DRAFT BEDROCK GEOLOGIC MAP of the DEEP RIVER QUADRANGLE, NEW LONDON and MIDDLESEX COUNTIES, CONNECTICUT, USA (2019)

CGNHS OF19-1

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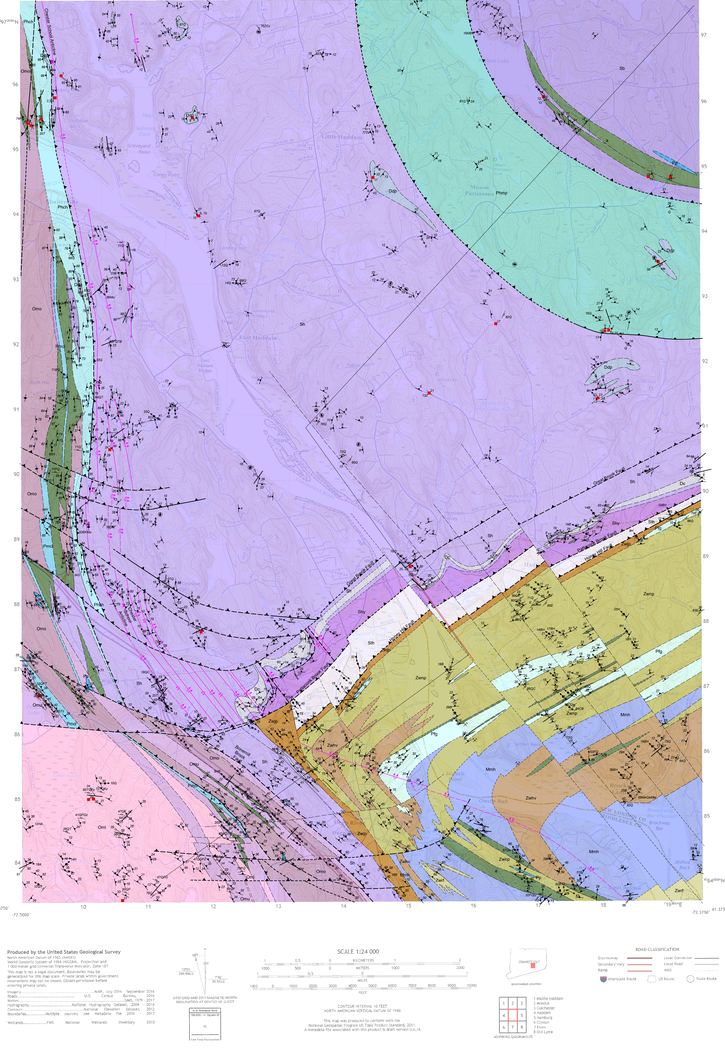

CORRELATION of MAP UNITS

Correlation of map units. Terranes had independent histories until Permian assembly.

EXPLANATION of MAP SYMBOLS

CONTACTS and FAULTS
solid where location is certain, dashed where approximate, dotted where concealed by water

- contact
- thrust fault
- normal fault

GEOLOGIC LINES
- overturned antiform
- overturned synform

PLANAR FEATURES
numbers indicate dip in degrees, letters refer to minerals defining each structure

- horizontal foliation
- inclined foliation
- vertical foliation
- overturned foliation
- inclined mylonitic foliation
- vertical mylonitic foliation
- inclined axial plane of fold
- vertical axial plane of fold
- cataclastic layering in axial plane of fold
- inclined vein
- vertical vein
- transposed vein
- pseudotachylite
- blastocataclastic layering
- ductile thrust fault
- inclined brittle fault
- vertical brittle fault

LINEAR FEATURES
- mineral lineation
- fold axis
- slickenline, thrust/reverse sense
- slickenline, normal sense

OTHER FEATURES
- sample locality
- abandoned quarry
- trench
- drill hole
- projected trace of drill core

Key to mineral abbreviations:
(minerals listed in decreasing order of abundance, or from core to rim where zoned)

Q	quartz
F	feldspar
K	K-feldspar
B	biotite
Mu	muscovite
Mt	magnetite
T	tourmaline
E	epidote
H	hornblende
A	anthophyllite
Z	zeolite
S	sillimanite
G	garnet
C	chlorite
Cc	carbonate
Su	sulfate
Io	Iron oxy/hydroxide
z	zoned, minerals listed from core to rim
e	euhedral

INTRODUCTION

After much bedrock geologic quadrangle mapping in Connecticut had been completed, Dixon and Lundgren (1968) proposed a regional structural synthesis for eastern Connecticut, based on the lithologic correlations of "basement" gneisses and "cover" metasediments across major fold nappes (Lundgren, 1962). However, as more local and regional geochronologic, geochemical, and thermobarometric data have become available, the application of the hypothesis of lithotectonic terranes in New England (Zen, 1983) has found increasing support with the identification of terranes in central and northern New England with at least partly unique geological histories (e.g. van Staal et al., 2009). This work challenged the interpretations of southern Connecticut geology that led to the stratigraphic correlations of coastal New England with Bronson Hill rocks. The present work was undertaken in part to reevaluate the stratigraphic and structural relationships upon which the interpretations of fold nappes were made, in the light of new concepts of lithotectonic terranes.

Since Pencu=Va (1842) mapping, the Deep River area was identified as an area critical to unravelling regional tectonic interpretations, because four major units now understood to be parts of three distinct terranes converge in this area. Legacy mapping was available to us (Lundgren, 1962; 1964; London, 1989; Wintsch, 1994), and topical studies have followed (Wintsch (1985; Wintsch and Aleinikoff, 1987; Wintsch et al., 1990a; 1990b; Wintsch et al., 1992). With a new understanding of ductile faulting, ductile fault rocks (London, 1988; Dipple et al., 1990), and a metasomatic-non-sedimentary origin of aluminous rocks that now contain sillimanite (Wintsch and Ambers, 1988), some schistose rocks in the map area formerly interpreted to be not correlated with metasediments are here mapped as ductile fault zones. What has emerged is a map that strongly supports the concepts of lithotectonic terranes, with structures that reflect intense and high-grade metamorphism and deformation caused by the lower crustal assembly of the three terranes during the Alleghanian orogeny.

DESCRIPTION of MAP UNITS

Major ductile faults separate the rocks in this quadrangle into three terranes. Rocks are described in the terranes in which they occur. In the following descriptions minerals are listed in the order of decreasing abundance. Mineral names in parentheses are not everywhere present. Grain sizes are defined as follows: fine grained, <0.06 mm; medium grained, 0.06 to 2.0 mm, and coarse grained, > 2 mm. Descriptions include observations made of continuous drill core from a 1500 foot deep hole drilled below Gillette Castle (Ambers et al. 1987).

All Terranes

Pp Pegmatite. White to buff weathering, coarse- to very coarse-grained, poorly to moderately foliated plagioclase-quartz-K-feldspar-(muscovite)-(garnet) granite in the Hebron Formation, and microcline quartz-plagioclase-(muscovite) granite in all units. Most dikes and sheets are up to two m wide and five m long and are too small to show on the map. Bodies generally lack mineralogical and textural zoning, but textures and the presence of euhedral muscovite suggest they are not anatectic in origin. Pegmatites commonly intrude ductile fault zones, especially in the Bonemill Brook, Mt Parnassus faults. In the Chester area they commonly intrude the axial plane of Chester Mountain dome. Dikes in the hanging wall of the Pattaconk Brook fault. Tan to pink weathering, massive, unfoliated, K-feldspar-plagioclase-(biotite)-(quartz) dikes 10-50 cm thick which cut the hinge and dip ~60°NW are common in all rocks south of Chester.

Bronson Hill Terrane

Pmcd Blastomylonite at Cedar Lake. Well-foliated, medium- to coarse-grained quartz-biotite-microcline-(anthophyllite) schist. Locally contains saucer-shaped lenses or nodules of sillimanite (partially retrograded to muscovite) approximately 1 cm thick and 1-15 cm in diameter. Rare planar sillimanite "antivenis" suggest the lenses were once continuous and have been disaggregated by ductile strain. Coarse grained muscovite-sillimanite-quartz-plagioclase-(biotite) nodules are abundant in the schist. Locally overprinted with randomly oriented muscovite porphyroblasts. Probably derived from Omu.

Pmch Cremation Hill blastomylonite. Tan and locally rusty weathering quartz-plagioclase-biotite-K-feldspar-(garnet)-(sillimanite)-(muscovite) migmatitic blastomylonite schist and gneiss. Dominant foliation surrounds and includes boudins and tectonic inclusions of pegmatite, plagioclase-quartz-biotite granular aplite, local amphibolite. Most common rock type in the map area. Commonly contains 5% of amphibole or clinopyroxene suggest that the rock was derived in part from the Hebron Formation. Mapped as the duckite Cremation Hill fault zone by London (1989).

Omo Monson Gneiss. Light to medium gray, medium-grained (0.5-1.0 mm), massively weathering, well foliated, biotite-muscovite-quartz-plagioclase-(microcline)-(garnet) granite gneiss. Protolith of tonalitic (normative granodiorite, 70 wt. %SiO2) and locally granitic composition. It is interlayered with amphibolite and with three distinct layers each approximately 3 mm thick. The biotite-rich layers commonly host a conspicuous, subhorizontal lineation of biotite streaks, and quartz-feldspar rods are common but less conspicuous. Concordant lenses and boudins of dark gray to black medium-grained granular hornblende-plagioclase-biotite amphibolite constitute 10% of most outcrops. Exposures near State Route 148 contain 0-10% orthoamphibole in blades 1-5 cm long that define a subhorizontal lineation. The number tight clustering of oscillatory zoned euhedral grains in a granitic phase give a late Ordovician age (451 ± 5 Ma) age (Aleinikoff et al. 2007) interpreted to be the age of the Monson gneiss.

Middletown Complex (from Aleinikoff et al. 2007)

Omu Upper member, Middletown Formation. Light gray to buff weathering, medium- to coarse-grained, moderately to strongly foliated and layered quartz- plagioclase-biotite-(microcline)-(garnet)-(amphibole)-(diopside) schist and gneiss. Foliation is defined by a strong preferred orientation of biotite and, where present, amphibole;flat frequently occurs parallel to a compositional layering defined by biotite ± amphibole-rich and poor layers. Amphibole/fibrolite needles up to 20 mm long define a northeasterly plunging penetrative lineation and constitute up to 30 vol % of the rock. Foliated amphibole sheets, some garnet-bearing, are intercalated throughout unit and vary in thickness from a few centimeters to several meters. Mapped as Cedar Lake belt of Monson gneiss by Lundgren (1963).

gar Garnet granofels and mylonite. Dark gray to black on weathered surfaces, red to purple on fresh faces. Contains 30-70% garnet with minor quartz, biotite, and opaques. Rock ranges from up to 2m thick to as thin as 2 cm. Garnet generally occurs as subhedral to euhedral grains 1-2 mm in diameter. Rare, but sillimanite bearing biotite schists mapped by Lundgren (1963) as Brimfield Formation are interpreted here to be metamorphosed ductile fault zones in Sbh that carry no stratigraphic significance; they are not mapped separately here. A late Silurian age is constrained by the youngest ages of detrital zircons, and the Early Devonian age of intrusion of the Canterbury Gneiss (Wintsch et al. 2007).

Shy Yantic Member, Hebron Formation. Light and medium gray weathering, medium- to coarse-grained, quartz-plagioclase-muscovite-biotite-(K-feldspar) blastomylonite, schist and gneiss. Distinctive 1-5 cm thick layers of quartz-plagioclase-microcline granofels are present in most outcrops and is characteristic of the rock. Common porphyroblasts of plagioclase 0.5-4 cm in diameter define an augen gneissic texture. Lower sharp contact marked by amphibolite. Sharp but interlayered upper contact with Hebron Formation. Interlayering suggests that both the Yantic member and Hebron Formation were as fault slices near the structural base of the complex. Contains a lens of olive gray to greenish gray weathering, medium-grained, moderately well foliated, well layered quartz-plagioclase/biotite-microcline-epidote schist, approximately 10 m thick and 200 m long exposed only on the south slope of Story Hill. The 27 m thickness under Gillette Castle is less than one third of the thickness present in the type section of Dixon (1964). Mapped by Lundgren (1963) as part of the Putnam gneiss and included by Dixon (1964) as a member of the Tatnic Hill Formation, but redefined by Wintsch et al. (1993) as a member of the Hebron Formation, and here as a unit within the Hebron Complex.

Tatnic Hill Formation. The Tatnic Hill Formation of Dixon (1964) is redefined here as including only a pelitic biotite-garnet-sillimanite schist. This is mapped as an unnamed "lower member" of the Formation. Her calcareous, "upper member and coarse-textured, quartz-plagioclase-biotite-K-feldspar-muscovite-biotite-hornblende-epidote-(diopside) gneiss" of the Tatnic Hill Formation are considered here to be part of the Hebron Complex.

Sth Tatnic Hill Formation. Buff to reddish brown weathering, fine to medium -grained, moderately well foliated quartz-plagioclase-biotite-(garnet)-(sillimanite)(K-feldspar) schist and augen gneiss. The rock is exposed only as a fault slice between the Honey Hill and Pattaconk Brook faults. Garnet-rich rock predominates near Old Depot Road and sillimanite and fibrolite constitute up to 5% of the rock near downtown Chester. Dark gray to black boudins of medium grained granofelsic hornblende-plagioclase (garnet) amphibolite are present near Old Depot Road. The unit is poorly exposed, and highly folded and cut by shear zones that probably define tectonic blocks (see Wintsch, 1979) now understood to be rotate boudins. Total thickness under Gillette Castle is 70 m. This is as little as 10% of the thickness in the type area of Dixon (1964), and suggests that much of this unit has been cut out by the Honey Hill and Pattaconk Brook faults. The correlation of this rock with the Tatnic Hill Formation is based in part on lithologic similarities, and on structural position between rocks of the Avalon and Environmental Sciences, Wesleyan University A maximum age of deposition of late Silurian is defined by detrital zircons and a minimum age of early Devonian is defined by metamorphic monazites (Wintsch et al. 2007). Mapped as part of Putnam gneiss by Lundgren (1963).

Merrimack Terrane

Sb Brimfield Schist. A strongly banded feldspar, quartz, biotite (garnet) schist, gray in fresh surfaces and rusty in weathered surfaces and especially in joints. Bands are 1-3 mm thick and composed of grains 0.25 to 1.0 mm in diameter in alternating layers that are biotite-rich and biotite-poor. Muscovite flakes up to 1 mm in diameter ornament the biotite schistosity but generally do not define the schistosity and so are interpreted to be retrograde. These bands anastomose around granitic and pegmatitic boudins as small as 2 mm thick but as thick as several meters. Most boudin necks are filled with feldspar. Local S-C fabrics suggest SE vergence. Garnet is present in some biotite schist layers. Coarse-grained (2-4 cm) feldspar-quartz-muscovite-biotite pegmatite dominates natural outcrops on hilltops because they are more resistant to weathering than is the host schist. Deposited in late Silurian as constrained by the ages of detrital zircons, and the age of a mafic intrusion several km north of the Deep River area (Wintsch et al. 2009).

ai Amphibolite. Black, massively weathering, medium to coarse grained, massive to moderately foliated, hornblende-plagioclase-(epidote)-(biotite) amphibolite. Preferred orientation of amphibole increases with strength of foliation. Geochemical compositions (high FeO/MgO ratios) show all the amphibolites are derived from tholeiitic basalts.

Hebron Complex

A new term introduced here to recognize that map units in this domain include both metasedimentary and meta-igneous rocks. These include the amphibolite facies rocks of both orthogneiss and a less well-known orthogneiss mapped by London (1989) named here the Bogwood Pond gneiss. It also includes the metasedimentary Hebron Formation and strongly deformed fault rocks derived of the three terranes during the Alleghanian orogeny.

Phmp Mt Parnassus Blastomylonite. A dark gray weathering quartz-plagioclase biotite schist and granofels. Unit characterized by clasts of broken pegmatite, and individual broken grains of feldspar, quartz, and muscovite. Clasts are commonly elongate floating in a matrix of biotite, showing variable strength of preferred orientation. Broken grains are interpreted as comminuted pegmatite and the biotite-rich matrix is interpreted to be recrystallized Hebron Formation. The rock is thus a variably foliated blastocataclasite (Wintsch, 1998a). As the fault zones are approached the pegmatites are boudinaged and may become stacked upon one another. In the immediate footwall of the Mt Parnassus fault zone the pegmatites are commonly cataclasites with a grain size < 1 mm where feldspars are equant, quartz grains are elongate (parallel to a weak schistosity defined by 1%-biotite. This matrix hosts relic K-feldspar and, locally, muscovite book porphyroclasts up to 3 cm in diameter.

Dc Canterbury Gneiss. Gray to buff, massively weathering, medium- to coarse- grained, moderately to well foliated, poorly layered quartz-microcline-plagioclase-biotite(muscovite) and locally porphyritic granitic orthogneiss and granofels. Rock is commonly strongly deformed; it may be blastomylonitic or an augen gneiss containing porphyroclasts of microcline up to 3 cm in diameter and is locally cataclastic and blastocataclastic. Rock is strongly layered in the mile-long septum of gneiss south of Chester, and in highly strained overturned fold limbs north of Chester where the rock is mylonitic foliation containing quartz and feldspar rods 2 mm long was quartzite. Under Gillette Castle and north of Pattaconk Brook the unit is 14 m thick, but to the south it thins to ~ 7 m thick and further south thins out completely. Lower contacts exposed on the southeastern side of Story Hill and along the low ridge southeast of Jennings Pond are sharp. Zircons in this unit several km away yield a magmatic age of 414 ± 3 Ma (Wintsch et al. 2007). The narrow range of the zircon ages supports a magmatic origin, and its irregular outcrop pattern across the state (see Rodgers, 1985) supports an intrusive origin.

Ddg Dogwood Pond gneiss. Pale tan weathering, medium to coarse-grained K-feldspar-plagioclase-quartz-biotite granitic gneiss and granofels. Locally crosscutting, but typically transposed into foliation in the host Hebron complex. Mapped as granitic gneiss by London (1989). Geochronically distinct from the Canterbury gneiss based on Published (Snyder, 1964) and unpublished data.

Pbch Hebron Formation. Dark violet-brown, medium to fine grained, well foliated quartz-plagioclase-biotite-(garnet) schist dominates and dark gray to olive gray green weathering, medium-grained quartz-plagioclase biotite-hornblende-(epidote)-(diopside)-(clinozoisite)-(calcite) granofels. Small amounts of pyrite are present locally that cause the rock to weather a rusty brown. All compositional layering is transposed into the dominant foliation. Thin calcareous layers 0.5 – 4 cm thick are interlayered with 1 cm to 1 m biotite schist. In East Haddam biotite schist layers are up to 1 m thick, with subordinate calcareous layers 2-4 cm thick. Weathering accentuates foliation and can be mistaken for transposed compositional banding. Unit is isolated by the Mt. Parnasus fault above, and the Pattaconk fault at the base north of Chester, and by the Honey Hill fault south of Chester. Plagioclase-rich pegmatites up to 4 m thick are common especially as the fault contacts are approached. Pegmatites are generally strongly transposed into the foliation, showing that the dominant foliation is also transposed. In the hanging wall of the Pattaconk Brook fault layering is commonly < 3 cm thick (Gillette Castle State Park type area), and epidote-actinolite schist and granofels are common. Here boudinage of feldspar-rich rocks (Canterbury Gneiss and pegmatite) becomes pervasive. Garnet is most abundant (~1%) in western exposures near the Deerfield Brook fault. South of Chester olive gray, flaggy weathering, medium-grained, well-layered and well-foliated quartz-plagioclasebiotite biotite biotite schist dominates. This schistose felsic overprints a cataclasite derived from a stretcher of Hebron Formation rocks and abundant pegmatites that produced tectonic inclusions and porphyroclasts. A brownish-gray weathering, medium to coarse-grained well foliated mylonitic muscovite-quartz plagioclase-biotite schist is exposed only in the hanging wall of the Pattaconk Brook fault west of Conn. Rt. 9. The Hebron Formation includes London's (1989) and Lundgren's (1963) Hebron Formation, and the calc-silicate unit (pgg) in his Putnam gneiss. Rare, thin sillimanite bearing biotite schists mapped by Lundgren (1963) as Brimfield Formation are interpreted here to be metamorphosed ductile fault zones in Sbh that carry no stratigraphic significance; they are not mapped separately here. A late Silurian age is constrained by the youngest ages of detrital zircons, and the Early Devonian age of intrusion of the Canterbury Gneiss (Wintsch et al. 2007).

Avalon Terrane

Pg Permian granite. Buff to salmon weathering, medium- to coarse-grained, unfoliated, massively weathering quartz-plagioclase-orthoclase-magnetite-biotite gneiss and granofels. Weak foliation is defined by a preferred orientation of evenly disseminated, sparse biotite and locally flat quartz grits. Locally contains conspicuous red spots around magnetite crystals. Unit includes a porphyritic phase with 1 cm euhedral K-feldspar phenocrysts. Dikes intrude and include Zwbh and Zwhn, southeast of Chester. A Permian age is established by a U-Pb monazite age in the adjacent Essex quadrangle (Wintsch and Aleinikoff, 1987).

Ptg Permian foliated granite. Fine- to medium-grained, orange to pink weathering, microcline-quartz-plagioclase-magnetite-(biotite)-(garnet) schist. Foliation is defined by a strong quartz shape preferred orientation and, where present, discontinuous biotite flakes. Euhedral magnetite porphyroblasts up to 1 cm in diameter comprise 1-2% of the matrix have bleached halos and are locally broken into porphyroclast trails that are elongate in the stretching direction.

Mmh Granite Gneiss of Millstone Hill. Light pink to gray weathering, medium- to coarse-grained K-feldspar-quartz-plagioclase-biotite gneiss and granofels. Locally magmatic, and strongly foliated near shear zones. Contacts are now defined by ductile faults, but locally crosscutting relationships further east (Goldsmith 1985), and a Devonian age (Aleinikoff and Wintsch, unpub.) show that it is intrusive into Avalonian rocks. Mapped as Sterling Granite Gneiss by Lundgren (1963), included in the Potter Hill gneiss of the Sterling Plutonic Group of Rodgers (1985) and included in the gneiss of Millstone Hill by Wintsch (1994).

Ddf Gneiss of Devitt Field. A light to medium gray weathering moderately well foliated plagioclase-quartz-biotite-(hornblende) schist and granofels. Rock locally differentiated into biotite-rich schists and felspar and quartz-rich granofels. A Late Devonian age is based on the U-Pb age of zircon (Aleinikoff and Wintsch, unpub.) in a sample collected at the Devitt Field parking lot in Deep River.

Waterford Complex. The Waterford complex is composed of several intrusive igneous bodies strongly attenuated by strain along the Honey Hill fault caused by the tectonic wedging of the Avalon terrane into the Merrimack terrane (Wintsch et al. 2014). Its intrusive contacts are now defined by the schists and granofelsic rocks are conspicuously banded, but in the interior father than ~ 1 km from the fault rocks become more granoflesic, and locally migmatitic. Relative age relationships are uncertain.

Zwgn Jennings Pond Lithofacies. Medium gray weathering medium- to coarse- grained well-foliated and well layered plagioclase-quartz-hornblende-biotite gneiss interlayered with variable amounts of dark gray to black, massive to well foliated, medium grained hornblende-plagioclase amphibolite. The upper contact of the unit is everywhere cut by the Honey Hill fault. Northeast of Chester the lower contact is interlayered with Zwh. South of Chester the unit contains locally conspicuous randomly oriented (retrograde) muscovite. East of Jennings Pond the felsic rock is locally granofelsic, and amphibolite may occur in 14 m thick, but to the south it thins to 7 m thick and further south thins out completely. Lower contacts exposed on the southeastern side of Story Hill and along the low ridge southeast of Jennings Pond are sharp. Zircons in this unit several km away yield a magmatic age of 414 ± 3 Ma (Wintsch et al. 2007). The narrow range of the zircon ages supports a magmatic origin, and its irregular outcrop pattern across the state (see Rodgers, 1985) supports an intrusive origin.

Zwgn North Plain Lithofacies. A mixed assemblage of felsic to intermediate igneous granofelsic. Close to the Honey Hill fault it is a highly to medium gray weathering, medium grained, moderately foliated quartz-plagioclase-biotite-hornblende-magnetite gneiss and subordinate amphibolite and biotite amphibolite. The rock contains of porphyroclasts of feldspars apparently broken from deformed pegmatites making this rock a foliated cataclasite. The rock displays a moderately well-developed mineral lineation, Deeper below the Honey Hill fault the unit includes granitic, granodiorite, tonalitic, and basaltic compositions. Most rocks are 0.5 to 1.0 m in diameter granofelsic to weakly schistose with equal parts of plagioclase, quartz, and K-feldspar with accessory biotite. Schistosity is defined by the preferred orientation (1-2% biotite and by quartz and feldspar grains with aspect ratios of 1.5 -1.5. Granitic and granodioritic rocks may contain clasters of ~200 µm grains of magnetite in equant aggregates about 1 mm in diameter. In some dioritic rocks magnetite may occur as subhedral grains up to 1 cm in diameter. These are surrounded by white mafic-free haloes composed of plagioclase and lesser quartz. Granodioritic and dioritic rocks may also contain lozenge of amphibole/pyroxene 2 cm thick and 10-20 cm long. Felsic veins transposed into the strong NW trending banding and foliation are so common in all these rocks that they must be considered characteristic of these compositions. Rare layers in the unit (Shippey Hill) subdetrital K-feldspar phenocrysts up to 1 cm in diameter are locally preserved. In some rocks they are deformed into augen shapes up to 2 cm long, and in others 0.5 to 1 mm K-feldspar grains mm occur in elongate clusters 2-3 cm long. These observations suggest that the protolith was a porphyritic granite with variably flattened K-feldspar phenocrysts. Age is ~590 Ma as established by U-Pb age of magmatic zircon (Aleinikoff and Wintsch unpub.) in a rock just south of Depot road in Chester. Mapped as the Hadlyme belt of Monson Gneiss by Lundgren (1963), but reinterpreted as a stratigraphic unit by Wintsch et al. (1990), of Lae Proterozoic age (Zartman et al., 1988; Aleinikoff, unpub.)

Zwrf Rope Ferry Gneiss. Light to medium gray weathering, medium-grained, variably foliated plagioclase-quartz-hornblende-biotite-magnetite-titanite gneiss and granofels. Inclusions of amphibolite are present in most outcrops and are locally abundant, comprising 5 vol%. Inclusions of layered calc-silicate granofels occur with amphibolite inclusions near the power line 100 m south of Vinyl Hill Brook, Essex, suggesting that at least some amphibolite inclusions are xenoliths and not dismembered dikes. The shapes of the mafic inclusions are highly dependent on strain, with aspect ratios ranging from 2.5:1 to 100:1; long axes typically plunge NE (Wintsch, 1985, step 1). All foliation is defined by a preferred orientation of hornblende and biotite. Zircons from the Base of Book Hill on Conn. Rt. 9 (Wintsch, 1985; step 2a; Wintsch and Aleinikoff, 1987) have been dated as approximately 620 Ma, which establishes a late Proterozoic crystallization age for the protolith of this gneiss. Mapped as the Hadlyme belt of Odovician Monson Gneiss (Omo) by Lundgren (1963).

Zwhv Hope Valley Alaskite. Cream to tan, massively weathering, medium- to fine- grained, poorly foliated to massive K-feldspar-plagioclase-quartz (biotite) gneiss and granofels. Microcline augen up to 1 cm in diameter and 5 cm long are elongate in the foliation and commonly exhibit Carlsbad twins. These are interpreted to be relic phenocrysts. In some rocks the phenocrysts are deformed into augen shapes up to 2 cm long, and in others 0.5 to 1 mm K-feldspar grains occur in elongate clusters 2-3 cm long. These observations suggest that the protolith was a porphyritic granite with variably flattened K-feldspar phenocrysts. Where strongly deformed this unit contains hornblende and biotite amphibolite inclusions and is therefore difficult to distinguish from Dmh and Pg. Included in the Hadlyme belt of Monson Gneiss by Lundgren (1963). Mapped as Zsh, part of the Sterling Complex by Rodgers (1985)

ai Amphibolite. Dark gray to black weathering amphibole-plagioclase (biotite) amphibolite. Occurs as lenses from 1 cm to several m in thickness. Present in all units, but is dominant in Zwjg.

NOTES ON STRUCTURE

Faults

One of the most significant features of the map area is the abundance of faults. Many of the faults mapped are ductile, and are characterized by strongly diluted gneisses and schists, commonly intruded by pegmatites. The NW trending, subvertical faults east of the Connecticut River are brittle, and probably contain lasmonite similar to that found in steep veins in the Gillette Castle drill core. The faults with the greatest tectonic significance are those that define terrane boundaries. Many other faults produce a pervasive fabric in the rocks, but have little displacement. Fault zones are described from structurally high to deeper in the structure.

Mt. Parnassus blastomylonite. This is a mappable zone of foliated cataclastic rocks. It crops out in a belt about 2 km wide, and is about 0.5 km thick. The zone separates the generally pelitic Brimfield Formation from the more calcareous Hebron Formation. The zone contained many pegmatites that are commonly into fragments 0.5 to 10 cm long. The fragments are in random orientation set in a matrix quartz, plagioclase, biotite and muscovite. The rock is cut by a younger fault in the foliation that is defined by muscovite. The predominance of biotite in the bulk rock suggests that the protolith was Hebron Formation with numerous pegmatites.

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Table 1. Major element geochemical results of selected samples.

map locality	map unit	Na2O (%)	MgO (%)	Al2O3 (%)	CaO (%)	P2O5 (%)	K2O (%)	CaO (%)	MnO (%)	TiO2 (%)	LOI (18°C)	LOI (1040°C)	SUM
1	Ddp	2.28	2.07	14.66	70.75	0.09	3.15	1.25	0.07	0.11	0.98	0.03	100.00
2	Sth (sillcarious)	1.23	1.38	15.08	72.79	0.02	3.26	1.36	0.06	0.15	0.74	0.00	100.11
3	Sth (schist)	2.06	5.13	17.56	57.35	0.17	3.88	4.04	0.07	0.58	0.94	0.31	0.12 100.00
4	Sth (mixed)	1.66	4.06	16.68	58.20	0.18	3.28	2.84	0.11	0.65	0.70	0.36	0.07 0.09 100.00
5	a	0.67	4.64	15.67	52.31	0.28	1.32	7.81	14.98	0.25	1.72	0.29	0.06 100.00
6	Ddp	1.87	6.70	13.92	47.60	0.16	2.29	20.32	8.84	0.22	0.84	0.08	0.04 100.00
7	a	3.17	5.03	15.59	51.93	0.17	1.93	6.68	13.62	0.31	1.58	0.46	0.05 100.00
8	Ddp	2.34	2.11	14.52	69.12	0.09	3.13	1.44	0.07	0.12	0.98	0.03	0.04 100.00
9	Sth (sillcarious)	0.91	5.46	9.10	56.06	0.17	0.21	22.67	4.11	0.33	0.89	0.17	0.67 100.02
10	Sth (schist)	1.27	3.78	10.67	69.98	0.14	2.60	6.75	0.49	0.59	0.67	0.02	0.06 100.00
11	Ddp	2.64	1.33	14.78	70.83	0.09	3.28	1.25	0.08	0.10	0.83	0.03	0.04 100.00
12	a	2.65	8.64	16.28	48.68	0.14	0.27	10.33	11.33	0.19	1.27	0.15	0.05 100.00
13	a	2.67	5.16	21.88	48.90	0.06	0.28	7.94	12.12	0.14	0.52	0.14	0.12 100.00
14	a	1.22	4.39	15.24	49.81	0.21	0.82	10.92	15.13	0.27	2.53	0.11	0.06 100.00
15	Sth	1.93	3.03	18.29	48.38	0.12	0.21	13.51	8.74	0.37	3.78	0.55	0.09 100.00
16	Ddp	3.79	0.70	16.46	69.62	0.13	4.66	1.68	0.10	0.02	0.98	0.20	0.07 100.00
17	Ddp	2.42	2.15	14.71	69.92	0.09	3.18	1.44	0.07	0.12	0.98	0.03	0.04 100.00
18	Ddp	3.42	0.48	15.12	73.48	0.07	4.10	1