STATE OF CONNECTICUT DEPARTMENT OF ENERGY AND ENVIRONMENTAL PROTECTION
GEOLOGICAL AND NATURAL HISTORY SURVEY

OPEN FILE MAP AND REPORT 94-1
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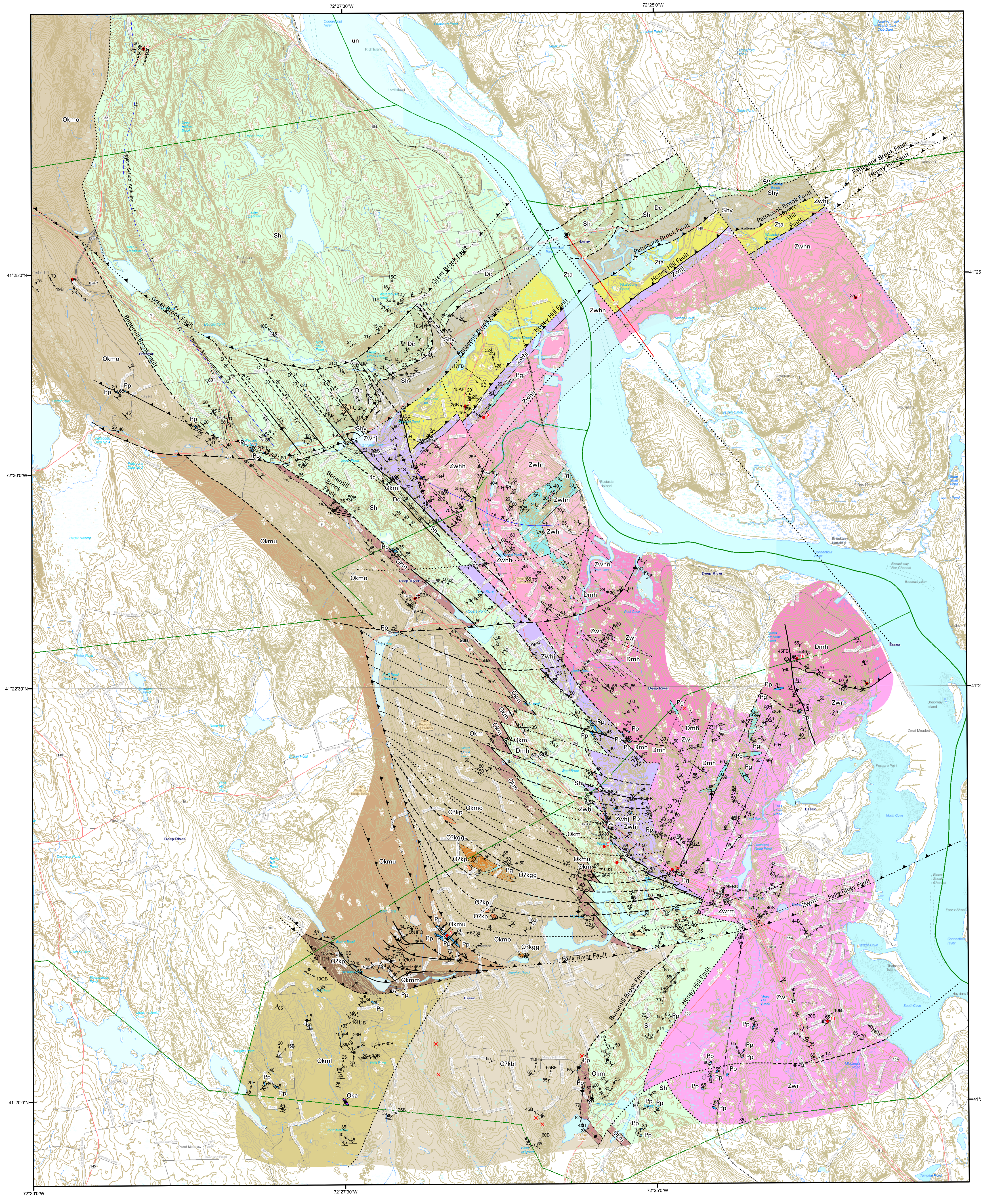
State Geologist



Basemap data from www.ct.gov/deep/gisdata
Hydrography 2005 edition
Topography 2006 edition
Contours 2016 edition
Coordinate system NAD 1983, State Plane Connecticut FIPS 0600 (US feet)
Datum: North American 1983

APPROXIMATE MEAN DECLINATION, 2018

SCALE 1:24,000

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

CONNECTICUT

MAP LOCATION

Geology mapped by R.P. Wintsch in 1978, 1980 and 1983; assisted by K.K. Thomas, 1980 and A. Owens, 1983.

Drafted by K.A. Lancaster in AutoCAD, 1994. Converted from AutoCAD by Thomas Nosal. Digitization and cartography in ArcGIS by Ian Hillenbrand.

PRELIMINARY BEDROCK GEOLOGIC MAP OF THE DEEP RIVER AREA, CONNECTICUT

By Robert P. Wintsch
Indiana University
1994

Explanation of Units

ALL TERRANES

Pp

Pp – Pegmatite - White to tan weathering medium-grained, sucrosic, quartz-plagioclase-microcline-(hematite) granite. Rock is unfoliated and weakly layered. Mapped only in one dike 600 in NE of Ivoryton. Included with Monson gneiss of Lundgren (1964). Assigned a Permian age by correlation with dated rocks in Bank Hill (Essex). Moderately to strongly foliated smaller bodies, some boudinaged, are ubiquitous to all rocks of the Deep River area, but are too small to map. Tan to pink weathering, massive, unfoliated, K-feldspar-plagioclase-(biotite)-(quartz) dikes 10-50 cm thick strike ~N70°E and dip ~60°NW. In the Chester area they commonly intrude the axial planes of assymetric folds in the hanging wall of the Pattaconk Brook fault. In the Essex area undeformed pegmatites averaging 1 m thick intrude low displacement faults. In the Hebron Formation south of the Falls River fault they intrude the axial planes of tight folds.

Pg

Pg – Permian granite – Ivoryton. White to tan weathering medium-grained, sucrosic, quartz-plagioclase-microcline-(hematite) granite. Rock is unfoliated and weakly layered. Mapped only in one dike 600 in NE of Ivoryton. *Included with Monson gneiss of Lundgren (1964). Assigned a Permian age by correlation with dated rocks in Book Hill (Essex).*

Permian granite – Deep River – 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. Locally contains conspicuous red spots around magnetite crystals. Unit includes a porphyritic phase with 1 cm euhedral K-feldspar phenocrysts. Thin dikes of this granite (1-4 m thick) cut Zwr on Book Hill, and thicker dikes intrude and include Zwhh and Zwhn, southeast of Chester. *One body dated by monazite U-Pb methods from the buckled dike at the base of Book Hill on Conn. Rt. 9 (locality 12, map, Table 1) is ~278 Ma (Wintsch, 1985; Wintsch and Aleinikoff, 1987) indicating a Permian age for the late deformation in the Essex area which deforms both the dike and the host gneiss. Not mapped separately by Lundgren (1964).*

BRONSON HILL TERRANE
Lithodemic Units: Killingsworth Complex

O?kgg

O?kgg – Granite Gneiss of Ivoryton - Tan to buff, medium to coarse-grained, weakly foliated quartz-K-feldspar-plagioclase-biotite gneiss and granofels. Contacts are not exposed; age uncertain, but may be younger than Ordovician host Monson gneiss. Mapped only in Omo northeast and east of Ivoryton. Included by Lundgren (1964) with the Monson gneiss.

Okmm

Okmm – Blastomylonitic schist and gneiss – Medium and dark gray, strongly weathered and friable, medium- and coarse-grained biotite-plagioclase-sillimanite-quartz-(garnet) schist, locally with conspicuous K-feldspar and plagioclase augen. Mapped only along the Falls River fault west of Ivoryton. Biotite-rich mylonitic schists, locally with conspicuous sillimanite lineations dominate the unit. A small (30 x 30 cm) peridotite pod, a light olive gray to olive brown weathering, medium-grained, well-foliated and layered plagioclase-diopside-biotite-quartz schist and granofels, and amphibolite boudins and tectonic inclusions, suggest complicated tectonic mixing in this unit. *Included by Lundgren (1964) with the Monson gneiss.*

O?kp

O?kp – Peridotite – Dark green to black, massively weathering, unfoliated, medium-grained olivine-clinopyroxene-amphibole-(garnet)-peridotite. Thin, black, well foliated hornblende schist and amphibolite separate the peridotite from host Monson Gneiss. Mapped as four small bodies north and west of Ivoryton. *Bodies cored by olivine (Fo 68)-clinopyroxene-amphibolite, 45-48 wt% SiO2. Normative compositions are lherzolite; margins are garnet amphibolite (Park, unpub, data). Rocks are less aluminous than those described by Tracy et al. (1984), and may be derived from cumulates.*

O?kbl

O?kbl – Boulder Lake Gneiss – Light to medium gray-weathering, medium- to coarse-grained, massive to poorly foliated plagioclase-quartz-biotite +/- hornblende tonalitic gneiss with characteristic amphibolite inclusions. This unit is poorly exposed in low ledges between Mares Hill and Birch Mill Pond. Rock is usually massive with evenly disseminated biotite and minor hornblende defining a weak gneissosity, but usually not a compositional layering. Locally a weak lineation defined by biotite +/- hornblende streaks is present. Rock is distinguished from Monson Gneiss by its more calcic composition, poorly developed fabric, lower amphibolite content, and by the presence of conspicuous amphibolite inclusions.

Okmo

Okmo – Monson Gneiss – Light to medium gray, medium-grained, massively weathering, well foliated, locally moderately layered quartz-plagioclase-biotite-(anthopyllite) gneiss of tonalitic (normative granodioritic, 70 wt.% SiO2) composition. Interlayered contact with structurally overlying Okm. On the eastern margin of the unit, near the ductile Bonemill Brook fault, a conspicuous compositional banding parallel to foliation is defined by alternating biotite-rich and biotite-poor layers each approximately 3 cm thick. The biotite-poor layers commonly host a conspicuous, sub-horizontal 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 consitute 10% of most outcrops. Exposures near State Route 148 contain 0-10% orthoamphibole in blades 1-5 cm long which define a nearly horizontal lineation. *Plagioclase gneisses of Turkey Hill and Cedar Lake of Lundgren (1963) of assumed Ordovician age (Leo et al., 1984; Zartman and Leo, 1985) by correlation with gneisses to the north.*

Stratified Units

Okm

Okm – Middletown Formation (undifferentiated) – Dark gray to black weathering, medium-grained, variably layered and foliated hornblende-plagioclase-quartz-(biotite) amphibolite gneiss and granofels interlayered with subordinate light gray weathering, medium grained quartz-plagioclase-biotite-(garnet) schist and granofels. Interlayering occurs on a scale less than 1 m, and interlayering at the 1-2 mm scale gives the schist a common pinstriped appearance. The unit is distinguished from Zwhj by the abundance (greater than 80%) amphibolite and by the more mafic composition of the felsic layers in Zwhj. Strain is too high to allow stratigraphic relationships to adjacent rocks to be established. A maximum thickness of 175 m is present north of Mill Pond. In fault contact with Sh, and with O?kbl. *Mapped by Lundgren (1963; 1964) as Middletown Formation.*

Okmu

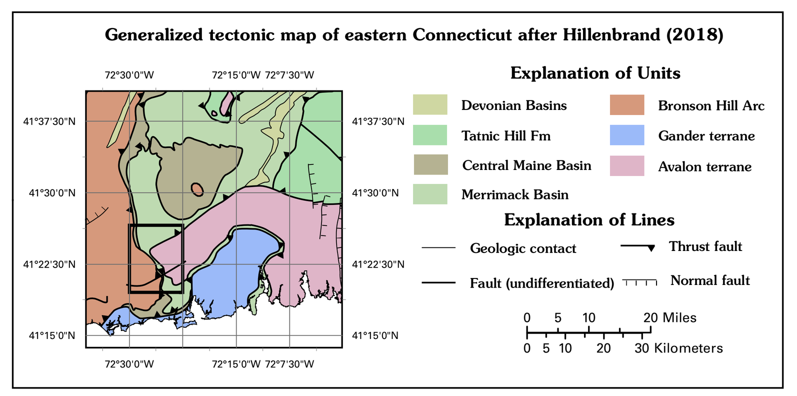
Okmu – Upper member, Middletown Formation – Light gray to buff-weathering, medium- to coarse-grained, moderately to strongly foliated and layered quartz-plagioclase-biotite-anthopyllite ± hornblende schist and gneiss. Rock is intensely deformed by folds and ductile shear zones associated with low-angle splays of the Falls River fault. Foliation is defined by a strong preferred orientation of biotite and anthopyllite and frequently occurs parallel to a compositional layering defined by biotite± anthophyllite rich and poor layers. Anthophyllite needles up to 20 mm long define a northeasterly plunging penetrative lineation in the ductile fault zones and constitute up to 30 vol % of the rock. *Mapped as Cedar Lake belt of Monson gneiss by Lundgren (1963) and as Monson gneiss (undifferentiated) by Lundgren (1964). Correlated here with 'western' tonalitic to trondhjemitic paragneiss of Webster and Wintsch (1987), and distinguished from Okml by the higher biotite (K2O and FeO) and anthophyllite content of the Okmu.*

Okml

Okml – Lower member, Middletown Formation – Light and dark gray, slabby weathering, medium-grained, uniformly well layered and strongly foliated quartz-plagioclase-hornblende-biotite schist, and minor massively weathering black amphibolite. A pervasive 5-10 mm thick banding is caused by alternating biotite hornblende rich and poor layers, and a coarser banding is caused by abundant 1-10 cm thick intercalated with the plagioclase-rich biotite schist. *Mapped as Monson gneiss (undifferentiated) by Lundgren (1964). Rock correlated here with 'eastern' tonalitic paragneiss of Webster and Wintsch (1987).*

Oka

Oka – Amphibolite – Black, massively weathering, medium-grained, well foliated hornblende-plagioclase amphibolite. Mapped only in one outcrop on the north side of Pond Meadow. *Rock is inferred to be metavolcanic because it occurs within metavolcanic unit Okml. Not mapped separately by Lundgren (1964).*



MERRIMACK TERRANE
Lithodemic Units

Dc

Dc – Canterbury Gneiss – Gray to buff, massively weathering, medium- to coarse-grained, moderately to well foliated, poorly layered quartz-microcline-plagioclase-biotite-(muscovite) granitic gneiss and granofels. Rock is commonly strongly deformed; it may be blastomylonitic or an augen gneiss containing porphyroblasts 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 with mylonitic foliation containing quartz and feldspar rods 2 mm long was quarried. North of Pattaconk Brook the unit is ~100 m thick, but to the south it is 30 m thick. Lower contacts exposed on the southeastern side of Story Hill and along the low ridge southeast of Jennings Pond are sharp. *Evidence that the gneiss is intrusive is not found in the mapped area, but is based on its irregular outcrop pattern across the state (see Rodgers, 1985), and its younger age (395 Ma, Zartman and Naylor, 1984) than the apparently Ordovician-Silurian age Hebron Formation host.*

Stratified Units

Sh

Sh – Hebron Formation – Olive green to gray weathering, medium-grained plagioclase-quartz-biotite-hornblende-(epidote)-(diopside)-(clinozoisite) granofels, and dark violet, medium to fine grained, well foliated plagioclase-quartz-biotite schist. Smalls amounts of pyrite are present locally which cause the rock to weather a rusty brown. Lithologies are interlayered on a 1-10 cm scale. North of the Pattaconk Brook fault layering is commonly >2 cm thick, and epidote-actinolite schists are common. South of this fault, olive grayy, flaggy weathering medium-grained, well layered and well foliated quartz-plagioclase-biotite schist dominates. In metasomatically altered fault zones fibrolite is intergrown with biotite, especially east of Deep River and north of Centerbrook. South of the Falls River fault, a pale buff to gray weathering medium grained quartz-plagioclase-biotite granofels with minor biotite-quartz-plagioclase schist dominates; hornblende-bearing rocks are rare. Here layers of uniform granofels 2-10 cm thick are separated by 1 mm thick biotite schists. The rock is pervasively isoclinally folded, and all foliation is parallel to axial planes of these folds. The unit is isolated by faults, and in spite of the lithologic dissimilarity, it is correlated with the Hebron Formation because it is on strike with it. However it may be a separate unit. The top of the unit is not exposed, and the base is cut out by the Pattaconk Brook fault north of Chester, and by the Honey Hill fault south of Chester. A brownish-gray weathering biotite schist is exposed only in the hanging wall of the Pattaconk Brook fault west of Conn. Rt. 9. Quartz and plagioclase porphyroclasts are set in an anastamosing matrix of muscovite and biotite, suggesting that both the fabric and mineralogy of the matrix are retrograde syntectonic structures. *This unit includes most of Lundgren's (1963) Hebron Formation, and his 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 metasomatized ductile fault zones in Sh that carry no stratigraphic significane; they are not mapped separately here. An age of pre-Early Silurian is inferred by correlation with the Merrimack group in New Hampshire (Bothner et al., 1993). Interpreted as Late Proterozoic (?) by Pease (1989).*

Shy

Shy – Yantic Member, Hebron Formation – Light and medium gray weathering, medium- to coarse-grained, quartz-plagioclase-muscovite-biotite-(microcline) schist. Distinctive 1-5 cm thick layers of quartz-plagioclase-microcline granofels are present in most outcrops and is characteristic of the rock. Common porphyroclasts of plagioclase 0.5-4cm in diameter define an augen gneissic texture. Sharp, but interlayered upper and lower contact with Hebron Formation. Contains a lens of olive gray to greenish gray weathering medium-grained moderately well foliated, well layered quartz-plagioclase-biotite-actinolite-epidote schist, approximately 10 m thick and 200 m long exposed only on the south slope of Story Hill. A maximum thickness of 130 m that is less than one third of the thickness present in the type section of Dixon (1964) is present in Chester. *Mapped by Lundgren (1963) as part of the Putnam gneiss and included by Dixon (1964) as part of the Tatnic Hill Formation, but redefined by Wintsch et al. (1993) as a member of the Hebron Formation, Merrimack terrane. A ~440 Ma Rb-Sr whole rock age by Pignolet et al. (1980) in the vicinity of Yantic, Connecticut provides the most local evidence of the age of metamorphism of these rocks.*

PUTNAM-NASHOBA TERRANE
Stratified Rocks

Zta

Zta – Tatnic Hill Formation – biotite-(garnet)-(sillimanite)-(microcline) schist and augen gneiss. 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 rock is exposed only as a fault slice between the Honey Hill and Pattaconk Brook faults. The unit is poorly exposed, and highly folded and cut by shear zones that probably define tectonic blocks. Maximum thickness of 350 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 Avalon and Merrimack terrane rocks. *Mapped as part of the Putnam gneiss by Lundgren (1963). Probably late Proterozoic age by correlation with the Nashoba block (Olszewski, 1980; Zartman and Naylor, 1984).*

AVALON TERRANE
Lithodemic Rocks

Dmh

Dmh – Granite Gneiss of Millstone Hill – Light pink to gray weathering, medium- to coarse-grained K-feldspar-quartz-plagioclase-biotite gneiss and granofels. Locally migmatitic, and strongly foliated near shear zones. Contacts are now defined by ductile faults, but locally cross-cutting relationships further east (Goldsmith 1985), and a possile Devonian age (Aleinikoff and Wintsch, unpub., Table 1, locality 10) suggest that it is intrusive into Avalonian gneisses. *Included in the Potter Hill gneiss of the Sterling Plutonic Group of Rodgers (1985), and mapped as Sterling Granite Gneiss by Lundgren (1963).*

Zwrm

Zwrm – Blastomylonitic schist – Medium to dark gray, coarse-grained, well foliated and layered, blastomylonitic and mylonitic plagioclase-quartz-biotite-garnet-sphene-rutile gneiss, and biotite-sillimanite-(garnet)-(quartz)-(plagioclase) schist. Rock contains conspicuous boudins and tectonic inclusions of pegmatite and amphibolite, both folded within the schists along axes plunging approximately 50°N40E, parallel to a pentetrative sillimanite lineation. This rock grades north in Zwr. Mapped only along and immediately above the Falls River fault in Essex. *Similarities in ratios among elements with low differential mobility, and mass balance calculations using whole rock chemical analyses of the gneiss and schists show that the schists are derived from the Rope Ferry Gneiss (Zwr) through metamorphic differentiation and limited metasomatism (Dipple et al. 1990). Mapped as part of the Putnam gneiss by Lundgren (1964), but given no stratigraphic significance in this study.*

Zwr

Zwr – Rope Ferry Gneiss – Light to medium gray weathering, medium-grained, variably foliated plagioclase-quartz-hornblende-biotite-magnetite-sphene gneiss and granofels. Inclusions of amphibolite are present in most outcrops and are locally abundant. Their shape is highly dependent on strain, and may have aspect ratios from 2.5:1 to 100:1; long axes typically plunge NE (Wintsch, 1985, stop 1). Inclusions of layered calc-silicate granofels occur with amphibolite near the powerline 100 m south of Viney Hill Brook, Essex, suggesting that all inclusions are xenoliths, and that this gneiss is an orthogneiss. Foliation dipping approximately 50° N48 N30°E is cut by foliation dipping approximately 50° N20° W. Both these foliations are cut by a third foliation dipping 60°-90° N70°W. All foliation is defined by a preferred orientation of hornblende and biotite, but foliation is better defined and more conspicuous in the younger two foliations. Mineral lineations are most strongly developed in the latest foliations which are parallel to high angle strike-slips faults which cut the unit. Amphibolite is a common accessory rock type. The unit is distinguished from the Hadlyme Formation by a slightly lower TiO2/FeO ratio, and the presence of xenoliths, and from the Boulder Lake Gneiss by a lower MgO content and the lack of magnetite. *Zircons from the base of Brook Hill on Conn. Rt. 9 (Wintsch, 1985, stop 2a; Wintsch and Aleinikoff, 1987, locality 12, map, Table 1) have been dated as approximately 620 Ma which establishes a late Proterozoic crystallization age for the protolith of the gneiss. Included with Ordovician Monson Gneiss (Omo) by Lundgren (1964).*

Lithodemic Rocks: Hadlyme Formation

Zwhj

Zwhj – Jennings Pond Lithofacies – Northeast of Chester the lower contact is interlayered with Zwh, consistent with a metavolcanic protolith. Between Chester and Deep River the unit contains locally conspicuous randomly oriented (retrograde) muscovite. East of Jennings Pond the felsic rock is locally granofelsic, and amphibolite may exceed 4 m in thickness. South of Deep River, foliation is very well developed, and fibrolite occurs in quartz-sillimanite nodules and is locally intergrown with biotite. Here the lower contact is cut by a ductile fault. North of Centerbrook a foliation dipping 60° N45E is cut by a more strongly developed locally mylonitic foliation dipping 50° N15E. The unit is bound entirely by faults, which cut out both the top and bottom of the unit, and limit its lateral extent from the Pattaconk Brook fault in Chester to the Falls River fault in the south. *Mapped as part of the Putnam gneiss by Lundgren (1963; 1964), but assigned to the Late Proterozoic age (Zartman et al., 1988) Hadlyme Formation by Wintsch et al. (1990b).*

Zwhn

Zwhn – North Plain Lithofacies, Hadlyme Formation – Light to medum gray weathering, medium grained, moderately foliated plagioclase-quartz-biotite-hornblende-magnetite gneiss and granofels. Close to the overlying Jennings Pond lithofacies (and to the Honey Hill Fault), the felsic gneiss becomes mylonitic, hosting a moderately well developed mineral lineation, and containing accessory microcline and boudins of dark gray to black medium grained granofelsic amphibolite. Southeast of this contact amphibolite is rare. *Mapped as the Hadlyme belt of Monson Gneiss by Lundgren (1963) but redefined as a stratigraphic unit by Wintsch et al. (1990b), of Late Proterozoic age (Zartman et al., 1988; Aleinikoff, unpub,).*

Zwhh

Zwhh – Hope Valley Alaskite, Hadlyme Formation – Cream to tan, massively weathering, medium- to fine-grained, poorly foliated to massive quartz-K-feldspar-plagioclase-(biotite) gneiss and granofels. Where strongly deformed is 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).*

Explanation of Lines

Major Folds

- Chester School Anticline, accurate
- Chester School Anticline, inferred
- Overturned anticline, accurate
- Overturned syncline, accurate

Other Lines

- Geology extrapolated up dip from core

Faults

- Fault, accurate
- Fault, approximate
- Fault, inferred
- Thrust fault, accurate
- Thrust fault, approximate
- Thrust fault, inferred

Geological Contacts

- Geological contacts, accurate
- Geological contact, approximate
- Geological contact, inferred

Explanation of Symbols

Strike and Dip of Planar Features

- Inclined foliation
- Vertical foliation
- Secondary Foliation
- Axial plane
- Cataclastic layering in axial plane of fold
- Small fault

Inclined Linear Features

- Fold axis, with plunge
- Mineral lineation, with plunge; A, Anthophyllite; B, Biotite streaks; F, Feldspar rods; H, Hornblende; Q, Quartz rods; S, Sillimanite
- Mineral lineation, horizontal

Minor Folds

- Antiformal
- Synformal
- Overturned
- Overturned isoclinal antiform

Other Features

- Location of float judged to be close to the surface
- Location of 1500' drill hole, cored continuously
- 13 Location of sample dated by K-Ar, 40Ar/39Ar, or U-Pb methods (see Table 1)

Bedrock Geology of the Deep River Area, Connecticut

INTRODUCTION

After much bedrock geologic quadrangle mapping in Connecticut had been completed, Dixon and Lundgren (1968) put forth a regional structural syntheses 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 geologic 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 (Zen, 1989). 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 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 Percival's (1842) mapping, the Deep River area was identified as an area critical to unraveling regional tectonic interpretations, because four major units, now understood to be parts of four distinct terranes (see index map), all converge in this area. Consequently, this area, between the villages of Chester and Centerbrook was selected for detailed mapping (scale 1:12,000) with the goal of determining the distribution of rocks types and structural relationships among the rock units. Major field work was done in 1978, 1980, 1983, and supplementary field, laboratory, and geochronological work underway continuously since 1983, with preliminary work reported in Wintsch (1985). Geochronological and geochemical work Within the map area (see Table 1) and regionally has had a compelling role in forcing new stratigraphic and dependent structural interpretations (Wintsch and Aleinikoff, 1987; Wintsch et al., 1990a; 1990b; Wintsch et al., 1992, Wintsch et al., 1993). With a new understanding of ductile faulting, ductile fault rocks (London, 1989; Dipple et al., 1990), and a metasomatic-non sedimentary origin for aluminous rocks that now bear sillimanite (Wintsch and Andrews, 1988), some schistose rocks in the map area formerly interpreted to be and 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 deep metamorphism and deformation caused by the Alleghanian assembly of the four terranes.

Because bedrock mapping at a scale of 1:24,000 was available to this study (Lundgren, 1963; 1964), the entire area was not remapped; only those areas that emerged as critical to understanding regional scale structure were reexamined. In particular, some areas underlain by the Hebron, Middletown, and Hadlyme formations were not remapped. Relationships among late Proterozoic felsic volcanics (Zwhh), Devonian (?) (Dmh) and Permian (Pg) intrusive granites northeast and southeast of Deep River are complex, and where strongly deformed, rocks are difficult to discriminate. Geological relationships are in part inferred, and although probably not critical to deciphering late Paleozoic structure, the area deserves more detailed study.
The map area was expanded to the NE and NW to accommodate localities where isotopic area data have been obtained; these areas are joined to this mapping using the geological boundaries given by Lundgren (1963), modified by reconnaissance work. The area of London's (1989) detailed mapping in the Moodus seismic area lies ½ mile northwest of the Deep River area map. The map shows the distribution of structural orientation data that reflect the areas remapped as well as the density of outcrop. Geologic units are patterned to give an immediate sense of the distribution of rock units and of terranes. It also includes the locations of samples collected for isotopic analysis (Table 1). The notes that follow describe the lithologic units mapped, and some details of the structures present in the map area. Specialized reports on selected structures and petrologic features within the area in addition to those cited above are planned.

STRUCTURAL GEOLOGY

Faults
By far the most significant feature of the map area is the abundance of faults. Most of the faults mapped are ductile, and are characterized by strongly foliated gneisses and schists, commonly intruded by pegmatites. Only the NW trending faults east of the Connecticut River are brittle, and probably contain prehnite 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, especially the set north of and subparallel to the Falls River fault, and the N3O°E set that cut Book Hill.

Honey Hill Fault
The Honey Hill fault forms the structural top of the Avalon terrane in southern Connecticut but joins with the Lake Char (eastern Connecticut) and the Bloody Bluff Fault (eastern Massachusetts) to form a regional scale terrane boundary with major displacement (Wintsch et al. 1992). It extends from Honey Hill SW to Chester, where it separates Avalon and Putnam-Nashoba terrane rocks. It then extends SE to Essex, where it separates Avalon and Merrimack terrane rocks, completely cutting out Putnam-Nashoba rocks, and Avalonian metavolcanics of the Hadlyme formation between Chester and Centerbrook. The fault zone is ductile, and is intruded by several generations of pegmatites as exposed by trenching of Janet Stone in the baseball park of Deep River (Stop 19, Wintsch et al., 1993).

Pattaconk Brook Fault
The Pattaconk Brook fault locally defines the position of, but also cuts out the regionally significant Clinton-Newbury fault (Wintsch et al., 1993), which marks the structural top of Putnam-Nashoba terrane rocks and the base of Merrimack terrane rocks. In the map area it most recently accommodated motion with a net left-lateral component, so that the fault cuts all rocks in the village of Chester, and separates rocks strongly deformed by map-scale sigmoidal folds in the hanging wall from rocks lacking such folds in the foot wall.

Great Brook Fault
The Great Brook fault marks the structural boundary between rocks in the foot wall that contain map-scale, west verging, overturned folds and flat lying well layered Hebron Formation schists and granofels in the hanging wall. The fault is not exposed at the surface, but strongly foliated biotite (muscovite) schists and phyllonites associated with the fault zone are present in the drill core at Gillette's Castle (Wintsch and Ambers, 1989; Ambers and Wintsch, 1990).

Bonemill Brook Fault
The Bonemill Brook fault (of Pease, 1982, in northern Connecticut) is a regional fault that separates rocks of the Bronson Hill and Merrimack terranes from the Deep River area in the south to at least southern Massachusetts (Peterson and Robinson, 1993). In the Deep River area, hornblende and plagioclase gneisses of the Bronson Hill terrane are strongly foliated and lineated along the western wall of this fault, where isoclinal, intrafolial folds are present. On the east side of the fault, Heborn Formation rocks are relatively highly foliated and layered, where map-scale folds overturned to the west dominate (see map). At the northwestern limit of the map area, the same fault is described by London (1989) as the Cremation Hill ductile fault zone.

Falls River Fault
Blastomylonitic schists of the Falls River fault underlie a strong lineament that cuts Avalon, Merrimack, and Bronson Hill rocks, but has little effect on map pattern. In the Bronson Hill terrane, it marks the southern limit of Monson Gneiss, and the northern limit of Boulder Lake Gneiss, but the Hebron Formation and Rope Ferry Gneiss are apparently not significantly displaced by it. The blastomylonite fault rocks are thick enough to map separately. They are tectonic orthoschists (Dipple et al., 1990) derived locally from the host gneisses (Okmm from Middletown Formation, and Zwrm from Rope Ferry Gneiss), but metasomatically modified to stabilize aluminous minerals garnet and locally sillimanite.

Chester School Anticline
The only regionally significant fold in the map area is the Chester School Anticline. This structure folds and overturns to the west all rocks and many early ductile faults along an axis plunging steeply to the northwest, but is in turn cut by younger faults. In the Hebron Formation north of Chester, the Chester School anticline is the western-most and largest of a series of west verging, overturned folds; its map trace is close to the Bonemill Brook fault zone. The structure is cored by a fold in the Hadlyme Formation of the Avalon terrane, where it is easily identified by the folded foliation and layering in gneisses and granofelses southwest of Chester village. This crest of the fold in the Avalon terrane probably underlines a broad open fold in the Hebron Formation that extends north of Chester, and emerges again in the Willimantic Window. This fold is a relatively young feature, and parts of the Honey Hill and Bonemill Brook faults west of its axis probably accommodated most of their displacement in a normal, NW dipping position, rather than in the present overturned orientation.

METAMORPHISM

Uniform Permian ages of hornblende in all rocks in the Deep River area show that the middle amphibolite facies or higher metamorphism of Lundgren (1966) occurred during the Alleghanian Orogeny (Wintsch et al., 1993). However, the fact that some sphene ages are not reset, especially in the northern part of the map area (locality 4), shows that the rocks were metamorphosed prior to the Alleghanian orogeny. This same deduction can be made from the regional patterns in cooling histories of the Bronson Hill, Merrimack, and Putnam-Nashoba terranes (Wintsch et al. 1993), which show that rocks of all these terranes were metamorphosed in the Acadian or before, and only remetamorphosed in the Alleghanian. Rocks of the Avalon terrane record only Alleghanian metamorphism.

Table 1. Sources of Geochronologic Data, Deep River Area

Location	Field No.	Minerals	Method	Source
1	Hd-2-6	hornblende, biotite	$^{40}Ar/^{39}Ar$	Wintsch and Sutter (1986)
2	90-153	hornblende	$^{40}Ar/^{39}Ar$	Boyd et al. (1994)
3	Mg 153-69	K-feldspar	K-Ar	Pressel and Armstrong (1980)
4	90-151	hornblende	$^{40}Ar/^{39}Ar$	Wintsch and Kunk, unpub.
		sphene	U-Pb	Aleinikoff and Wintsch, unpub.
5	90-150	hornblende	$^{40}Ar/^{39}Ar$	Wintsch and Kunk, unpub.
		sphene	U-Pb	Aleinikoff and Wintsch, unpub.
6	90-148	hornblende	$^{40}Ar/^{39}Ar$	Wintsch and Kunk, unpub.
7	90-152	hornblende	$^{40}Ar/^{39}Ar$	Wintsch and Kunk, unpub.
		sphene	U-Pb	Aleinikoff and Wintsch, unpub.

Location	Field No.	Minerals	Method	Source
8	DRM-3	hornblende, biotite	$^{40}Ar/^{39}Ar$	Wintsch and Sutter (1986)
9	90-114, 115	zircon, sphene	U-Pb	Aleinikoff and Wintsch, unpub.
10	90-103	zircon, sphene	U-Pb	Aleinikoff and Wintsch, unpub.
11	88-NLG-1	zircon, monazite	U-Pb	Aleinikoff and Wintsch, unpub.
12	84-412	zircon, monazite	U-Pb	Aleinikoff and Wintsch, unpub.
	84-413	hornblende, biotite, K-feldspar	$^{40}Ar/^{39}Ar$	Wintsch et al. (1992)
	84-413	zircon, sphene	U-Pb	Wintsch and Aleinikoff (1987)
	84-413A	muscovite	$^{40}Ar/^{39}Ar$	Wintsch et al. (1992)
	92-971	zircon, sphene	U-Pb	Aleinikoff and Wintsch, unpub.
13	86-278	sphene	U-Pb	Aleinikoff and Wintsch, unpub.

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Process Steps

This map was originally digitized and drafted by Kari Lancaster in 1994 using AutoCAD. Thomas Nosal, 2018, downloaded the files from 3.5" diskettes to create a .DXF file which was converted to AutoCAD X.X and imported to ArcMap 10.2.2. Both sheets on the map was georeferenced using six points, placed at geographic coordinates drawn on the map. Points, lines, and polygons were digitized following NCGMP09 standards using the AZGS geologic map toolbar.