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Preliminary Bedrock Geologic Map of the Clinton Quadrangle, Worcester County, Mass. by John H. Peck[1]

A digital conversion of USGS Open File Report 75-658

Conversion and digital cartography by Joseph P. Kopera[2]

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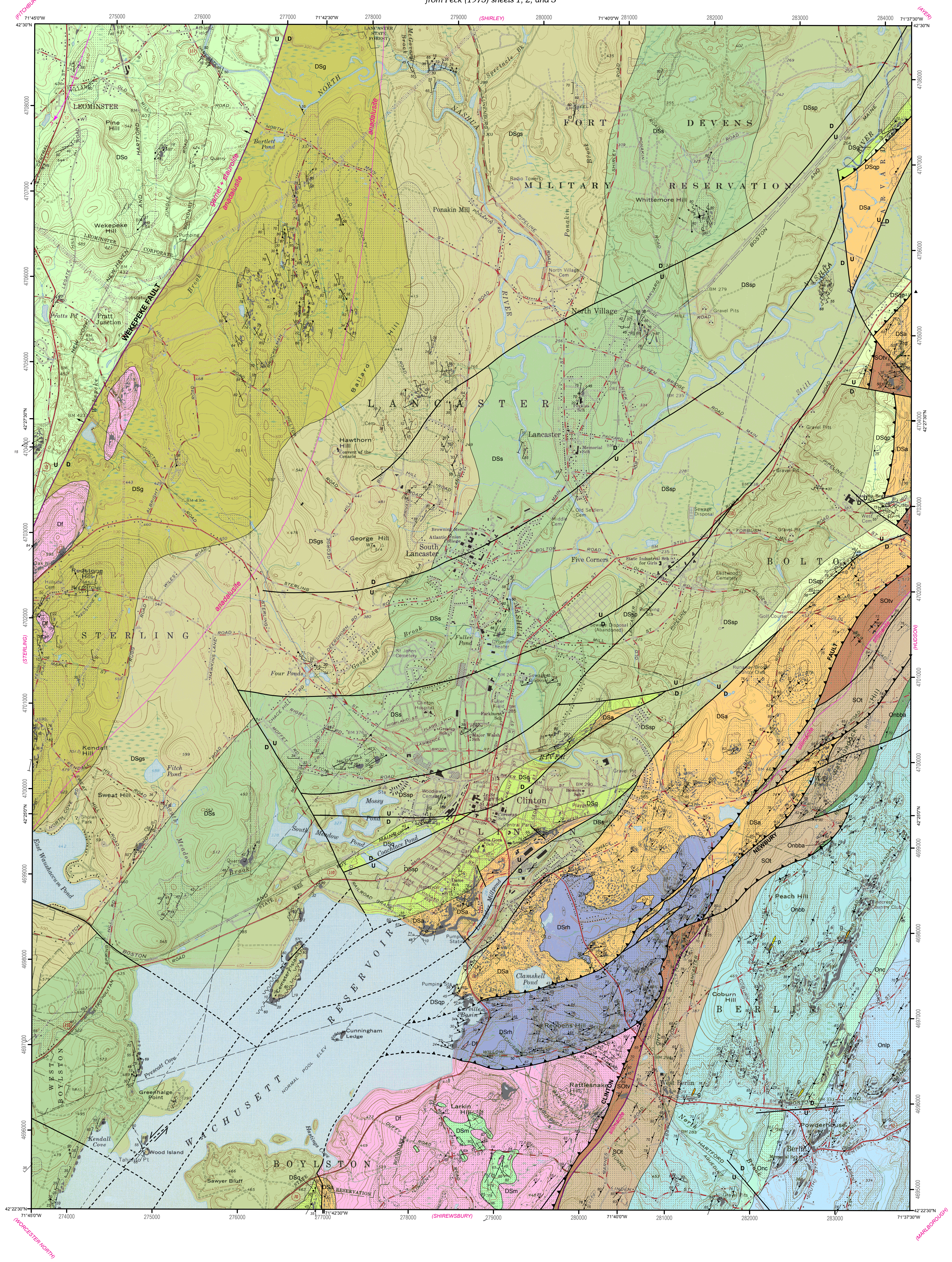
MGS DIGITAL CONVERSTION #12-01
PRELIMINARY BEDROCK GEOLOGIC MAP OF THE
CLINTON QUADRANGLE, WORCESTER COUNTY, MASS.
(USGS OFR #75-658)
1975 (ORIGINAL)
2012 (DIGITAL VERSION)

Geology and Ductile Struture

from Peck (1975) sheets 1, 2, and 3



Topographic Base from U.S. Geological Survey, 1965. Reprojected in 2012.

PROJECTION:
Lambert Conformal Conic
GCS NAD1983 NSRS 2007 Mass. State Plane Mainland (FIPS 2001)

1000-meter tick marks from UTM (Zone 19 N), NAD 1983

SOURCE INFORMATION:

Map is digital facsimile of:

Peck, J.H., 1975, Preliminary bedrock geologic map of the Clinton quadrangle, Worcester County, Mass., U.S. Geological Survey Open File Report 75-658. 30p and 3 plates. 1:24000 scale.

Geology mapped by 1969-74 by John H. Peck. Assisted by A.R. Uenditti, 1969-1970, R.C. Collins, 1970, and P.T. Banks, 1971. Contacts under Wachusett Reservoir by M.H. Pease and P.J. Barosh

Digital conversion, editing, and cartography by J.P. Kopera, 2012

Comments to the Map User

This map is a digital conversion of a previously published map product by an organization other than the Massachusetts Geological Survey. No modification of portrayed geology, lithologic descriptions, relative and absolute ages, stratigraphic, nor structural interpretations has been made except updated citations to references that were in press at time of original publication, and where explicitely noted in magenta. Formation names, ages, terminology, and any interpretations shown on the map may be in conflict with and/or superseded by more recently published work.

This map is intended to be superseded by Peck, J.H, and Kopera, J.P., *in progress*, Updated preliminary bedrock geologic map of the Clinton 7.5' quadrangle, Worcester County, MA, MGS Open File Report xx-xx, X Sheets, Adobe PDF & GIS Digital Product, 1:24000 Scale.

A geologic map displays information on the distribution, nature, orientation and age relationships of rock and deposits and the occurrence of structural features. Geologic and fault contacts are irregular surfaces that form boundaries between different types or ages of units. Data depicted on this geologic quadrangle map are based on reconnaissance field geologic mapping, compilation of published and unpublished work, and interpretation of geophysical and remote sensing data. Locations of contacts are not surveyed, but are plotted by interpretation of the position of a given contact onto a topographic base map; therefore, the accuracy of contact locations depends on the scale of mapping and the interpretation of the geologist(s). Any enlargement of this map could cause misunderstanding in the detail of mapping and may result in erroneous interpretations. Site-specific conditions should be verified by detailed surface mapping and subsurface exploration. Topographic and cultural changes associated with recent development may not be shown.We recommend *Reading Maps with a Critical Eye: Becoming an Informed Map Reader,* by the Maine Geologic Survey, to make the best use of a geologic map *(http://www.maine.gov/doc/nrimc/mgs/mapuse/informed/informed.htm).*

This map has not been peer reviewed or edited to conform with editorial standards of the Massachusetts State Geologist or with the North American Stratigraphic Code. The contents of the report and map should not be considered final and complete until reviewed and published by the Massachusetts Geological Survey as a Geologic Map (GM) product.

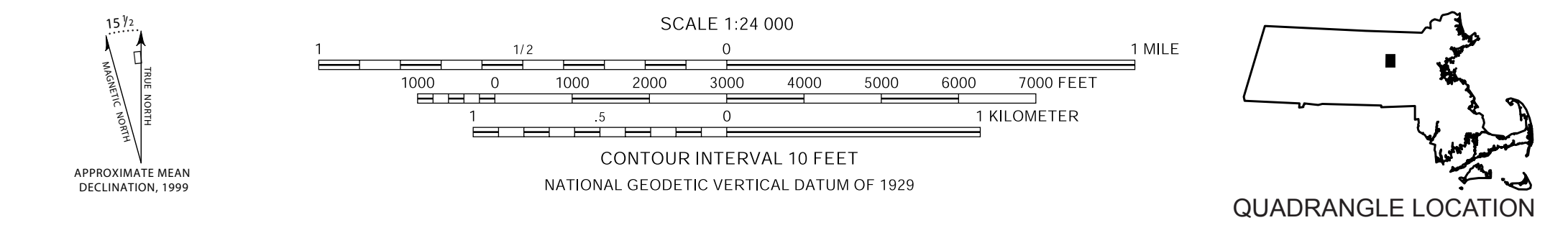
The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the University of Massachusetts, Commonwealth of Massachusetts, and the United States Federal Government.

This digital conversion is an interim product of ongoing research that was supported by U.S. Geological Survey, National Cooperative Geologic Mapping Program, under assistance Award No. G11AC20251

Citation:
Kopera, J.P., 2012, Digital conversion of Peck, J.H., 1975, Preliminary bedrock geologic map of the Clinton quadrangle, Worcester County, Mass., U.S. Geological Survey Open File Report 75-658, 30 p and 3 sheets, 1:24000 scale. Massachusetts Geological Survey: University of Massachusetts, Amherst. Scale 1:24,000. 1 sheet and digital product: Adobe PDF and ESRI ArcGIS database.

This map was produced on request directly from digital files (PDF format) on an electronic plotter. Due to the variety of electronic plotters, printers, and papers that can be used to reproduce this map, the Massachusetts Geological Survey cannot guarantee that printed versions will retain cartographic accuracy tolerances used in map production (FGDC-STD-013-2006, Section 4).

A digital copy of this map (PDF format), including GIS datalayers, is available at *http://www.geo.umass.edu/stategeologist*



EXPLANATION OF MAP SYMBOLS

Contact: inferred in all areas except where coincident with outcrop symbol

Fault, U, upthrown side; D, downthrown side. Arrow shows direction of dip where known. Dotted where beneath water. Half arrows show relative strike slip movement

Thrust Fault: sawteeth on upper plate; arrow shows direction and amount of dip where known

Metamorphic Isograds:
sillimanite - sillimanite-muscovite
andalusite - andalusite, chiastolite
garnet + staurolite - garnet-staurolite

Data insufficient to draw other boundaries

Pattern shows area of mylonitized and brecciated rock. Areas contain many exotic slivers not related to major parent rock but which cannot be shown separately.

EXPOSURE

Solid - Individual outcrops. Where in non-stippled area surrounded by stippled area, delineates where rock is just below ground surface.

Stippled areas show where bedrock is inferred to be 10 feet or less beneath the ground surface.

Abandoned quarry

PLANAR FEATURES

Editorial Note: The intersection of the ends of symbols denote the locations of measurements when there is more than on measurement per location.

Strike and dip of bedding; ball indicates tops were determined from sedimentary structures. Tic on both sides of symbol indicate vertical dip.

Overturned bedding and / or foliation parallel to bedding; ball indicates tops were determined from sedimentary structures.

Strike and dip of mineral foliation.. Tic on both sides of symbol indicate vertical dip.

Strike and dip of parallel bedding and foliation. Tic on both sides of symbol indicate vertical dip.

Strike and dip of fracture cleavage

Strike and dip of slaty cleavage (closely spaced slip Cleavage). Tic on both sides of symbol indicate vertical dip.

Strike and dip of axial plane of small fold in bedded rock or of foliaiton; arrow shows bearing and plunge of fold axis

Strike and generalized dip of beds crumpled by chevron folds with subhorizontal axial planes. Tic on both sides of symbol indicate vertical dip.

Strike and dip of quartz vein or aplite dike. Tic on both sides of symbol indicate vertical dip.

Strike and dip of shear or crush zone. Tic on both sides of symbol indicate vertical dip.

BRITTLE PLANAR FEATURES

Strike and general direction of dip of curved fault surface. *(Editorial note: dip arrows not shown on map as they could not be discerned for any faults on blue-line prints used for digitzation)*

Strike and dip of small fault. White dot shows where measurement was taken.

Strike and sense of movement of small slip

Strike and dip of joint. Tic on both sides of symbol indicate vertical dip. White dot shows where measurement was taken.

LINEAR FEATURES

Bearing and plunge of small fold axis

Map sense of small folds looking down plunge: may be combined with fold axis symbol

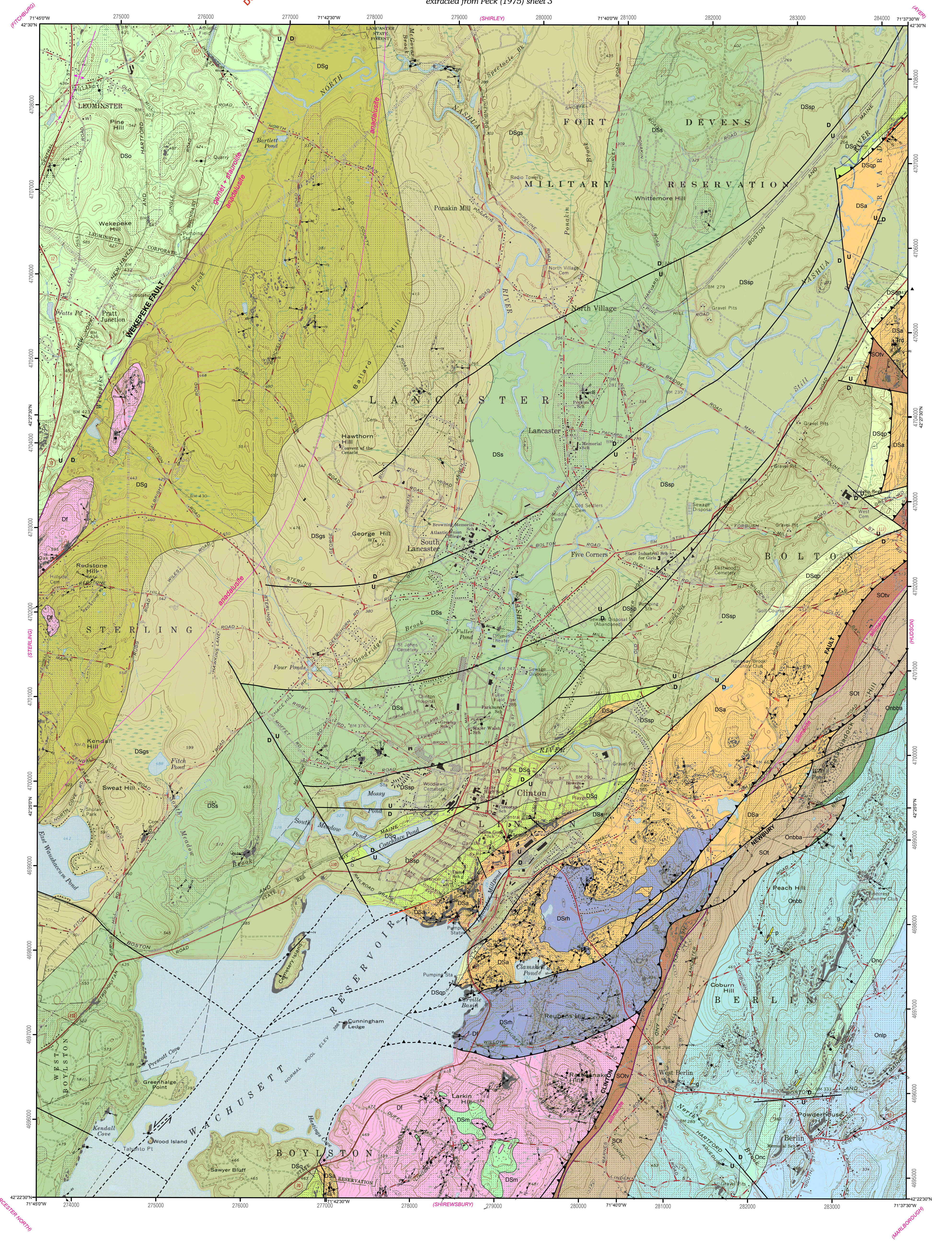
Bearing and plunge of crinkles on bedding or foliation combined with bedding or foliation symbol

Bearing and plunge of aligned minerals. Symbol may be combined with bedding or foliation symbol

Cross section lines shown on Peck (1975) are not included in this product as no cross sections were apparently published as part of Peck (1975)

Joints and Brittle Faults

extracted from Peck (1975) sheet 3



EXPLANATION OF MAP UNITS

from Peck (1975)

Trd
Diabase

Diabase, dark greenish gray to dark gray weathering brownish gray. Fine-grained porphyritic near border. Medium-grained even textured away from edges, columnar jointed. Composed of fabradorite, angite, and biotite with accessory magnetite, calcite, and quartz. Dike about 40 feet thick.

Df
Fitchburg Granite

Granite, light gray, medium to coarse-grained well foliated to nonfoliated, consists of quartz microcline and/or orthoclase, albite-oligoclase, and muscovite. Biotite is present in some localities but not in most. Tourmaline is a characteristic accessory mineral. Minor accessories are garnet, magnetite, apatite and zircon. Forms resistant knobs. In the southeastern area of outcrop has many small inclusions and some larger mapped roof pendents of calcareous metasiltstone (DSm). The small outcrops in the northwestern belt may be part of a larger body at depth which might be the cause of the andalusite grade metamorphism in the surrounding rocks. Was quarried at Larkin Hill for use in building Wachusett Dam. Strongly sheared near the Clinton-Newbury Fault and near the Wekepeke Fault. Not metamorphosed, but fractured to varying degrees. Quartz veins cutting the rock are common.

DSa
Ayer Granodiorite

Light to medium gray, medium to coarse-grained, porphyritic, granodiorite or quartz monzonite. The rock weathers light gray to dark gray. Consists of quartz, microcline, albite-oligoclase, biotite and chlorite. Minor constituents are muscovite, epidote, sericite, apatite, zircon, garnet, and magnetite. Phenocrysts of microcline, often in Carlsbad twins, are abundant and constitute as much as 20 percent of the rock in many outcrops. The phenocrysts are as much as 15 cm. long on the islands in Carville Basin but are usually 4 to 8 cm. long and about 2 or 3 cm. wide. The composition is about evenly distributed between that of a granodiorite and a quartz monzonite. The rock is strongly foliated in some locations especially near the borders. Elongate xenoliths parallel to the walls are common near contacts. The granodiorite is apparently a syntectonic intrusive because it parallels the structure of the invaded rocks, it is strongly foliated near the contacts, and it has protoclastic textures suggesting it was injected during stress conditions. The phenocrysts are all fractured with feldspar or quartz filling the fractures in some places, but with calcite filling the fractures near faults. Quartz is granulated and matrix feldspars are fractured and granulated to some extent. Biotite is in thin sheets many of which show banding and shredding. Much biotite has been altered to chlorite.

In the northeastern part of the quadrangle the Ayer has been brecciated and mylonitized and, although it retains its felsic character, becomes so strongly sheared as to obliterate most of the original igneous texture. These areas are shown as Ayer Granodiorite but contain significant amounts of other rock types as thin slivers and blocks. The extent of mixing of rock types into the shear zones sometimes produces a strongly foliated rock with the appearance of a conglomerate. Contact phases of the Ayer are non-porphyritic in a few places but not in most.

DSg
Metagraywacke, and chiastolite schist

Medium to dark gray metagraywacke weathering light to medium gray and medium to dark gray chiastolite schist and medium to dark gray phyllite with or without chiastolite porphyroblasts. The schist and phyllite weather dark gray, the more granular layers weather a lighter gray. Well bedded in thin to very thick graded beds. Cross lamination in the metagraywacke is common. Metagraywacke composed chiefly of quart: plagioclase, biotite, chlorite, muscovite and some carbonaceous material. Schist and phyllite are composed mostly of quartz, sericitic carbonaceous material, and large porphyroblasts of chiastolite and andalusite. Small 1mm or less porphyroblasts of garnet, many showing retrograde alteration to chlorite are abundant in fresh rock below the zone of weathering but are not seen in weathered outcrop. Graded beds are characteristic of the unit and consist generally of greater than 50 percent sand to silt size granular metagraywacke grading upward to dark gray very fine grained, quartz sericite schist or phyllite containing randomly oriented porphyroblasts of chiastolite or pink andalusite. The porphyroblasts (many of which are altered to muscovite) are as much as 1.5 cm. in diameter and 16 cm. long although most are about 1/2 cm. across and 3 or 4 cm. long. Near Ballard Hill, rock in this unit is below the andalusite isograd and the phyllite in the upper parts of graded beds has no andalusite but probably has garnet. Cross laminations in the metagraywacke indicate current transport from a westerly direction. This unit corresponds to the "Chiastolite schist facies of the Worcester Phyllite" of Emerson, 1917 and unit 4 of Peck (1976). Cut by medium to light gray quartz veins, mostly iron-free, a few cm. thick. Veins are mostly late, cross-cutting both bedding and cleavage but some are folded with axes parallel to cleavage.

DSgs
Phyllite and Metagraywacke

Dominantly dark gray phyllite with thin layers of med. gray metagraywacke. Phyllite weathers med to dark gray; metagraywacke weathers med to lt gray. Phyllite is very fine grained, consists of quartz, sericite, chlorite, and carbonaceous matter. Accessory minerals include tourmaline, garnet, pyrite, plagioclase, muscovite and rarely calcite. Metagraywacke is mostly silt size quartz and plagioclase with muscovite, biotite and chlorite and accessory pyrite, zircon, and calcite. The phyllite and metagraywacke are well bedded in graded beds; usually thin to medium bedded. Percentage of phyllite in graded bed is greather than that of metagraywacke, usually between is 10 and 40 percent. Cross laminations are common in the metagraywacke parts of the graded beds. Rocks of this unit show strong is- development of slaty cleavage which is often refracted at the phyllit-metagraywacke boundary. Forms poor outcrop. Apparently weathers more rapidly than other units, or was eroded more deeply by glaciation. No contacts with either the overlying or underlying units are exposed, but presumably these rocks are gradational and conformable with units above and below. Previously mapped as Worcester Phyllite by Emerson, 1917. Constitutes the upper part of Unit 3 of Peck (1976). A few lenses of calc-silicate bearing meta-siltstone occur within this unit a short distance southwest of the quadrangle along the shore of Wachusett Reservoir. Characterized primarily by the greater percentage of phyllite than metagraywacke in thin to medium graded beds. Cut by quartz veins similar to overlying unit.

DSs
Slate and Phyllite

Medium to dark gray, very fine grained even textured slate and phyllite. Weathers dark gray with some rusty spots from oxidation of pyrite. Mostly quartz, sericite, chlorite, and carbonaceous material with accessory pyrite, feldspar, epidote, zircon, and calcite. Cut by thin quartz veins consisting almost entirely of coarse crystalline white to gray quartz. Very little iron staining of veins. Forms locally prominent outcrops and is apparently somewhat more resistant to erosion than rocks above and below. Thin to medium bedded but bedding is usually obscure due to the lack of compositional differences between beds and to the strong development of slaty cleavage in the rock. Some outcrops can be classified as slate, others as phyllite only by the development of sericite flakes along the cleavage. The rock is sometimes hard to classify as one or the other. Some beds are graded with very thin metasiltstone or metagraywacke layers at the base. Most graded beds in this unit have less than 10 percent silt size constituents. Probably extreme distal turbidites originally with only the very finest detritus able to be transported to the site. Contains thin impure graphite layers in outcrops along Rt. 110 near the southwestern border of the quadrangle. Quarried previously for roofing granules in the quarry near the junction of Clinton, Sterling and Lancaster town boundaries Quarried from a number of scattered small pits for tombstones and roof slate in the late 1700's and early 1800's, mostly in the Town of Lancaster. Mapped previously as Worcester Phyllite by Emerson, 1917: Constitutes the lower part of Unit 3 of Peck (1976). May be correlative with Lower Devonian (?) slates and phyllites in southeastern New Hampshire and southern Maine, see Hussey, 1962 and Billings 1956.

DSsp
Metasiltstone and phyllite

Laminated metasiltstone and phyllite; minor calcareous metasiltstone. Metasiltstone is brownish-gray to light-gray, fine-grained, mostly well sorted, and consists dominantly of quartz with minor feldspar and ankerite (weathered to limonite) The weathered rock is a distinctive spotted brown from weathering of ankerite. Phyllite is very fine-grained, dark greenish gray, medium gray or locally light greenish gray composed mostly of quartz, sericite and chlorite. Phyllite weathers to a greenish gray or black. Natural outcrops are characterized by the alternating layers of brown siltstone and greenish phyllite. Fresh rock is mostly gray. Nearly the whole length of outcrop is characterized by small chevron folds with sub-horizontal axial planes accentuated by the thin laminae of the rock. The unit has persistent laminations very little cross lamination and is interpreted to be a deep marine deposit. Graded beds are rarely present. Conformable with quartzite below with a contact well exposed under the bridge along the railroad at the dam on Coachlace Pond in Clinton. Mapped previously as Oakdale Quartzite or Worcester Phyllite by Emerson, 1917. Comprises Unit 2 of Peck (1976). Assumed to be conformable with rocks above but contact is not exposed in the quadrangle. Metasiltstone and phyllite is well bedded, thin to thick bedded but all beds are sets of laminae. Characterized by distinctive brown weathering, alternating laminae of differing composition, and lack of any carbonaceous material. Forms poor outcrop, weathers rapidly to a brown soil containing small chips of siltstone. Cut by many small quartz veins many containing iron carbonate and/or limonite after iron carbonate. Chevron folding of this unit may be due to deformation in the upper plate of the Clinton-Newbury thrust.

DSq
Quartzite

Light gray to medium gray, even textured, very fine grained quartzite with thin layers of dark gray phyllite locally. Well bedded, thin to thick-bedded with some internal laminations. Mostly tabular bedded but some lenticular beds present Forms resistant outcrop especially along the contact with the Ayer Granodiorite which intrudes the quartzite. Grades laterally to interlayered gray phyllite and thin quartzite (DSqp). Probably a submarine channel filling or winnowed shoal deposit. Is not persistent along strike. Underlain gradationally by interlayered gray phyllite and thin quartzite with contact fairly well exposed on the east side of the hill south of Hastings Cove at the southern boundary of the quadrangle. Closely jointed in most outcrops. Very tough and breaks into sharp fragments. Interbeds of dark gray phyllite as much as 10 cm. thick occur within the unit but are more common near the top and base. Conformable with overlying metasiltstone and phyllite.

Composed almost entirely of very fine grained quartz showing relict detrital grains. Some secondary iron mineralization along joints near major faults. Included in the Oakdale Quartzite of Emerson, 1917. The Tower Hill Quartzite member of the Boylston Formation of Grew, (1973). Constitutes Unit 1 of Peck (1976).

DSqp
Quartzite and phyllite

Light gray to medium gray very fine-grained quartzite interlayered with dark gray to silver gray phyllite. Proportions of quartzite and phyllite vary considerably within the unit. Grades laterally into, and in places underlies, quartzite (DSq). Apparently a lateral equivalent of DSq but probably also somewhat older. Underlies presumably conformably, interlayered metasiltstone and phyllite of unit DSsp but contact is not exposed. Phyllite sometimes makes up more than 50 percent of outcrop; in other places somewhat less. Mostly very thin to thin bedded, alternating between quartzite and phyllite. Graded beds not conspicuous. Quartzite is nearly all very fine granular quartz showing relict detrital structure with some sericite locally present. Phyllite is mostly very fine quartz and sericite with some carbonaceous material locally. Cleavage is locally strongly developed in the phyllite but not in the quartzite layers. Strongly deformed, sheared and contorted where adjacent to faults. Difficult to recognize individual beds in sheared areas. Similar in many respects to Units DSqs except for the paucity of graded beds. Similar to Unit SOtv except for the lateral gradation into quartzite and the structural setting. Beds included in this Unit were mapped in the Hudson quadrangle by Hansen (1956) as Worcester Formation and/or Vaughan Hills Member of the Worcester Formation. Not described separately by Peck (1976). Forms very poor outcrop, generally seen only near contacts with more resistant rock.

DSo
Oakdale Formation

Chiefly medium gray, olive-gray, purplish-gray and greenish-gray granulose quartz plagioclase biotite schist weathering light-to medium brownish gray. Contains thin beds of dark gray quartz, biotite, garnet, staurolite schist and thin lenses and pods of greenish-gray calc-silicate rock. The chief rock type is well bedded in thin to medium beds commonly laminated or cross laminated poorly to moderately foliated; and fine to medium (0.3 to 1 mm) grained. Consists of quartz oligoclase-andesine, and brown biotite. Minor amounts of chlorite, actinolite, garnet, staurolite, muscovite, and calcite are present. At some localities the calcite content is high enough to react vigorously on application of dilute HCL. Brown biotite has altered to chlorite along fractures yielding a green mottling effect in hand specimen. Foliation is not strongly developed and the rock is very granulose, Previously has been called "quartzite" or "feldspathic quartzite". Characterized by the distinctive brown biotite, the purplish-gray to greenish gray color of the fresh rock and the even textured granular nature resembling a micaceous fine grained sandstone. Dark gray schist interbeds are strongly foliated and have black or very dark brown biotite. Garnet and staurolite are more common in these more pelitic schists than in the granular rock. Calc-silicate pods and lenses are common within the rock section and consist mainly of quartz, epidote and actinolite. Some layers contain calcite, and grossularite garnet.

At one locality marked "K" on the map pegmatitic pods within the rock are composed of interlocking aggregates of coarse grained perthite, kyanite, and chlorite; and fine grained secondary muscovite. Forms poor outcrop but underlies at shallow depth much of area northwest of the Wekepeke Fault. May correlate with the Berwick Formation of southern Maine and New Hampshire and with the Hebron Formation of northeastern Connecticut.
Editorial Note: "K" location not found on paper blueline.

DSrh
Reubens Hill Igneous Complex

Greenish-gray chlorite hornblende schist, dark greenish gray amphibolite, medium gray to brownish-gray plagioclase, biotite, quartz schist, greenish gray diorite, and plagioclase, hornblende, biotite, chlorite schist. Unit consists of rock types which were derived originally from mafic to intermediate flows, tuffaceous sediments, tuffs, hypabyssal intrusive rocks, intrusion breccias and intrusive diorite. Most of the more northerly body seems to have been diorite which retains the look of an intrusive rock. This body is intruded irregularly by the Ayer Granite. The diorite is fine to medium grained and consists mostly of saussuritized plagioclase (andesine?) hornblende and biotite. Some of this intrusive rock is also present in the southernmost outcrop area but its relations with the volcanic rocks are obscure. Chlorite, hornblende, epidote, plagioclase schist forms much of the outcrop at Carville Basin and on Reuben Hill. This medium-to coarse-grained schist was originally a submarine basalt flow. Chemical analysis indicates that it probably was an olivine rich oceanic basalt. Structures resembling pillows are fairly common and seem to support an origin as a submarine flow. A few pods of dark gray to black rock within the chlorite hornblende schist are composed of very coarse augite with finer hornblende in fractures These may be relict lithic fragments incorporated in the flow rock. Much of the rock in this unit is bedded and apparently is intermediate composition andesitic crystal tuff or aquagene crystal lithic tuff. Other bedded rocks are apparently basaltic tuffs with very fine laminations still preserved. The mutual relationships among all the different rock types is very complex and has not been deciphered sufficient to map meaningful subdivisions within the complex. Its heterogenity is its most prominent characteristic.

Bedding within the unit is very thin to very thick. Fragments of preexisting rock types are common in the volcanic and shallow intrusive rocks.

This unit is the Reuben Hill Amphibolite of Skehan, 1968. The diorite of Crosby (1899, p. 75-77) and the Straw Hollow Diorite of Emerson, (1917). Part of the unit is diorite but the predominant rock types are schists and amphibolites derived from basic to intermediate volcanic rocks.

DSm
Metasiltstone

Light brownish gray to light gray metasiltstone and calcareous metasiltstone with some beds of dark gray knotted phyllite. Mostly this bedded laminated metasiltstone containing very fine granular quartz, plagioclase, brown biotite, and chlorite with locally significant amounts of calcite. Weathers light brown, Forms large folded roof pendents in the Fitchburg Granite near the southern boundary of the quadrangle and as a bedded sequence in a fault block near Reubens Hill. Interbedded with the metasiltstone in the fault block are thin beds of phyllite consisting of quartz, sericite, and some biotite and chlorite. Knots within the phyllite consist of granulated quartz with possibly some other quartz-like mineral (cordierite?). Data from Skehan's (1968) tunnel samples show that the metasiltstone is interlayered in the lower part of the Reubens Hill igneous complex but this relationship is not seen at the surface. A few calc-silicate minerals are present near the contact with the Fitchburg, notably actinolite.

SOtv
Vaughan Hills Member of Tadmuck Brook Schist

Quartzite, quartz-sericite schist, and gray phyllite interlayered. Dominantly thin beds of light gray thinly laminated quartzite alternating with thin layers of greasy light gray to greenish gray quartz sericite schist or dark gray phyllite consisting of quartz, sericite and some carbonaceous material. Generally very thinly bedded but bedding often obscured by contorted folding and strong shearing near the Clinton-Newbury fault. Weathers gray, light greenish gray or reddish rusty brown from breakdown of iron sulfides. Forms the upper part of the Tadmuck Brook Schist and is cut out in many places by the Clinton-Newbury fault. Near the contact with the lower part of the Tadmuck Brook may contain some andalusite porphyroblasts and biotite pseudomorphous after staurolite. Separated from the lower Tadmuck Brook Schist by having more than quartzite beds and is somewhat more phyllitic. Not an easily separable unit, contact arbitrary. Very highly sheared in many places.

SOt
Tadmuck Brook Schist

Light brown, light-gray to dark gray, greenish gray and yellowish gray sulfidic muscovite quartz, biotite, sillimanite schist, sulfidic muscovite, quartz, biotite, sillimanite schist, sulfidic muscovite, quartz, biotite andalusite, staurolite schist, and some dark gray phyllite. Much of the rock is strongly sheared and bedding is obscure but some quartzite beds within the schist outline original bedding which in most places is parallel to the foliation. Sillimanite is present in most outcrops. Large knots of andalusite and the carbonaceous variety chiastolite are present along the belt southwest from Lancaster Road in Berlin. The quartzite beds interlayered in the schist are not very abundant and are feldspathic and micaceous. Numerous quartz veins, many of which also parallel the foliation are present. The schist is characterized by its rusty weathering and its content of pyrrhotite and/or pyrite which gives the rusty outcrops a distinctive yellowish to greenish tinge. The sulfide weathers rapidly yielding a white soluble efflorescence during dry weather. Many of the porphyroblasts are altered. Andalusite to sericite and staurolite to biotite to chlorite. Mapped by Hansen (1956) in the Hudson quadrangle as Mica Schist Facies of the Worcester Formation, Shown by Emerson, (1917) as the Brimfield Schist, Described and named by Bell and Alvord (1976). Forms low punky outcrop. A very distinctive unit.

Onbba
Amphibolite bed in Beaver Brook Member of Nashoba Formation

Dark greenish gray fine to medium grained amphibolite composed mostly of quartz, andesine, and dark green hornblende (or other amphibole). Interlayered with quartz, oligoclase, biotite gneiss and minor quartz, plagioclase, biotite schist. Forms a recognizable unit only in the northeastern part of the outcrop belt on Wataquodock Hill apparently pinches out to the southwest by thinning of the amphibolite beds and fingering laterally into gneiss and schist. Some thin to thick beds of amphibolite occur near the top of the Beaver Brook Member farther southwest but are not abundant enough to map in a separate unit. A continuation of the amphibolite unit at the top (base) of the Nashoba Formation mapped by Hansen (1956) in the Hudson quadrangle. Amphibolite is in thick to very thick beds, often thinly laminated. Hornblende is elongate parallel to foliation and bedding. Possibly a basaltic tuff or thin flow which is thicker to the northeast. Gradational with and intertongues with gneiss and schist of the Beaver Brook Member. Contact with the overlying Tadmuck Brook is apparently conformable but may be an unconformity, because of the abrupt change in lithology and chemistry of the original sediment and because of regional apparent cutoff to the northeast and southwest along strike.

Onbb
Beaver Brook Member of Nashoba Formation

Medium gray to dark gray medium to coarse grained quartz, oligoclase, biotite, muscovite, sillimanite gneiss with interlayered but relatively minor amounts of quartz-oligocf^se, biotite garnet schist, sulfidic quartz biotite, muscovite garnet schist fine-to medium grained amphibolite, and calc-silicate gneiss Amphibolite beds occur at the top just below the Tadmuck Brook Schist in some localities, Amphibolite and calc-silicate gneiss is more abundant near the bottom of the unit and may grade into the calcareous marker unit (Onc) below. Bedding is mostly thin to medium, tabular to lenticular and crosslamination is recognizable in some of the beds. Contorted into apparent flow folds in many outcrops. Well jointed. Some schist layers have abundant garnets some as much as 2 cm across but mostly 1/2 cm or less. These garnetiferous schist layers are sulfidic and sillimanite rich but thin and apparently discontinuous. The gneiss probably constitutes more than 60 percent of the unit. Gneisses and schists are strongly foliated with bedding and foliation essentially parallel.

p

Pegmatites consisting of microcline, albite, quartz, biotite and muscovite are common and intrude the gneiss conformably or cross cut at a very slight angle. Two have been shown on the map but most are too small. They constitute a fairly large part of some outcrops within this unit.

g

Small bodies of light gray fine to medium grained even textured biotite granite intrude the Beaver Brook Member, two small dikes are shown on the map. Most are too small to show. The granite is probably similar to and correlative with Acton Granite mapped by Hansen (1956) in the Hudson quadrangle The granite is late and cross cuts the foliation in the gneiss.

Onc
Calcareous marker bed

Light gray, light greenish gray, light pinkish gray marble dark greenish gray amphibolite, purplish to brownish gray biotite schist, dark gray biotite schist, medium gray muscovite, biotite garnet schist and greenish-gray diopside-tremolite calc-silicate gneiss. Thin to medium bedded, well foliated, alternating with each other and quartz, oligoclase, biotite, sillimanite gneiss as in the normal Nashoba Formation. Constitutes a mappable although not very resistant unit. Correlative rocks included in the base of the Beaver Brook Member by Bell and Alvord (1976). Marble beds are in sets up to 10 m thick but generally less than 1 m; amphibolite is medium to coarse grained and consists of hornblende or actinolite with quartz and andesine with some dark brown biotite. Biotite within the calcareous marker unit is generally brown to reddish brown. Marble beds are impure containing diopside, tremolite-actinolite, sphene. grossularite garnet, reddish brown biotite, scapolite and possibly some fosterite. Schists within the marker bed are garnetiferous and weather rusty brown. Most of the rocks within the marker unit weather rapidly and the marble beds weather to a brown punky rock leaving residual grains of calc-silicate minerals and quartz

Onlp
Long Pond Member of Nashoba Formation

Chiefly medium gray, medium grained, thin to medium bedded well-foliated quartz, oligoclase, biotite, muscovite, sillimanite gneiss. Garnet is locally common. A few thin to medium beds of dark green amphibolite occur locally. Pegmatites intrude the gneiss concordantly and constitutes as much as 25 percent of the rock but are too small to map. The pegmatites consist mainly of microcline, albite, quartz and biotite. Most are foliated to some extent. Very little schist is present in these rocks. The gneiss is unevenly to evenly banded, shows relict bedding, and in some localities cross laminations. K-feldspar is a common accessory as segregations parallel to foliation or as individual crysts. Sillimanite is present in nearly all outcrops but not abundant in most, The gneiss is composed mostly of quartz (40 percent), oligoclase (30) percent, biotite 20 percent; muscovite 5 percent and the remainder sillimanite, garnet, magnetite zircon, apatite, and chlorite. Folded into apparently plastic flow folds. Resistant, forms prominent knobby outcrops. Well jointed.

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