Preliminary Bedrock Geologic Map of the Marlborough Quadrangle, Middlesex and Worcester Counties, Massachusetts

by

J. Christopher Hepburn and Richard G. Di Nitlo

U.S. Geological Survey Open File Report 78-222

Note: We call the reader's attention to the existence of an alternate interpretation of the geology of the Marlborough quadrangle, available as Barosh, P. J., 197__ , Reconnaissance Bedrock Geologic Map of the Marlborough quadrangle, Massachusetts: U.S. Geological Survey Open File Report 78-222.

1978

PRELIMINARY BEDROCK GEOLOGIC MAP OF THE MARLBORO QUADRANGLE, MIDDLESEX AND WORCESTER COUNTIES, MASSACHUSETTS

by

J. Christopher Hepburn and Richard G. DiNitto

1977

Descriptions of Mapped Units (Youngest to Oldest)

TrJd

Diabase

(Triassic to Jurassic)

Dark-gray, fine- to medium-grained, porphyritic to non-porphyritic diabase occurs in dikes commonly one to three metres in width, except for one approximately 30 metres wide which is shown on the map. The dikes are nowhere abundant but are generally more common in the southern part of the quadrangle than in the northern part. The dikes strike north to north-northeast and dip steeply.

ihhg

Indian Head Hill Granodiorite

(Devonian to Silurian ?)

Light-gray to gray, pinkish-white to light-gray-weathering, fine- to medium-grained, massive, mostly equigranular, unfoliated to poorly foliated, biotite-muscovite granodiorite to quartz monzonite. Biotite commonly exceeds muscovite; hornblende and epidote are locally present. Amphibolitic xenoliths and small intrusions of coarse-grained granite and pegmatite occur locally.

ihhgc

Coarse-Grained Indian Head Hill Granodiorite

Medium- to coarse-grained, dark-gray, foliated, biotite granodiorite to diorite occurs at the southwest end of the intrusion. Hornblende is more common in this area than it is to the northeast.

The Indian Head Hill Granodiorite is named herein for exposures at the north end of Indian Head Hill, Marlboro. Emerson (1917, p. 176-177) noted the differences between the granite of Indian Head Hill, "a porphyritic biotite granite", and the Dedham Granodiorite but did not differentiate between these

two on his map. The Indian Head Hill intrudes the Marlboro Formation and is suggested to be Devonian or Silurian in age on the basis of its binary composition and weak foliation.

Nelson (1975) mapped the eastward continuation of the Indian Head Hill in the Framingham quadrangle as part of his unnamed Granodiorite. Barosh et al (1977) included the Indian Head Hill in the Dedham Granodiorite.

pg

Porphyritic Granite

(Silurian)

Light- to medium-gray, medium- to coarse-grained, foliated, porphyritic biotite granite to quartz monzonite. Phenocrysts of potassium feldspar to 8 cm in length constitute up to 30% of the rock. Foliation is caused by the alignment of both the biotite and feldspar crystals. The latter phenocrysts form an irregular flow banding.

The porphyritic granite is poorly exposed and mapped largely on the basis of samples from building excavation sites. Lithologically it is similar to and tentatively correlated with the porphyritic phase of the Ayer Granite Complex (the Clinton Quartz Monzonite of Gore, 1976). Zartman (personal communication, 1976) has radiometrically dated the Ayer as Silurian, 425 m.y.

fg

Foliated Granite

(Silurian ?)

Light- to medium-gray, light-gray to buff-weathering, predominently medium-grained, well-foliated, massive muscovite-biotite granite to quartz monzonite with local inclusions of dark-gray biotite amphibolite. Feldspar and to a lesser extent quartz occur as phenocrysts (1x3 cm) in a foliated micaceous groundmass. The phenocrysts may comprise up to 40% of the rock.

The foliated granite trends into the Hudson quadrangle, where it was mapped as part of the Gospel Hill Gneiss by Hansen (1956). It is distinctly different from the main body of the Andover Granite, as it is porphyritic, well foliated, and contains no garnet. The foliated granite is of probable Silurian age, as it appears to intrude the Ordovician Andover Granite. Lithologically it has some similarities to rocks in the Ayer Complex (Gore, 1976) which has been dated as Silurian by Zartman (personal communication, 1976).

shd

Straw Hollow Diorite

(Ordovician to Silurian ?)

Dark-gray to dark-gray-green, medium-grained, poorly foliated hornblende-biotite-quartz diorite with accessory magnetite, garnet and pyrite. Hornblende lineation is locally common, but foliation is rare except in sheared zones near the southeastern contact.

The diorite appears to be in fault contact with the Marlboro Formation. The contact with the Nashoba, while believed to be intrusive, may also be locally faulted.

The Straw Hollow Diorite was named by Emerson (1917) for exposures in the adjoining Shrewsbury quadrangle. The mapped body of diorite in the Marlboro quadrangle is continuous with exposures of the Straw Hollow mapped by Hansen (1956) in the Hudson quadrangle.

Recently the Straw Hollow has been correlated with the Assabet Quartz Diorite of Hansen (1956) by Barosh et al (1977).

The age given for the Straw Hollow is established by a rather tenuous correlation of the Straw Hollow with the Newburyport Quartz Diorite, which has been dated as 445 ± 15 m.y. (Zartman, personal communication, 1976). The Silurian to Ordovician age must be considered questionable until further age determinations can be made.

sgd

Salem Gabbro-Diorite

(Ordovician)

Foliated to unfoliated gabbro or diorite with prominent pink-weathering feldspar megacrysts. The unfoliated variety is dark-gray-green, medium-grained gabbro to diorite with prominent pink-weathering feldspar megacrysts to 2 cm in length; these megacrysts commonly comprise 1% to 10% of the rock. However, a small percentage of the gabbro-diorite contains no phenocrysts. Small light-pink aplite dikes and stringers are common.

The foliated varieties are fine- to medium-grained, dark-gray to gray-green biotite gabbro-diorite with lesser amounts of biotite amphibolite, all with prominent pink-weathering feldspar megacrysts to 2 cm in length. These megacrysts comprise 1% up to 20% of the rock. Some of the foliation is cataclastic in origin, particularly near the Bloody Bluff Fault Zone.

The correlation of some of the rocks included here in the Salem is in question. Gabbroic rock without the feldspar megacrysts is lithologically similar to the typical Salem mapped elsewhere. Shride (personal communication, 1977) has noted that the gabbroic rocks with feldspar megacrysts probably represent a border phase of the Salem, particularly near the Bloody Bluff Fault Zone or where they intrude granitic rocks. Whether the well-foliated biotite amphibolites

represent Salem that has been altered and perhaps sheared or whether they represent inclusions of earlier mafic material that have had feldspar porphyroblasts grow within them during Salem intrusion is unknown at the present time.

The Salem as mapped in the Marlboro quadrangle is continuous with a body of Salem mapped by Nelson (1975) in the Framingham quadrangle. The foliated megacrystic rocks included here in the Salem may be lithologically similar to part of Nelson's (1975) Claypit Hill Formation.

Zartman (1977) has shown that the Salem is most likely Ordovician in age based on Rb/Sr isochrons from biotite of 460 to 490 m.y.

ag

Andover Granite

(Ordovician)

Light- to medium-gray, tan and pinkish-gray, slightly to well-foliated, medium- to coarse-grained muscovite-biotite granite to quartz monzonite with abundant small garnet phenocrysts. Micas commonly comprise 10% to 20% of the rock, with muscovite predominant. The Andover becomes strongly foliated only near its borders where the foliation parallels the contact. Pegmatites occur locally but are not common.

The Andover intrudes the upper members of the Marlboro Formation and is in probable fault contact with the schist and granulite member of the Marlboro. The Andover appears to have been intruded by the Foliated Granite. A relatively large body of the Marlboro (p€ms) lies within the Andover and is probably a roof pendant.

Hansen (1956) mapped the continuation of the Andover in the Hudson and Maynard quadrangles as the Gospel Hill Gneiss and regarded these rocks as the "granitized product of the Nashoba and Marlboro Formations" (p. 39). Since the Gospel Hill Gneiss can be divided into units that have precedence, the Andover Granite, the Marlboro and the Nashoba Formations, Bell and Alvord (1976) have suggested the name Gospel Hill Gneiss be abandonned. Zartman (1976, personal communication) indicates that the most likely age for the Andover is Late Ordovician, based on a Rb/Sr whole rock date of 460 m.y.

pЄn

Nashoba Formation

(Late Precambrian ?)

The Nashoba is poorly exposed within the Marlboro quadrangle but consists of gray to dark-gray, medium-grained, well-foliated, layered, biotite-plagioclase-quartz gneiss that has commonly undergone extensive minor folding.

The contact of the Nashoba with the Straw Hollow Diorite dips steeply to the northwest and is locally faulted.

The Nashoba was named by Hansen (1956) for exposures in the Maynard and Westford quadrangles.

pЄm

Marlboro Formation

(Late Precambrian)

The Marlboro Formation of probable Late Precambrian age was named by Emerson (1917), who designated the type locality as the "wall-like outcrop north of Main Street in Marlboro" (p. 25). Bell and Alvord (1976) split out the upper part of the Marlboro, which they named the Sandy Pond Member, from the remaining, lower, undifferentiated Marlboro. During the current mapping, the Marlboro has been subdivided into four informal members, from top to bottom: a granulite member, a rusty schist member, a schist and granulite member, and the Sandy Pond member. The Sandy Pond member correlates lithologically with that of Bell and Alvord (1976), although in the Marlboro quadrangle it mades up the base of the formation and may include the entire Marlboro of Bell and Alvord (1976). In the vicinity of the type locality, Emerson (1917) mapped a body of Brimfield-like schist, which is here included largely within the schist and granulite member of the Marlboro.

pЄmg

Granulite Member, Marlboro Formation

Medium- to dark-gray, light-gray to tan-weathering, homogeneous, massive, fine- to medium-grained granulite consisting of biotite, muscovite, plagioclase and quartz. Locally small

feldspar porphyroblasts give the rock a mottled appearance. On weathered surfaces the granulite may appear more schistose than where fresh. Minor lenses of rusty-weathering, fine-grained, sillimanite-mica schist and black, medium- to coarse-grained amphibolite occur locally. One lens of rusty schist (pЄmgr) is large enough to map separately.

The base of the granulite member grades downward into the underlying rusty schist member. The contact is placed where massive granulite exceeds the rusty schist. The upper boundary of the Marlboro Formation is in fault contact with the overlying Nashoba Formation.

pЄms

Rusty Schist Member, Marlboro Formation

Predominantly rusty-weathering schist and fine-grained amphibolite. The schist is a black to dark-gray, rusty-weathering, fine-grained, moderately to well-foliated, thin- to medium-bedded biotite-muscovite-plagioclase-quartz schist with local thin layers rich in sillimanite or garnet. Fine-grained, black to dark-gray, light- to medium-gray-weathering, well-foliated hornblende-plagioclase-biotite-quartz amphibolite occurs commonly at the base of the member and is intermittently interlayered with the schist elsewhere in the section. Dark-gray, rusty-weathering, fine-grained, moderately foliated, biotite-muscovite-plagioclase-quartz granulite that

is locally calc-silicate bearing is present but rare as thin interbeds. The basal contact is gradational into the underlying granulite and schist member of the Marlboro.

pЄmsg

Schist and Granulite Member, Marlboro Formation

Dark-gray, tan to light-gray-weathering, fine- to medium-grained, thin- to thick-bedded, moderately foliated, calc-silicate and garnet coticule-bearing biotite-plagioclase-quartz-muscovite±hornblende granulite. Coticule and calc-silicate layers form approximately 10% of the member. Some granulite layers are highly feldspathic. Interbedded with the granulite is a silvery to brown to dark-gray, rusty- to silvery-white-weathering, fine-grained, thinly layered, well-foliated, garnet coticule-bearing biotite-plagioclase-quartz-muscovite schist. Some garnets occur as porphyroblasts up to 3 cm in diameter. Thin, quartz and feldspar stringers or pods to 20 cm in length are common. Two sets of cleavage, one parallel to foliation and the second parallel to the axial planes of small tight folds, are common in the schist. The granulite and schist occur in roughly equal proportions. Black, medium-gray-weathering, fine-grained, thin- to thick-bedded, hornblende-plagioclase-biotite amphibolite occurs as local interbeds. This member grades downward into the Sandy Pond member of the Marlboro Formation; the contact is drawn where granulite and schist exceeds amphibolite.

p€msp

Sandy Pond Amphibolite member, Marlboro Formation

Dark-gray to black, light-to medium-gray, charcoal-black, or rarely rust-weathering, fine-to medium-grained, locally coarse-grained amphibolite consisting of hornblende, plagioclase, biotite, quartz, and epidote. The epidote occurs locally as boudins or knots ranging from 5 cm to one metre in length. Plagioclase and quartz occur commonly as thin (2-5 cm) stringers parallel to foliation, that are 2 cm to one metre in length. Generally, the amphibolites are well-foliated, thick to massively bedded or thinly laminated. Minor folds are common in the upper half of the Sandy Pond member.

Locally interlayered to 0.5 metre thick within the amphibolite are dark-gray to black, fine-grained, thin-to medium-bedded, well-foliated, biotite-plagioclase-muscovite-quartz$\pm$hornblende$\pm$garnet schists and dark-gray to black, light-gray-weathering, fine-grained, moderately foliated layers of plagioclase-biotite-muscovite-quartz$\pm$hornblende calc-silicate granulites.

At the base of the member a dark-gray, medium-to coarse-grained moderately foliated, biotite-rich, quartz-plagioclase-biotite gneiss with interlayered biotite schist has been separated on the map (p€mspb).

The base of the Sandy Pond member is in fault contact with the underlying Westboro Formation and Milford Granite.

pЄas

Altered and Sheared Rocks

(Late Precambrian)

This unit includes a variety of highly altered and sheared rocks in and north of the Bloody Bluff Fault Zone. Included in this unit are: 1. massive, fine-grained, light-green to dark-green, poorly foliated, chlorite, epidote greenstones and highly altered and sheared mafic rocks; some with small (to 1/2 cm) megacrysts of altered feldspar; 2. fine-grained, tan-gray weathering, altered felsite; 3. altered, sheared, and mylonitized fine-to medium-grained, well-folidated, light-pink to gray biotite granite and granodiorite, locally with scattered accessory magnetite; and 4. well-layered to laminated, fine-grained, light-tan felsic mylonite to green to dark-gray-green, mafic mylonite. Locally specular hematite forms prominent, late fracture fillings in the mylonite.

It is believed these rocks represent a series of mafic to felsic volcanics and plutonics that have been sheared and altered. The alteration probably occurred at several times in the history of the rocks during shearing episodes and in early hydrothermal alteration. It is possible that at least some of the sheared granitic rocks in this zone are related to the Milford Granite.

These rocks were included in the Wolfpen Tonalite by Emerson (1917) and are probably equivalent to at least parts

of the Kendal Green and Claypit Hill Formations of Nelson (1974, 1975). Since the majority of the rocks surrounding Wolfpen Hill, Southboro (Emerson's 1917 type area) are not tornalites, it is suggested this name be abandonned.

Milford Granite

(Late Precambrian)

The Milford Granite is characterized by a light-pink to pink-gray color, a generally medium to coarse grain size, the predominance of biotite as the mafic phase, the general absence of muscovite, and the light-blue color and granulated texture of the quartz grains. The Milford varies from granite to granodiorite in composition (Nelson, 1975).

Three lithologic subdivisions have been mapped within the Milford Granite. The contacts between these informal members are gradational for the most part. Within each member minor amounts of the other Milford rock types occur locally but are less abundant than the principal mapped lithology. No age relations have been established between these subdivisions.

Conspicuous dark-greenish-gray, crumbly, fine-grained, chloritized, biotite amphibolite and biotite schist layers, up to three metres in width, are found in all the members of Milford and are interpreted to be altered mafic dikes or sills. They parallel the foliation where foliation can be seen within the Milford and are easily distinguished from younger Mesozoic diabase dikes.

Perry and Emerson (1907) originally named the rock for quarry exposures in the town of Milford, south of the Marlboro quadrangle. Recent age dating on samples from these quarries yielded a Rb/Sr whole rock isochron of 614 ± 24 m.y. and zircon Pb^{207}/Pb^{206} ages of 630 m.y. (Naylor, 1975).

mg

Milford Granite

Light-pink-gray to light-pink, medium- to coarse-grained granite to quartz monzonite characterized by the lack of foliation and presence of blue granulated quartz. Biotite commonly forms 5% to 7% of the rock but ranges from 3% to 10%. Muscovite is usually absent except as a secondary mineral. Hornblende is locally present but generally rare. Magnetite is a common accessory mineral.

Included within this subdivision are areas of unfoliated, medium- to coarse-grained, mafic-poor granite similar to the above but with total mafic minerals less than approximately 3%.

mgfs

Foliated Milford Granite = Scituate Granite Gneiss

Light-pink-gray to gray to light-pink, foliated, medium- to coarse-grained granite to granodiorite. Biotite is the principal mafic mineral and ranges from 5% to 12%. Muscovite is generally absent except as a secondary mineral occurring principally along fractures. Locally the granite is altered with the formation of sericite, chlorite and epidote. Magnetite, ilmenite and apatite are the most common accessory minerals. The principal difference between mgfs and mg is the presence in this member of a conspicuous foliation formed by

biotite and/or elongated and flattened, lensoid-shaped, granular aggregates of light-blue-gray quartz to 0.5 cm in size. The foliation planes are spaced a few millimetres to 2 cm apart. Some of the foliation is cataclastic in origin.

The altered mafic dikes are more common in this unit than in the other two members.

This member is lithologically similar to and probably continuous, at least in part, with the Scituate Granite Gneiss mapped to the southwest in south-central Massachusetts and northeastern Connecticut (R. Dixon and R. Goldsmith, personal communication, 1977).

Included within mgfs are small bodies of light-gray, medium-grained, biotite-feldspar-quartz granodiorite gneiss. The biotite in these rocks may reach 15% to 20% and forms a prominent foliation. These bodies are generally less than 30 metres across and are aligned parallel to the foliation. These gneissic rocks may be related to the Ponaganset Granite Gneiss, although they do not generally show the prominent lineation present in the Ponaganset.

mgfsmp

Mafic-Poor Foliated Milford Granite

Light-pink-gray to gray to very light-pink, fine- to medium-grained granite to aplite. Mostly similar to mgfs

except that the percentage of biotite is noticeably lower, ranging from 1% to 3%. Magnetite is a common accessory; in places phenocrysts reach 0.5 cm in size. In these rocks the foliation is commonly produced by the alignment of quartz granular lenses, as the biotite is not abundant enough to produce a continuous foliation. Included in this unit are bands of fine-grained, foliated, light-pink aplite or possible felsic volcanics(?) of alaskitic composition. The foliation in this unit may be in part due to cataclasis.

This member may be partially equivalent to the Hope Valley Alaskite mapped to the southwest in Connecticut (R. Goldsmith and R. Dixon, personal communication, 1977).

pЄw

Westboro Formation

(Late Precambrian)

The Westboro Formation is characterized by quartzite, feldspathic quartzite, and micaceous quartzite, but also includes a variety of other rocks. The quartzites are light-to dark-gray, tan, or pink-gray, fine-grained, and massive to well-bedded. Bedding ranges from a few cm to three metres in thickness, although the average bed is commonly 1/4 to 1/2 metre thick. Micaceous partings are common along bedding surfaces. Feldspathic quartzite predominates over orthoquartzite within the formation.

The quartzites grade into gray to dark-gray, locally rust-stained, micaceous quartzite and quartz-rich mica schist. Bedding in these rocks ranges from one cm to 1/4 metre thick. Thin micaceous partings are common.

Calc-silicate rocks from a conspicuous although minor part of the formation. Commonly these rocks form thin beds less than 1/2 metre thick of fine- to medium-grained, light-green actinolite-carbonate calc-silicate granulite or light-green, calc-silicate - bearing quartzite. Some calc-silicates occur as small pods or lenses within the quartzites. A few beds of fine-grained, light-purplish-brown biotite calc-silicate granulite are present.

Included in the Westboro Formation are mica schists and amphibolites. The mica schists are quite variable, ranging

from light-gray to fine- to medium-grained muscovite-quartz schist to dark-gray, rusty weathering biotite-quartz-feldspar schist. The amphibolites are generally thin, less than one metre thick, dark-gray to dark-gray-green hornblende-plagioclase±biotite±epidote amphibolite or schistose amphibolite.

p€ws

Biotite Schist member, Westboro Formation

The lower part of the Westboro Formation in the Marlboro quadrangle consists largely of poorly exposed, dark-gray, fine- to medium-grained biotite schist with minor thin impure quartzite beds. Also common in this member are biotite amphibolite, hornblende amphibolite, quartz-rich biotite schist, and plagioclase-biotite gneiss.

The Westboro Formation has been mapped where quartzite beds were present or where rocks typical of p€ws occurred between the Milford Granite and known quartzite exposures. The best exposure of the Westboro occurs in highway cuts on Interstate 495 just north of the Southboro-Westboro town line, north of Mt. Nebo in the south-central part of the quadrangle. Although this exposure was not available to Emerson in 1917 when he named the Westboro Quartzite, it is suggested that the exposures here represent a more complete section of the Westboro (at least 200 metres of continuous exposure) than any others currently available in the designated type area. Besides the belt of Westboro in the south-central part of the quadrangle, the Westboro also occurs as several small lenses, roof pendants, or fault slivers within the Milford Granite.

The contacts of the Westboro Formation are not exposed in the quadrangle. However, the occurrence of numerous small dikes of light-pinkish granite and aplite that resemble parts of the Milford Granite, and cut the Westboro, support the Late Precambrian age for the Westboro suggested by Emerson (1917), Nelson (1974) and others.

Bell and Alvord (1976) formally changed the name of the Westboro Quartzite to the Westboro Formation because of the abundance of other rock types within the formation, particularly away from the type of area. The Westboro is a probable correlative of the Plainfield Formation in Connecticut as has been noted by Dixon (1976) and others.

REFERENCES

Barosh, P.J., Fahey, R.J., and Pease, M.H., Jr., 1977, Preliminary Compilation of the Bedrock Geology of the Boston 2° sheet, Massachusetts, Connecticut, Rhode Island and New Hampshire: U. S. Geol. Survey Open File Rept.

Bell, K.G. and Alvord, D.C., 1976, Pre-Silurian stratigraphy of Northeastern Massachusetts, in Page, L.R., ed., Contributions to the Stratigraphy of New England: Geol. Soc. Amer. Memoir 148, p. 179-216.

Dixon, H.R., 1976, Summary discussion of stratigraphy of Eastern Massachusetts and Connecticut, in Page, L.R., ed., Contributions to the Stratigraphy of New England: Geol. Soc. Amer. Memoir 148, p. 277-284.

Emerson, B.K., 1917, Geology of Massachusetts and Rhode Island: U. S. Geol. Survey, Bulletin #597, 289p.

Emerson, B.K., and Perry, J.H., 1907, The green schists and associated granites and porphyries of Rhode Island: U.S. Geol. Survey Bulletin #311, 74p.

Gore, R.Z., 1976, Ayer crystalline complex at Ayer, Harvard, and Clinton, Massachusetts, in Lyons, P.C., and Brownlow, A.H., eds., Studies in New England Geology: Geol. Soc. Amer. Memoir 146, p. 103-124.

Hansen, W. R., 1956, Geology and mineral resources of the Hudson and Maynard quadrangles, Massachusetts: U. S. Geol. Survey Bulletin #1038, 104p.

Naylor, R.S., 1975, Age provinces in the Northern Appalachians: Annual Review of Earth and Planetary Sciences, v. 3, p. 387-400.

Nelson, A.E., 1974, Changes in nomenclature of Precambrian to lower Paleozoic (?) formations in the Natick quadrangle Eastern Massachusetts, and their tentative correlation with rocks in Rhode Island and Connecticut: U. S. Geol. Survey Bulletin #1395-E.

-----, 1975, Bedrock geologic map of the Framingham quadrangle, Middlesex and Worcester counties, Massachusetts: U. S. Geol. Survey Geol. Quad. Map GQ-1274.

Zartman, R.E., 1977, Geochronology of some alkalic rock provinces in eastern and central United States: Ann. Rev. Earth and Plant. Sci., V. 5, p. 257-286.

Marlboro Quadrangle

Symbols used on map

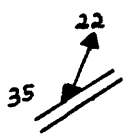
Strike and dip of bedding

Strike and dip of schistosity in a stratified rock

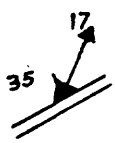
Strike and dip of parallel bedding or layering and schistosity

Strike and dip of foliation in plutonic igneous rock

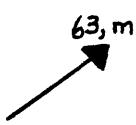
Outcrop containing cataclastic foliation or field evidence of shearing



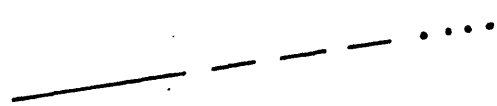
Strike and dip of axial plane of minor fold, schistosity folded; arrow indicates bearing and plunge of fold axis



Strike and dip of axial plane of minor fold, schistosity and bedding or layering folded; arrow indicates bearing and plunge of fold axis

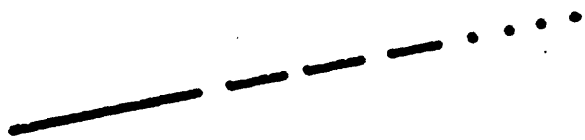


Bearing, plunge and type of lineation, m= mineral lineation, c=crinkle lineation, q= quartz rodding or quartz streaming lineation The symbol for minor folds or lineations may have been displaced from the actual reading site to prevent crowding on the map



Contact

dashed where approximately located; dotted where inferred or gradational

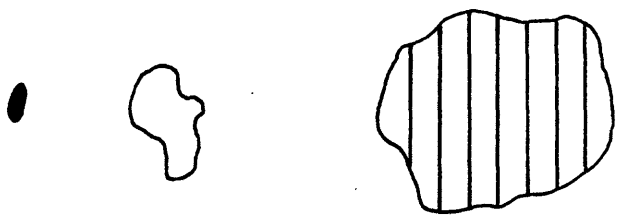


Fault

dashed where approximately located; dotted where inferred

Thrust Fault

sawteeth on upper plate, dashed where approximately located; dotted where inferred



Outcrop

solid, individual outcrops and those generalized from very closely spaced small outcrops; open circles, larger individual outcrops and those generalized from closely spaced small outcrops; vertical lined pattern, larger areas of closely spaced outcrops and areas where bedrock is inferred to be 3 metres or less beneath ground surface

Preliminary Bedrock Geologic Map of the Marlboro Quadrangle

COLUMNAR SECTION FOR INTRUSIVE ROCKS