Preliminary Studies of Five Mesozoic Stocks in the Newfield 15' Quadrangle, Maine

Richard A. Gilman
State University of New York
College at Fredonia
Fredonia, New York 14063

ABSTRACT

Five discordant plutons ranging in composition from quartz diorite to granite and alkaline syenite are exposed in the Newfield, Maine 15’ quadrangle. Two of the five plutons contain xenoliths of volcanic or hypabyssal rocks. Only the Abbott Mountain stock shows an internal complexity that is suggestive of magmatic differentiation; each of the other four stocks consist of a single phaneritic rock type. Where exposed, contacts are moderate-to-steep, abrupt, and marked by brecciation of the country rock and by quartz enrichment of the pluton. Emplacement of the plutons did not affect the orientation of the schistosity in the adjacent country rocks, thus suggesting emplacement by fracturing and stoping. Three of the plutons contain syenites that carry small amounts of Na-rich pyroxene and fayalite as well as occasional feldspathoids.

The five plutons are part of a band of Mesozoic stocks (the White Mountain Magma Series of Billings, 1956) that extends from the Maine coast through central and northern New Hampshire. This has recently been subdivided by McHone and Butler (1984), who include the Abbott Mountain stock within their coastal New England province. Chemical analyses of the Abbott Mountain stock show minor chemical differences between the three recognized varieties of syenite, and suggest that the leucocratic syenite may be a differentiate of the enclosing fayalite syenite. The stock has been dated at 221±8 Ma (Foland and Faul, 1977).

INTRODUCTION

In recent years several studies have provided new data on the ages of a group of Mesozoic alkalic plutons exposed in a belt extending from southern Maine to the Monteregian Hills of Quebec, and have led to models for incorporating these bodies into the plate tectonic scheme (McHone and Butler, 1984; Crough, 1981; McHone, 1981; Foland and Faul, 1977). While all of the plutons are considered to be post-tectonic in the sense that none show the effects of Paleozoic tectonism and metamorphism, the range in published ages, from 240 Ma to 85 Ma, remains wide. Some authors have attempted to fit this age range to the drifting of the North American plate over one or more hot spots (Crough, 1981; Morgan, 1981), while others relate the magmatism to leaky transform faults (Uchupi et al., 1970) or extensional fracturing (McHone and Butler, 1984). The problem of origin remains unresolved.

The plutons have been generally referred to as members of the White Mountain Magma Series (Billings, 1956). More recently, however, McHone and Butler (1984) have suggested a further subdivision of these plutons based on age, distribution, and petrologic character. Of particular interest here is their proposed separation of plutons in southern Maine -- their coastal New England province -- from the main group of plutons belonging to the White Mountain Magma Series province in New Hampshire. The two proposed provinces abut approximately along the Maine/New Hampshire border (McHone and Butler, 1984, Fig. 1) in the vicinity of the Abbott Mountain stock, one of the five small plutons exposed in the Newfield quadrangle (Gilman, 1978, 1983). The purpose of this paper is to document the field and petrographic character of these plutons and to present preliminary chemical studies of one of them (Abbott
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Figure 1. Regional setting of the five plutons studied in the Newfield 15' quadrangle, Maine.

Mtn.) in the hope that it will generate interest in additional investigations of a more detailed geochemical/petrologic nature.

REGIONAL SETTING

The five plutons are distributed along a more-or-less north-south line in the center of the Newfield quadrangle (Fig. 1). The stocks intrude a host rock consisting of granodiorite and sillimanite-grade schist and migmatite of the Rindgemere Formation (Silurian-Devonian). They vary in composition from quartz diorite to alkali syenite and granite, and some have associated aphanitic (volcanic?) members. The stocks are postkinematic, showing no effects of metamorphic overprinting, and are sharply discordant with respect to the structural trends of the host rock near their contacts. The stocks have been given appropriate geographic names; from north to south they are the Randall Mountain, Symmes Pond, Picket Mountain, Abbott Mountain, and Acton stocks.

RANDALL MOUNTAIN STOCK

Randall Mountain is located in the north-central part of the Newfield quadrangle between the villages of South Parsonsfield and East Parsonsfield (Fig. 2). The pluton is easily accessible on all sides by means of blacktop and gravel roads. The area is completely forested except for bald ledges at the summit of Randall Mountain. Nevertheless, there are good exposures on the steep south and southeast slopes and on the ridge crests, but north-facing slopes are more gentle and outcrops there are scarce.

The stock consists of (1) fine- to medium-grained, gray to brown syenites, and (2) gray, fragmental, trachyte porphyry.

Syenite is the most abundant rock type. Hornblende and/or biotite are visible in hand specimen while pyroxene was recognized only in thin section. The rocks vary from a porphyritic phase carrying up to 30% phenocrysts (dominantly feldspar of 2.0 to 4.0 mm length) set in a fine-grained groundmass, to an equigranular, medium-grained phase with feldspar grains averaging 3.0 to 5.0 mm with a maximum length of 10.0 mm. This textural variation does not appear to be mappable and the change from one type to another is gradual. Mafic minerals are conspicuous, but never amount to more than 5% of the rock.

Neither igneous lamination nor other primary structures were found in outcrop, although loose blocks on the ridge northeast of the summit of Randall Mountain show a well developed parallel arrangement of feldspar crystals. Variations of the syenite may be seen in a traverse up the south side of the mountain; the syenite at the summit is an equigranular, medium-grained type.

The syenites have been subdivided into porphyritic and equigranular types for thin section descriptions. The equigranular type is characterized by 2.0 to 5.0 mm, subhedral, interlocking orthoclase laths with minor fine-grained interstitial feldspar. Orthoclase usually constitutes more than 95% of the rock. It is always dusted by alteration products, commonly shows Carlsbad twinning, and consists of either homogeneous orthoclase or patchy microperthite. Interstitial nepheline and albite were found in one specimen each. Mafic minerals consist of biotite, clusters of fine-grained green hornblende, and pyroxene. The pyroxene occurs as euhedral to subhedral, 0.5 to 1.0 mm grains which in some cases show deep green colors indicative of aegirine-augite, and is commonly altered in part to hornblende. Of the accessory minerals, sphenite is particularly evident, occurring in large, subhedral grains.

In thin section the porphyritic syenite shows 3.0 to 5.0 mm phenocrysts primarily of K-feldspar with lesser amounts of plagioclase, pyroxene, hornblende and biotite, set in a groundmass of feldspar, mafics, and accessory minerals ranging from 0.2 to 0.8 mm in diameter. Phenocrysts constitute from 5 to 30% of the rock. K-feldspar phenocrysts are usually subhedral and display an irregular, microperthitic intergrowth over the entire grain. Clinopyroxene phenocrysts are pale green and show faint pleochroism. The groundmass consists primarily of feldspar laths, frequently displaying a weak trachytic texture. Hornblende, augite, biotite, and accessories complete the groundmass. Sphenite is again the most abundant accessory. Two of the specimens studied contain nepheline as either phenocrysts...
Mesozoic stocks in the Newfield 15’ quadrangle, Maine

Figure 2. Location and composition of the Randall Mountain stock.

In thin section the phenocrysts are predominantly anhedral to subhedral orthoclase with minor perthitic intergrowths. Plagioclase phenocrysts were observed in a few samples, but always subordinate to orthoclase. Other phenocrysts include clinopyroxene and biotite. Clusters of subhedral, interlocking orthoclase grains represent either compound phenocrysts or fragments of an early phase of the syenite. Rock fragments consist of trachyte commonly showing well developed flow structure. The groundmass consists of subparallel laths of feldspar that sometimes wrap around rock fragments and phenocrysts. Augite, hornblende, biotite, and accessories are also present.

Dikes of fragmental trachyte porphyry are similar to the rocks just described, the major microscopic difference being the tendency for the groundmass to be allotriomorphic-granular rather than trachytic. Rock fragments include trachyte and syenite. A small dike cutting the syenite on the summit of Randall Mountain consists of 0.2 mm to 0.4 mm laths of subhedral orthoclase with a homogeneous pilitaxitic texture. A pink felsite dike in the valley east of the summit is distinctly different from others in the area. It consists of 0.2 mm laths of plagioclase with minor interstitial quartz in a groundmass showing a well developed trachytic texture.

The contact of the syenite with the country rock is exposed on the west side of Randall Mountain in a zone approximately 30 meters wide consisting of angular blocks of schist enclosed in pinkish, quartz-bearing syenite. The contact dips steeply to the northwest. Elsewhere the contact is not exposed, but the limits of the body are fairly well delineated by exposures of the surrounding country rocks. The contact is discordant, there being no deflection of the regional schistosity.

ABBOTT MOUNTAIN STOCK

Abbott Mountain lies just east of the village of North Shapleigh (Fig. 3). Exposures are excellent along the tops of ridges and are good on the steeper slopes, but lower slopes and the surrounding areas are generally covered by thick glacial deposits. Fresh samples are frequently difficult to obtain due to the rounded, weathered nature of the exposures; bald outcrops are often covered with thin sheets of crumbled rock. The area is accessible by dirt road on the north side, and by discontinued roads on the south and west sides and through the center.

The stock consists predominantly of a brown to gray, coarse-grained syenite with fine-grained diorite dikes at the margin. The coarse-grained syenite has been subdivided into three varieties on the basis of microscopic study. The most widespread type contains fayalite and aegirine-augite as minor constituents. A second variety is similar to this, but in addition contains minor amounts of quartz. The third variety is nearly devoid of mafic minerals.

The fayalite syenite (ops on Fig. 3) contains from 90 to 95% euhedral-to-subhedral, randomly arranged feldspar laths averaging 5.0 mm in length with maximum lengths of 10.0 mm. The
Abbott Mountain stock

Is  Leucocratic syenite
ops  Olivine-pyroxene syenite
opqs  Olivine-pyroxene-quartz syenite
d  Diorite dike
Dr  Rindgemere Formation

Strike and dip of foliation
Exposed contact
Covered contact

Figure 3. Location and composition of the Abbott Mountain stock.

feldspar is dominantly orthoclase or microcline microperthite with patches and veins of albite distributed either uniformly throughout the grain or restricted to grain margins. Pyroxene constitutes from 2 to 7% of the rock and usually occurs in 0.5 to 2.0 mm euhedral-to-subhedral grains, commonly with hornblende alteration. The pyroxene is a darker green than common augite, suggesting aegirine-augite, but pleochroism is faint or nonexistent. Fayalite (sign (-), 2V approximately 40°) constitutes up to 3% of the rock and is found as 0.5 to 2.0 mm equant, anhedral grains that are partially altered along fractures to red iddingsite and a yellowish serpentine. In some grains the original olivine has been completely replaced. Biotite, apatite, zircon, and opaques complete the assemblage. This variety occurs in the east, south, and west parts of the area, including Abbott Mountain where there are abundant exposures.

The quartz syenite (opqs on Fig. 3) contains minor interstitial quartz; otherwise it is similar to the fayalite syenite. Orthoclase and microcline microperthite constitute 85 to 95% of the rock occurring as subhedral grains ranging from 4.0 to 8.0 mm in length. Grains of medium green, non-pleochroic aegirine-augite are usually subhedral and average 1.0 mm in diameter; some have been totally altered to secondary minerals. Quartz varies in amounts from a trace to 8% and occurs as anhedral grains (less than 0.5 mm) in the interstices between feldspar laths. Relatively large (up to 0.5 mm) grains of euhedral zircon are also found in this variety. Biotite, apatite, and opaques complete the assemblage. This variety has been found only in the contact zones of the stock and appears to form a nearly continuous shell between the country rock and the syenite of the interior.

The leucocratic syenite contains feldspar as the only essential mineral, with mafic and accessory minerals never constituting more than one or two percent of the rock. The feldspar consists of euhedral to subhedral grains ranging from 4.0 to 8.0 mm long. Both microperthite and antiperthite are present in various ratios, but antiperthite is frequently the more abundant. The K-feldspar is commonly clear in the center of the grains and perthitic at the margins; microcline twinning is sometimes evident. The antiperthite consists of albite showing extremely thin twin lamellae and patches of K-feldspar. Accessory minerals are hornblende, zircon, and opaques. This variety is found in the north-central part of the stock, but its boundaries and contact relations are not well known. One sample from the margin carries small amounts of aegirine-augite and fayalite suggesting that it is gradational into the fayalite syenite.

Fine-grained (0.1 to 1.0 mm) diorite consists of approximately equal amounts of weakly zoned, intermediate plagioclase (An35-50) and mafic grains arranged in an intergranular texture. Augite constitutes about 35 percent of the rock and usually occurs as subhedral interstitial grains, but occasionally is found in larger, poikilitic grains. Biotite occurs in small, red-brown irregular plates and constitutes 5 to 10% of the rock. Brown hornblende is occasionally associated with augite. Accessories are apatite and opaques. This lithology has been found in several localities at the margin of the stock where it occurs as brown-weathering dikes that cut the country rock. Inclusions of the diorite have been found enclosed in the border phase of the syenite.

Aplitic dikes cut the syenite and consist of stubby, euhedral to subhedral phenocrysts of orthoclase (1.0 to 2.0 mm) embedded in a fine-grained (0.2 mm) groundmass of quartz and feldspar. Riebeckite and biotite are present in small amounts.

Field observations and petrographic study demonstrate a consistent pattern in the distribution of the major rock types of the stock. The diorite is only found at the margin of the stock as dikes cutting the country rock. These are isolated intrusions rather than a continuous body such as a ring dike. Fracturing and
dike emplacement may have been extensive in the area now occupied by the syenite. The dikes may also extend farther out into the country rock, but exposures are limited and they have not been found more than a few tens of meters from the stock margin.

The quartz-bearing phase of the syenite has been found only at the margin of the stock at several locations. Because the rock was not recognized as a separate type during field mapping, no attempt was made to establish the continuity of this type around the entire stock. The massive, coarse-grained rock, however, probably forms a marginal phase about a hundred meters wide around most of the body except along the northern edge.

The fayalite syenite constitutes the main body of the stock on the west, south, and east sides. The leucocratic syenite is found in the north-central part of the stock. Sampling was not specifically planned to determine its extent because distinctive microfeatures of this unit were not recognized in the field. One sample, apparently representing the margin of this unit from the ridge northwest of Abbott Mountain, has a mineral assemblage intermediate between the leucocratic syenite and the fayalite syenite. The contact, therefore, has been drawn through this location; elsewhere it has been drawn separating known exposures of the two rock types based on microscopic study.

The relative ages of the rock units are defined on the basis of cross-cutting relations, inclusions, and inferred petrogenetic trends. The diorite dikes are clearly the oldest phase of intrusive activity. These cut the schist and pegmatite country rock and are in turn cut, brecciated, and included in the syenite. No indications of the relative ages of the quartz syenite and the fayalite syenite were observed. Both rocks are medium-to coarse-grained and it is possible that their contact is gradational. Likewise, there is evidence of a transitional contact between the fayalite syenite and the leucocratic syenite. The decrease in mafic constituents of the leucocratic syenite may reflect a later stage of differentiation, thus suggesting a younger age relative to the fayalite syenite. Riebeckite-bearing aplitic dikes are younger than the fayalite syenite, but are of unknown age relative to the leucocratic syenite.

The attitude of the contact with the country rock is well displayed on several of the ridges. On Abbott Mountain the contact can be followed along the southeast side nearly to the summit. The outcrop pattern indicates that the contact dips southeastward. Similar outcrop patterns are found at several localities around the margin of the stock; on the north side the contact dips northward at as little as 30°, but on Sugarloaf Mountain the contact is nearly vertical. The overall shape of the contact is that of a dome with dips ranging from moderate (30°) to nearly vertical, the former predominating.

The stock is discordant with respect to the foliation in the surrounding schist. This is best shown along the northeastern margin where the schistosity strikes uniformly northwestward with a westerly dip. There has been no reorientation of the schistosity as a result of the intrusion of the stock.

Foland and Faul (1977) obtained a K/Ar date of 221±8 Ma for the fayalite syenite. Earlier work by Christopher (1969) using apatite fission-track geochronology gave an age of 119 Ma. That date is now interpreted as an unroofing date rather than a crystallization age (Foland and Faul, 1977).

Chemical analyses of eight samples from the Abbott Mountain stock are given in Table 1. It is evident that the three varieties of syenite are similar chemically. However, of the three, the leucocratic syenite is considerably lower in CaO and MgO, and is slightly higher in Na2O. The increased abundance of free quartz at the margin of the stock is not clearly reflected in the variations in chemistry. Thus no major SiO2 contamination by the country rock is apparent. However, norm calculations (Table 2) show a greater than threefold increase in quartz in the border phase. Normative feldspar compositions are nearly constant throughout the body with only a slight increase in albite toward the leucocratic syenite, and an accompanying decrease in orthoclase and anorthite. Considering the trace elements, only the leucocratic syenite shows any appreciable difference from the other syenites in that Rb, Zr, and Nb are higher, and Sr and Ba are lower.

**SYMMES POND STOCK**

The Symmes Pond stock lies just east of Symmes Pond (Fig. 4). Its margins are poorly defined, but neighboring outcrops of schist and granite limit the size to approximately that shown on the map. A breccia zone can be observed on the south side of Hall Road where it crosses the southwest side of the stock. The stock consists of green-brown, coarse-grained syenite containing fragments of foliated granodiorite country rock. The syenite contains small amounts of sulfides including molybdenite and has been the site of minor prospecting in past years. In thin section the rock consists of 95% microperthite and about 2 to 3% each of fayalite and clinoxyroxene. The fayalite is partially altered to serpentine and occurs as 1.0 mm equant grains. The clinoxyroxene is medium green and non-plagioclase, possibly an aegirine-augite. The petrographic and mineralogical character of this syenite is similar to the fayalite syenite of the Abbott Mountain stock. Dikes of tan trachyte are found cutting the country rock on the hill northeast of the stock.

**PICTURE MOUNTAIN STOCK**

The Picket Mountain stock lies just south and west of the village of Newfield (Fig. 4). Outcrops are limited to ridges on Picket, Knox, and Zekes Mountains and in the Little Ossipee River at Newfield. The contact can be established within a few meters on the west slope of the small hill east of Picket Mountain where the granite is in contact with pegmatite and foliated granodiorite.

The stock consists of a homogeneous gray-brown, medium-grained, equigranular to subporphyritic granite. The mafic minerals are biotite and hornblende. The feldspar is dominantly
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### TABLE 1. WHOLE ROCK CHEMICAL ANALYSES: ABBOTT MOUNTAIN

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XRF analyses by X-RAY ASSAY LAB. LTD., Don Mills, Ontario.
* Total iron as Fe₂O₃.

### TABLE 2. CIPW NORMS: ABBOTT MOUNTAIN

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Note: Calculations used Fe₂O₃/FeO = 2

- K-feldspar, sometimes present as phenocrysts, and chalky-weathering plagioclase. Quartz is visible in all samples.
- Thin section study shows that the rock is comprised of about 25% quartz, 50% microperthite, 20% plagioclase, and 5% mafics. Quartz ranges in size from tiny interstitial grains up to grains 3.0 mm in diameter. Microperthite phenocrysts are up to 5.0 mm long, show Carlsbad twinning, and a vein-type perthitic intergrowth. Plagioclase is restricted to small (0.5 mm) subhedral grains in the groundmass. Biotite and hornblende are ragged. Hornblende is less abundant than biotite and is often altered to matted biotite.

### ACTON STOCK

The Acton stock is a small body of quartz diorite located on the east side of Grant Road approximately midway between Acton and South Acton (Fig. 5). Part of the area is an apple orchard and therefore is easily accessible. A few exposures are...
Mesozoic stocks in the Newfield 15' quadrangle, Maine

Picket Mountain and Symmes Pond stocks

s  Syenite
gr  Biotite-hornblende granite
gdr  Foliated granodiorite

Exposed contact

Covered contact

Figure 4. Location and composition of the Symmes Pond and Picket Mountain stocks.

Two rock units are present: medium-grained, gray-weathering quartz diorite, and dark gray porphyritic and fragmental andesite. The contact between the two units is not exposed but, based on the absence of quartz diorite fragments in the fragmental andesite, it is tentatively concluded that the quartz diorite is the younger.

The medium- to coarse-grained, gray quartz diorite constitutes most of the body. Igneous laminations are evident in a few exposures. In thin section the rock consists of approximately 80% plagioclase, 15% pyroxene, and 5% opaque minerals, apatite, and quartz. The plagioclase is occasionally strongly zoned, but unzoned grains (An90) are abundant. The grains are subhedral with interpenetrating grain margins and may be surrounded by finer-grained, anhedral plagioclase. Grains average about 4.0 mm, but are as large as 8.0 mm long. Orthopyroxene and clinopyroxene are subhedral, average 1.0 mm in diameter, and are partially altered to fibrous amphibole and biotite. Interstitial quartz is present in minor amounts. A fine-grained border phase is exposed along the west margin and is sometimes the host of a breccia containing fragments of hornfelsed schist. Small dikes of tan aplite cut the medium-grained quartz diorite.

Dark gray, porphyritic and fragmental andesite constitutes the northern part of the body, but the contact with the country rock has not been found. The rock is massive and has abundant phenocrysts of light gray-weathering plagioclase and small, angular fragments of dark, aphanitic rock types that are seen most clearly on weathered surfaces. In thin section the rock consists of 20% plagioclase phenocrysts set in a microcrystalline groundmass of plagioclase, biotite, and opaques. In some cases the plagioclase phenocrysts appear to be fragments of phenocrysts having sharp but irregular edges. At one location a

Figure 5. Location and composition of the Acton stock.
10 cm dike of lighter colored fragmental rock cuts the andesite. The fragments are usually less than 3 cm in diameter, subangular, and consist of various aphanitic rocks and schist. The fragments are set in a matrix of microcrystalline biotite, feldspar, and quartz. The andesite is also cut by a dike of tan felsite.

**SUMMARY AND PETROLOGIC IMPLICATIONS**

The characteristics of the five plutons along with petrologic implications can be summarized as follows:

1. All the stocks are post-tectonic in that none show overprinting of tectonism or metamorphism. In the past they have been considered members of the White Mountain Magma Series, but recently McHone and Butler (1984) have separated the Abbott Mountain stock from the series on the basis of radiometric age (221 ± 8 Ma; Foland and Faul, 1977) to include it with an older igneous province they call the coastal New England province. While none of the other four plutons of this study have been dated, neighboring plutons of known ages are either Early Jurassic or Early Cretaceous (Foland et al., 1971; Foland and Faul, 1977).

2. The most abundant rock type is alkali syenite that in many cases carries Na-rich pyroxene and fayalite, and in a few instances includes nepheline and sodalite. Quartz diorite and granite are present in one stock each.

3. With the possible exception of the Abbott Mountain stock there is no evidence of magmatic differentiation. Each of the other stocks consists of a single phaneritic rock type that may show localized textural variations, but is mineralogically homogeneous. The Abbott Mountain stock, on the other hand, shows a distribution of fayalite syenite and leucocratic syenite that suggests differentiation may have taken place. Chemical analyses of the Abbott Mountain stock indicate that differences exist between the three varieties of syenite, but that detailed geochemical studies are needed to further explore the effects, if any, of magmatic differentiation.

4. Two of the stocks (Acton and Randall Mountain) include aphanitic rocks that predate the coarse-grained members. In both cases these volcanic, or hypabyssal, rocks contain abundant lithic fragments of other aphanitic igneous lithologies. This is similar to the pattern found in the Burnt Meadow Mountain complex a few miles to the north, (Gilman, 1977, 1979) as well as in other White Mountain Magma Series plutons (Billings, 1956).

5. The discordant nature of the plutons suggest fracturing and stopping as the emplacement mechanism. Where the margins of the plutons are exposed on Randall and Abbott mountains, the contacts dip steeply-to-moderately outward from the center of the pluton. This suggests that in these two cases the present erosion surface may be close to the top of domal-shaped intrusions.

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**REFERENCES CITED**


