Open file 78-394

Shrewsbury Quadrangle, Barosh

DESCRIPTION OF MAP UNITS

IGNEOUS ROCKS

g

Gabbro-Quartz Diorite, medium- to dark-gray or dark greenish gray, weathering same or darker with a brownish cast, fine- to medium-grained, equagranular to seriate, massive rock consisting of Hornblende biotite gabbro, hornblende biotite diorite and some hornblende biotite quartz diorite. The biotite flakes of different orientations form clots, .5 - 1 cm across, in places. Grew (1970) reports the different rock types form layers 1 to 2 meters in thickness. The gabbro-quartz diorite appears to be the youngest intrusive body in the quadrangle because of the lack of apparent regional metamorphic foliation.

mqm

Muscovite Quartz Monzonite, light-gray weathering about the same, equagranular, massive to moderátely foliated, medium-grained rock approximately muscovite or muscovite biotite quartz monzonite. Its contact with the Nashoba formation is very broadly gradational with a wide migmatite zone present and the contact is broadly generalized. Many pendents and xenoliths of metasiltstone occur in the muscovite quartz monzonite, forming many of the ridge crests near the northern boundary of the quadrangle (J. H. Peck personal commun.) in addition to those of the Nashoba further south. The intrusive is similar to other two mica quartz monzonites in the region; the Fitchburg granite to the west and the Chelmsford granite to the northeast.

pqm

Porphyritic Biotite Quartz Monzonite, light- to medium-gray, weathering the same of slightly darker, moderately foliated medium to coarse-grained porphyritic rock chiefly biotite quartz monzonite, but ranging from biotite granite to biotite quartz diorite. Large phenocrysts of K feldspar, as much as 8 cm across, are common. Nonporphyritic phases are present locally. Xenoliths are locally present. The rock forms one or more of the porphyritic phases of the Ayer intrusive complex.

ag

Andover Granite (?), light- to medium-gray, weathering slightly darker with a rusty cast, slightly- to well-foliated, mostly medium-coarse to coarse-grained equigranular quartz monzonite in which quartz, plagioclase, and potassium feldspars occur in nearly equal proportions and constitute 85 to 95 percent of most specimens. Mica ranges from about 3 to 12 percent with biotite exceeding muscovite at most localities.—

This rock is tentatively correlated with the similar Andover Granite to the northeast.

The Andover Granite intrudes the Nashoba Formation and associated metamorphosed stratified rocks that lie between the Clinton-Newbury and Bloody Bluff fault zone to the northeast of the Shrewsbury Quadrangle. The stratigraphic position of these rocks is not known, but regional considerations suggest that they vary from Precambrian to Early Paleozoic. According to Zartman (1976, personal commun.) the best radiometric date for the Andover at the present time is a Rb/Sr whole rock date of 460 $\pm$ my, Late Ordovician.

mg

Milford Granite, light-gray to light pinkish gray, weathering about the same or slightly lighter, fine- to medium-grained, equagranular to rock porphyritic that varies in composition from granite to granodiorite. Biotite is locally present, but generally the mafic minerals are altered to chlorite and, in the lighter-colored varieties, only minor chlorite, accompanied by some sericite, is present. Some of the rock is only slightly foliated and altered to produce pink feldspar and chloritized mafic minerals as at the interchange on Interstate Route 495 and Route 9 in the Marlborough Quadrangle. The rock is generally foliated and altered, with much of the rock appearing slightly bleached. The foliation is highly variable changing from very slight to strongly foliated over a distance of a meter or less. The grain size has been greatly reduced in the strongly foliated part and the intrusive becomes similar in appearance to the xenoliths of quartzite which are common. The foliation parallels the bedding in the xenoliths. The rock contains numerous scattered xenoliths of very light-gray quartzite and dark greenish gray chloritic granular schist of the Westboro Formation. The rock is generally well jointed with the most prominent joints parallel to the foliation. Samples of the Milford Granite from the Milford Quadrangle, Massachusetts, yielded a 620 ± 15 my, Precambrian, zircon age according to Richard Naylor (personal commun.).

fg

Foliated Granite, light- to medium-gray, weathering the same to slightly darker, medium-grained, equigranular to slightly porphyritic foliated rock approximately quartz monzonite to granodiorite in composition. Contains 10 to 20 percent mafic minerals with biotite dominant. The rock is highly variable in degree of foliation and appearance. It grades into rock like the Milford Granite and appears to be a slightly more mafic border phase of the Milford. The unit intrudes the Westboro Formation and contains xenoliths of quartzite and dark greenish gray granular schist of the Westboro Formation. The foliated granite is interpreted to be mixed with the Westboro Formation from exposures along the southern border of the quadrangle.

METASEDIMENTARY AND METAVOLCANIC ROCKS

p, pl

Phyllite, medium to dark gray, weathering dark gray with some rusty spots from oxidation of pyrite, very fine-grained even textured phyllite (Peck, 1975). The rock consists of mainly quartz, sericite, chlorite and carbonaceous material, with accessory pyrite, feldspar, epidote, zircon, and calcite. Some outcrops can be classified as slate, others as phyllite only by the development of sericite flakes along the cleavage. The phyllite is thin- to medium-bedded, but the bedding is usually obscure due to the lack of compositional differences between beds and to the presence of strong slaty cleavage in the rock. Some graded beds have very thin metasiltstone or metagraywacke layers at the base, but most graded beds in this unit have less than 10 percent silt size constituents. A marble unit, pl, is present near Flagg Cove of Wachusett Reservoir. It consists of light gray marble in beds 30 cm to as much as 2.5 m thick interbedded with mica schist in beds 1.7 m or more thick (Grew, 1970).

The phyllitic beds between the quartzite and phyllite unit and the Clinton-Newbury Fault zone have been included in this unit by correlation. The beds are mapped as the Boylston Formation by Grew (1970) and the Boylston south of Worcester is equivalent to the phyllite along the Wachusett Reservoir.

sp

Metasiltstone and phyllite, interbedded laminated gray metasiltstone and phyllite with a minor amount of calcareous metasiltstone. The unit has been studied mainly by Peck (1975, 1976) in the Clinton area and most of the description is from his work. The metasiltstone is brownish gray to light-gray, fine grained, mostly well sorted, and consists dominantly of quartz with minor feldspar and ankerite. Weathering of ankerite to limonite gives exposures of the rock a distinctive spotted brown appearance. The phyllite is very fine-grained, dark-greenish-gray, medium-gray or locally light-greenish-gray and is composed mostly of quartz, sericite and chlorite. The phyllite weathers to greenish-gray or black. Metasiltstone and phyllite is well bedded in thin to thick beds. The unit has persistent lamination and only very little cross lamination. Graded beds are rarely present. The phyllite is characterized by small chevron folds with sub-horizontal axial planes accentuated by the thin laminae of the rock. This gives the rock a characteristic crinkled appearance. The unit is assumed to be conformable with rocks above, but the contact is not exposed. The unit crops out poorly.

The unit was mapped previously as Oakdale Quartzite or Worcester Phyllite by Emerson, 1917. It comprises Unit 2 of Peck (1976). This unit is approximately 1,300 - 2,300 m thick in the

Clinton area (Peck, 1976). The unit is equivalent to the Eliot formation of Maine and New Hampshire. The unit is especially similar to the lower part of the Eliot (Hussey, personal commun.). The Eliot Formation and the Berwick and Kittery Formations which overlie and underlie the Eliot have been correlated with fossiliferous Silurian rocks further north in Maine (Hussey, 1962) making this metasiltstone and phyllite unit probably Silurian in age also.

q

Quartzite, light- to medium gray, weathering same or with buff cast, well bedded, thin- to thick-bedded very fine-grained quartzite interlayered with minor dark gray to silvery-gray phyllite. The quartzite is not persistent along strike and represents the predominantly quartzite portion of a sequence of quartzite and phyllite (J. H. Peck personal commun.). This unit conformably underlies the metasiltstone and phyllite unit in the Clinton Quadrangle (Peck, 1975, 1976). The quartzite forms resistant outcrops especially along the contact with the Ayer which intrudes it.

The quartzite unit is included in the Oakdale Quartzite of Emerson (1917), forms the Tower Hill Quartzite Member of the Boylston Formation of Grew (1970), and constitutes Unit 1 of Peck (1976). This unit is as much as 100 m thick in the Clinton quadrangle (Peck, 1976).

qp

Quartzite and phyllite, light-gray to medium-gray very fine-grained quartzite interlayered with dark-gray to silvery-gray phyllite. The proportions of quartzite and phyllite vary considerably within the unit. The interlayered sequence grades laterally into, and in places underlies the quartzite unit. Phyllite makes up more than 50 percent of the outcrop at some places. The interlayerd quartzite and phyllite sequence is mostly very thin- to thin-bedded, changing to well-bedded, thin- to thick-bedded with some internal laminations where the unit grades in to the predominantly quartzite unit. The interlayered sequence forms very poor outcrop and is generally seen only near contacts with more resistant rock. The interlayered quartzite and phyllite lithology is similar to the top of the Tadmuck Brook Schist exposed in the Clinton quadrangle but the Tadmuck Brook Schist lies south of the Clinton-Newbury fault and is not associated with thick quartzites (J. H. Peck, personal commun.).

msp

Metasiltstone-phyllite, light-brownish-gray to light-gray meta-siltstone and calcareous metasiltstone with some beds of dark-gray phyllite. Most of the metasiltstone is thin-bedded, laminated and contains very fine granular quartz, plagioclase, brown biotite, and chlorite with locally significant amounts of calcite (Peck, 1975). It weathers light brown. The unit forms pendents, not mapped separately, in the Fitchburg Granite near the southern boundary of the Clinton quadrangle, along Interstate highway 290, and as a bedded sequence in a fault block near Reubens Hill in the Clinton quadrangle (Peck, 1975). Dark gray, weathering lighter and slightly rusty, thin bedded phyllite is present along Interstate highway 290 in the center part of the quadrangle. Granulated quartz with possibly some other quartz-like mineral (cordierite?) form knots in the phyllite (Peck, 1975). The metasiltstone is interlayered in the lower part of the Reubens Hill igneous complex in the Wachusetts-Marlboro tunnel (Skehan, 1968) this relationship is not seen at the surface (Peck, 1975). The Reubens Hill is considered to underlie the quartzite and phyllite unit (Peck, 1976). Possibly the unit on highway 290 is a facies of the Tadmuck Brook Schist.

tb

Tadmuck Brook Schist, chiefly dark gray phyllite in the upper part, medium-gray sericite-staurolite-andalusite phyllitic schist in the middle part, and medium-gray sillimanite-quartz-mica schist in the lower part, all interstratified with some lenticular bodies of thin-bedded amphibolite, non-bedded or massive amphibolites and a few quartzite beds locally at the top of the schist. Much of the formation contains sulfide-rich layers that slake on weathering and stain large outcrops conspicuously rusty brown and sulfur yellow.

Elsewhere, where sulfides are rare to absent the rocks weather light- to medium-gray or greenish-gray.

The Tadmuck Brook Schist is best exposed along Interstate Highway I-290. In much of the area to the south its presence is inferred; it is again exposed in Auburn, Massachusetts.

nu, num

Nashoba Formation, undivided, consists of light- to dark-gray rocks in relatively homogeneous members composed chiefly of medium-grained muscovite biotite-oligoclase-quartz gneiss alternating with members of more heterogeneous lithology including fine-grained amphibole-biotite gneiss and schist, amphibolite, mica schist locally sulfidic, calc-silicate-bearing gneiss and a few lenses of marble. The formation is used here as originally defined by Hansen (1956) to include all the stratified rocks between the Marlboro Formation and the Tadmuck Brook Schist. The formation has subsequently been restricted (Bell and Alvord, 1976) by separating the distinctive Fishbrook Gneiss and underlying Shawsheen Gneiss from its base. Alvord (1975) also divided the restricted Nashoba into 10 members. Only those members known to occur in the Marlboro Quadrangle as described below. The Nashoba Formation is intruded by the Andover Granite and Assabet Quartz Diorite. The formation is in fault contact to the northeast with the Newbury Volcanics, a sequence of essentially unmetamorphosed volcanogenic rocks containing Late

Silurian or Early Devonian fossils (Shride, 1976). The Nashoba has a maximum thickness of 15,010 m (Bell and Alvord, 1976). A broad migmatitic zone, num, is present in the northwestern part of the quadrangle adjacent to the muscovite quartz monzonite body.

nb, nbc

Beaver Brook Member, composed of a heterogeneous variety of rock type; chiefly medium- to dark-gray amphibole-biotite gneiss, calc-silicate (tremolite-diopside) bearing gneiss and fels, and amphibolite. A zone of discontinuous beds of limestone in the lowermost 400-500 m, nbc, are shown separately. The remainder above include medium-grained sillimanitic muscovite-oligoclase-quartz gneiss complexly interstratified with sulfidic sillimanite-muscovite-biotite-oligoclase-quartz schist, both thin bedded and massive amphibolite, and amphibole-biotite gneiss. The upper contact with the Tadmuck Brook Schist appears conformable locally, and is faulted in places but the regional overlap of the Tadmuck Brook on to successively lower members of the Nashoba Formation appears to be an unconformity (J. H. Peck personal commun.). The member has a maximum thickness of 1,580 m (Bell and Alvord, 1976).

nl, nlc, nla

Long Pond Gneiss Member, consists mostly of medium-gray medium-grained thin- to medium-bedded, well foliated sillimanitic muscovite-biotite-oligoclase-quartz gneiss, characteristic of the Nashoba Formation, interstratified with a few lenticular bodies of thin- to medium-bedded dark green amphibolite and massive amphibolite. A large lens of amphibolite is shown separately, nla. One interval, nlc, contains abundant calc-silicate bearing gneiss and some marble lenses. Pegmatite and granitic gneiss form as much as 25 percent of the rock. Relict bedding and, in some localities, cross laminations are present (Peck, 1975). The upper contact is covered, but mapping indicates it is conformable and gradational. It has a maximum thickness of 1,160 m, (Bell and Alvord, 1976).

nf, nfc

Fort Pond Member, consists of varied lithology; the lower part is mostly of medium- to dark gray fine-grained amphibole-biotite gneiss, calc-silicate (diopside-tremolite) bearing gneiss or fels, and amphibolite. The upper part consists chiefly of the same rock as the lower part but includes in addition, some sulfidic sillimanite-mica schist and interval, nfc, of discontinuous beds of marble. The upper contact with the Long Pond Gneiss Member is believed to be conformable, but at many localities the contact is faulted (D. C. Alvord, person. commun.). The member has a maximum thickness of 1,470 m.

nn

Nagog Pond Gneiss Member, chiefly light- to medium-gray, medium-grained muscovite-biotite-oligoclase-quartz gneiss, that characterizes the Nashoba Formation, interstratified with some amphibole-biotite gneiss and lenticular bodies of thinly bedded amphibolite and massive amphibolite. The upper contact is concealed, but is considered conformable (D. C. Alvord, person. commun.). The maximum thickness of the member is 1,370 m, (Bell and Alvord, 1976).

m

Marlboro Formation, upper part is chiefly dark gray to nearly black thinly layered fine-grained amphibolite interlayered with massive medium to coarse-grained amphibolite and minor amounts of other rock types. This is separated as the Sandy Pond Member to the northeast (Bell and Alvord, 1976). The lower part consists of similar rocks that are much more thickly bedded; mainly in medium to thick beds. The area of the formation also includes some small bodies of intrusive quartz diorite and a great amount of Andover Granite (?).

The base of the Marlboro is faulted. The top is conformable and gradational into the Shawsheen Gneiss farther northeast (Bell and Alvord, 1976). The contact is placed where muscovite-biotite gneiss and schist greatly exceeds amphibolite. The Marlboro has a maximum thickness of 2,140 m (Bell and Alvord, 1976).

w

Westboro Formation, light-gray to buff, weathering about the same, commonly laminated, well-bedded thin- to thick-bedded quartzite; dark greenish gray, weathering about the same to slightly lighter, mainly medium-bedded chloritic granular schist becoming biotitic locally; and a minor amount of light greenish gray and light purplish gray, weathering about the same, thin-bedded silicic metasiltstone. These rocks are interbedded with the quartzite which forms a little less than half of the main outcrop band and occurs mainly in the lower half. Quartzite forms the bulk of the scattered pendents and xenoliths of the Westboro in the surrounding intrusive rocks. The Westboro Quartzite was named by Emerson (1917) for exposures around Westboro adjacent to the southeast part of the quadrangle, but would better be referred to as a formation due to the large amount of granular schist in the unit. The Westboro is the oldest unit known in the quadrangle and may be considered Precambrian as it is intruded by the Milford Granite dated as Precambrian. Areas shown as Westboro contain large amounts of foliated intrusive rock locally.

References

Alvord, D.C., 1975, Preliminary bedrock geologic maps of the Westford and Billerica quadrangles, Middlesex County, Massachusetts: U.S. Geol. Survey open-file report 75-387, 12 p., scale 1:24,000.

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. America Mem. 148, p. 149-216.

Emerson, B.K., 1917, Geology of Massachusetts and Rhode Island: U.S. Geol. Survey Bull. 597, 289 p., scale 1:250,000.

Grew, E.S., 1970, Geology of the Pennsylvanian and pre-Pennsylvanian rocks of the Worcester area, Massachusetts: Cambridge, Mass., Harvard Univ., unpub. Ph.D. thesis, 263 p.

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

Hussey, A.M., 2d, 1962, The geology of southern York County, Maine: Maine Geol. Survey Spec. Studies Ser. no. 4, 67 p.

Peck, J.H., 1975, Preliminary bedrock geologic map of the Clinton quadrangle, Worcester County, Massachusetts: U.S. Geol. Survey open-file report 75-658, 31 p., scale 1:24,000.

____, 1976, Silurian and Devonian stratigraphy in the Clinton quadrangle, central Massachusetts, _in_ Page, L.R., _ed._, Contributions to the stratigraphy of New England: Geol. Soc. America Mem. 148, p. 241-253.

Shride, A.F., 1976, Preliminary maps of bedrock geology of the Newburyport East and Newburyport West quadrangles, Massachusetts-New Hampshire: U.S. Geol. Survey open-file report 76-488, 3 p., scale 1:24,000.

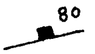
Skehan, J.W., 1964, Folio of maps and cross sections of the Wachusett-Marlborough tunnel, Clinton to Marlborough, Massachusetts: Boston, unpub. rept. for Metropolitan District Commission, 42 maps and sections, scale 1:2400.

______, 1968, Fracture tectonics of southeastern New England as illustrated by the Wachusett-Marlborough Tunnel, east-central Massachusetts, in Zen, E-an, and others, eds., Studies of Appalachian geology--northern and maritime: New York, Interscience Publishers, p. 281-290.

SYMBOLS

strike and dip of foliaton; foliation and bedding in meta sedimentary and metavolcanic rocks


strike of vertical foliation



strike and dip of joint


strike of vertical joint

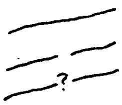

strike and plunge of lineation


anticlinal axis, showing direction of plunge

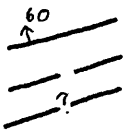

synclinal axis, showing direction of plunge


axis of minor anticline, showing direction of plunge

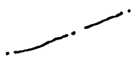

axis of minor syncline showing direction of plunge



contact, dashed where approximate, querried where probable



fault, showing dip and relative movement: U, up; D, down; dashed where approximate, querried where probable


topographic lineament

Open file 78-394

Shrewsbury Quadrangle, Barosh

CORRELATION OF MAP UNITS

IGNEOUS ROCKS

METASEDIMENTARY AND METAVOLCANIC ROCKS