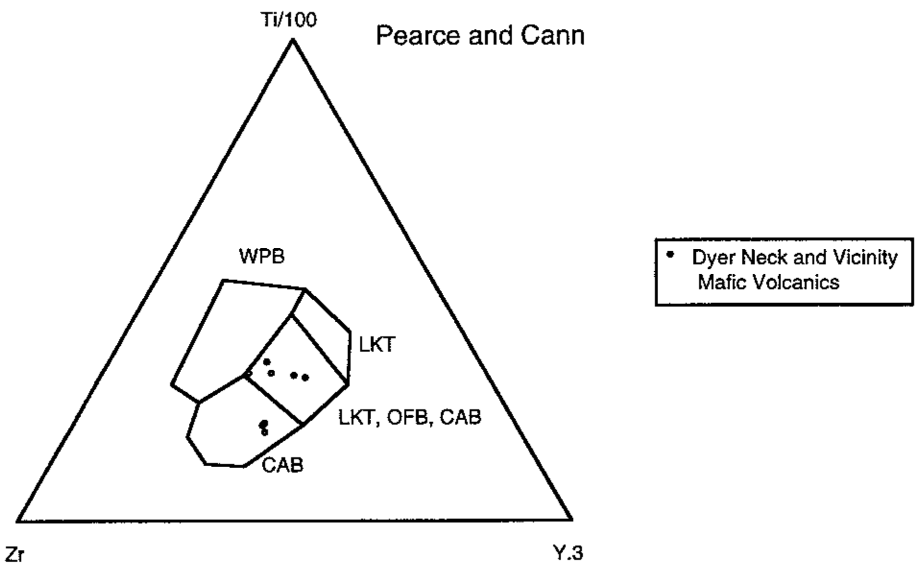

Figure 2: Pearce and Cann Discrimination diagram showing mafic volcanics in the Calc-Alkaline-Basalt to Mid Ocean Ridge Basalt fields

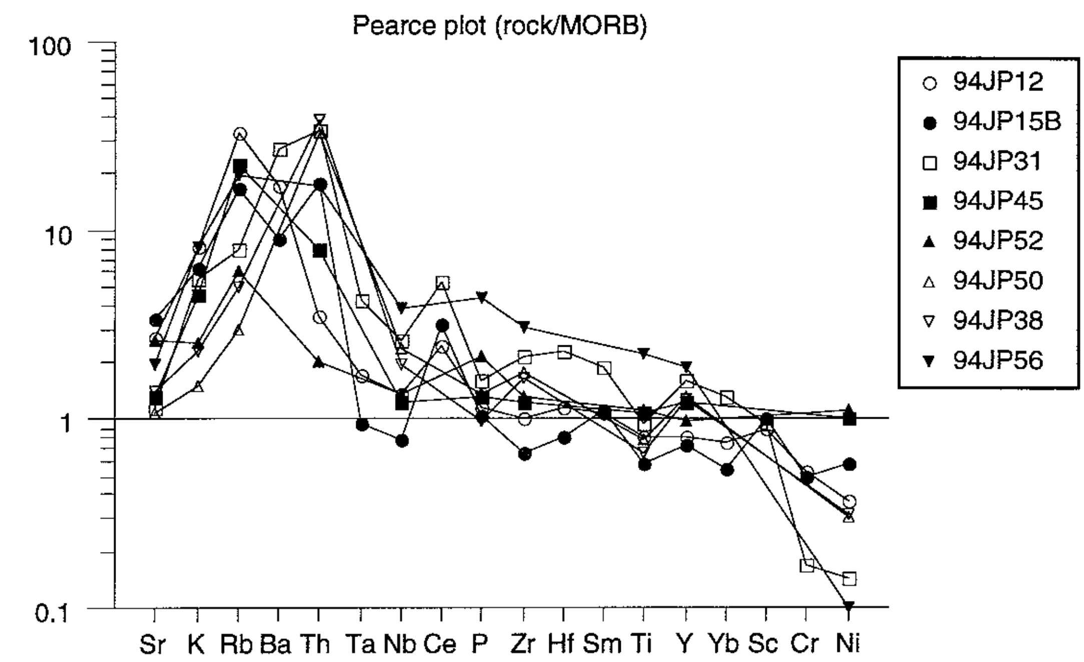

Figure 3: Spider diagram showing mafic samples normalized to MORB

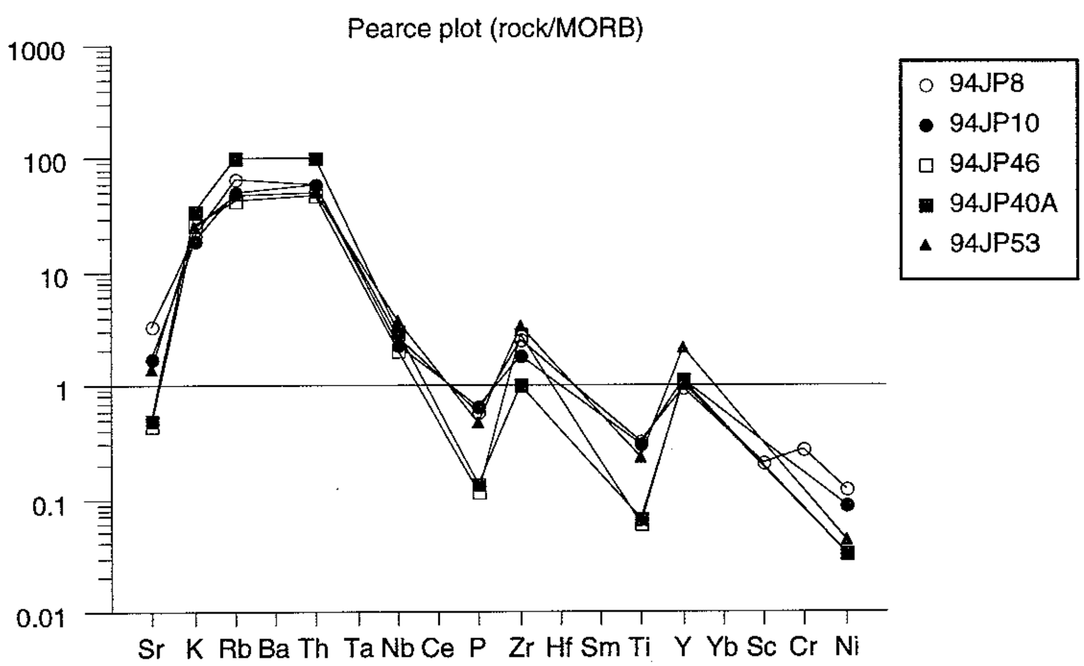

Figure 4: Spider diagram showing felsic samples normalized to MORB