Copy To Boston office for open file use
2/15/75

Preliminary Bedrock geologic map of the Ashley Falls quadrangle, Massachusetts and Connecticut

By

Nicholas M. Ratcliffe and Henry Robert Burger

Prepared in Cooperation with the Massachusetts Department of Public Works and the Connecticut State Geologic and Natural History Survey

1975

U. S. Geological Survey
OPEN FILE REPORT 75-148

This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards or nomenclature.

257017

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

MAP IN MAP DRAWER

Introduction

The bedrock of the Ashley Falls quadrangle ranges in age from Precambrian to Middle or Upper(?) Ordovician, and occurs in three lithotectonic sequences, classed in relative terms as autochthonous, parautochthonous, and allochthonous. The autochthon includes Precambrian rocks and Dalton Formation in the Brush Hill, Umpachene Falls, and Leffingwell Hill windows, as well as the detached plate of Paleozoic rocks directly above the windows but east of the Bow Wow Road fault. Rocks west of the Bow Wow Road fault also belong to the relatively autochthonous sequence. The window rocks form the deepest tectonic level exposed in the southern Berkshires. The detached plate occupies an intermediate structural level that is overlain by tectonically farther traveled rocks of the parautochthon.

Parautochthonous rocks consist of Precambrian Gneisses of the Berkshire massif above the Benton Hill fault, the Dalton Formation and Cheshire Quartzite above the June Mountain Alum Hill-Rattlesnake Hill-Clayton and Canaan Valley faults. These low angle thrusts transported Precambrian rocks a minimum of 21 km westward across the underlying autochthon at latitude 42°15' north (Ratcliffe, 1975a).

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
887-100

The allochthonous sequence consists of the Everett Formation above the June Mountain fault, and Canaan Mountain Schist above the Canaan Mountain thrust. These rocks are thought to be late Precambrian, Lower Cambrian, and Cambrian in age, and eastern eugeosynclinal equivalents of the Dalton, Cheshire, and units a, b, and perhaps c of the miogeosynclinal Stockbridge Formation of the autochthon. The structural position of these rocks is uncertain. However, the Everett Formation of the June Mountain slice (Ratcliffe, 1975b) is thrust onto and involuted into the parautochthonous Dalton in the Great Barrington quadrangle but is overridden by the gneisses of the Beartown nappe (rocks above the Benton Hill fault in this quadrangle).

Periods of folding and metamorphism both predated and postdated the justaposition of the lithotectonic sequences, so that the low angle thrusts are folded, locally overturned, thus producing the pattern of disconnected small klippe. Five episodes of folding are recognized (see Table 1). For regional relationship of fault slices and tectonic units see Figure 1 of the Monterey quadrangle report (Ratcliffe, 1975a) and Figure 2 of Ratcliffe and Harwood (1975).

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

Generation of Fold developed in area	Character of folds	Important crystalloblastic rock & textures	Fault activity	Metamorphic Character	Orogenic Period or Event
	No folds recognized		High angle reverse and normal faults	Postmetamorphic	?
F5	N25° to N45° E trending upright to northwest overturned folds of foliation, schistosity and of blastomylonite.	Sillimanite in axial surface of F4 fold is crenulated by F5 folds in the Monterey Quadrangle	No faults recognised	Late or Postmetamorphic	ACADIAN
F4	N30° to 45° W trending upright to southwest overturned folds of schistosity and of blastomylonite	Sillimanite aligned in F4 axial surface foliation in Monterey Quadrangle Staurolite, garnet include F3 and older fabrics	Calcsilicate gouge zone beneath Beston Hill Fault recrystallized	Peak of Barrovian metamorphism intensity increases to S.E.	ACADIAN
F3	N to NNW trending isoclinal recumbent folds of schistosity and of Precambrian gneissic layering, particularly intense near low angle thrust faults	New biotite – muscovite, hornblende, clinozoisite. Blastomylonite, mylonite gneiss, mylonite schist formed near thrusts, cataclastically destroying older fabrics	Low angle synmetamorphic thrusts and recumbent folds involving remobilization of basement rocks of Berkshire massif. Detachment along Brush Hill – Umpachene Falls – Leffingwell Hill Fault	Metamorphism sufficiently high to produce biotite, hornblende, and muscovite, waning stages of F2 metamorphism	TACONIC
F2	Upright and overturned folds of bedding in autochthonous rocks and formation of pre F3 folds in parautochthonous Paleozoic rocks at some site to the east. Coarse schistosity and minor F2 folds formed in allochthon rocks at some site to the east	First generation muscovite, biotite and quartz segregations form schistosity in all Paleozoic and Late Precambrian? rocks	No faults recognized	Regional metamorphism in autochthon as high as biotite zone, postdating emplacement of Everett slice of Taconic allochthon exposed to the west, but preceding emplacement of Canaan Mountain Schist and Everett Formation? at June Mountain.	TACONIC
	UNCONFORMITY				
	No folds recognized but pre-Walloomsac uplift and erosion of Stockbridge units 9 to 2.		Pre-Walloomsac high angle fault in Egremont Quadrangle (Zen & Ratcliffe 1971)		Pre-TACONIC middle Ordovician DISTURBANCE
	unconformity & metamorphic discontinuity				
F1	Isoclinal, generally east-west trending folds. Folds not distinguished in this quadrangle	Gneissosity in Precambrian rocks formed	Tyringham Gneiss and other granitic gneisses intruded into paragneisses	Regional dynamothermal metamorphism as high as sillimanite + muscovite zone	"GRENVILLE"

Table 1. Important characteristics of Fault and Folding Episodes recognized in the Ashley Falls and adjacent Monterey Quadrangles (Ratcliffe 1975a)

Stratigraphy

Precambrian rocks of the autochthon.--Precambrian granitic gneiss (p€gg), rusty-weathering blue-quartz gneiss (p€w), hornblende garnet amphibolite (p€hg), biotite quartz plagioclase paragneiss (p€bg), and minor rusty graphitic calc-silicate (p€wcs) form the basement rocks in the windows on the northeast corner of the map. These rocks resemble closely the Tyringham Gneiss, Washington Gneiss, and associated lithologies (see explanation) exposed in the parautochthonous sequence to the northeast in the Monterey quadrangle and therefore do not represent a sequence of basement gneiss different from that of the main part of the Berkshire massif. These exposures constitute the deepest tectonic level exposed in the Berkshires and are regarded as autochthonous because they are unconformably overlain by the Dalton Formation and in turn are tectonically overlain by the normal miogeosynclinal and exogeosynclinal (Walloomsac) sequence of the Stockbridge and Vermont valleys. This sequence is generally rggarded as autochthonous based on apparently normal stratigraphic contacts with the south-plunging end of the Green Mountain Anticlinorium at the Vermont-Massachusetts state line (MacFadyen, 1956). Based on the numerous low angle overthrusts exposed at the surface in the Berkshires (see Fig. 1, Ratcliffe, 1975a), it is likely that similar buried faults with slices of detached miogeosynclinal rocks and basement extend westward ~~beneath the miogeosynclinal sequence.~~ Therefore, the term autochthonous is used in a relative sense only.

Precambrian rocks above the Benton Hill fault.--These gneisses form part of a coherent stratigraphic sequence mapped to the east by Harwood (personal communication) that closely resembles the stratigraphic sequence in the Precambrian rocks of the Beartown Mountain slice to the north (Ratcliffe, 1975a, b, c).

Paleozoic rocks.--The stratigraphic relationships in this quadrangle are similar to those described in the adjacent Bashbish Falls (Zen and Hartshorn, 1966), Egremont (Zen and Ratcliffe, 1971), and Great Barrington (Ratcliffe, 1975b, in press) quadrangles. Differences in stratigraphy are described in the explanation. A new calc-silicate and quartzite unit (OЄsbq) has been recognized in the Stockbridge. This discontinuous unit may be correlative with a rusty-weathering, more feldspathic calc-silicate unit (OЄbsr) exposed at the unit c-unit b contact in the Great Barrington quadrangle (Ratcliffe, 1975b, in press).

A major unconformity exists beneath the Walloomsac Formation. Within the quadrangle the Walloomsac rests on all units of the Stockbridge, and has cut down to within 10 m of the Cheshire Quartzite in the eastern part of the quadrangle. The basal calcitic facies of the Walloomsac Owm contains significant beds of diopside calc-silicate rocks, feldspathic marbles, and minor quartzite and quartz pebble conglomerate. These lithologies are characteristic of the eastern basal facies of the Walloomsac, as exposed in the eastern part of the Bashbish Falls quadrangle (Zen and Hartshorn, 1966), and in the Stockbridge and Great

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

Barrington quadrangles (Ratcliffe, 1975b, 1975c), and probably indicate the significant contribution of detrital dolomite, quartz, and feldspar derived from preferential erosion in the east of the lower part of the Stockbridge and older rocks. This pattern of progressively greater depth of erosion in the eastern part of the Stockbridge belt has been reported by Norton (1968) from the Windsor quadrangle to the north.

Canaan Mountain Schist.--The Canaan Mountain Schist (Rodgers and others, 1956) extends into the southern part of the quadrangle in the core of the southeast-plunging Church Hill F_4 synform. Four map units have been recognized and are described in the explanation. Because of the striking lithologic similarities to certain rocks in the Dalton, Hoosac, and Everett Formations, all of Cambrian(?) and Lower Cambrian age, the Canaan Mountain Schist has tentatively been assigned a Cambrian(?) and Lower Cambrian age.

Structural geology

The five periods of folding and two Paleozoic metamorphic episodes are recognized and are described in Table 1. These features have been recognized over a broad area in western Massachusetts. Recumbent fold structures and blastomylonite related to the overthrusting of the Berkshire massif have been discussed by Ratcliffe and Harwood (1975).

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

Prethrust (F_2) structures and earlier metamorphism.--Axial traces of a series of upright, overturned, and locally recumbent folds that predate the low angle overthrusts are shown on the map. The prominent schistosity in the schistose Paleozoic rocks as well as the dominant platy cleavage that is accentuated by aligned phlogopite in carbonate rocks is axial planar to these folds of bedding. The present axial surfaces are sharply refolded by F_3 folds east of Benton Hill and broadly refolded by F_4 and F_5 folds elsewhere. The Konkapot F_2 syncline, with a core of Walloomsac, is draped over the south-plunging end of the Hawlett Road antiform, producing a rim syncline that continues northward into the adjacent Great Barrington quadrangle where the axial surface dips to the north-northwest (Ratcliffe, 1975b). To the east the Konkapot syncline passes through an upright position, thus producing the depression in F_5 Umpachene Falls antiform east of Konkapot. Similar F_2 folds locally with upright axial surfaces are responsible for the generally northeast trending distribution of Stockbridge units a, b, and c in the south-central part of the map.

The coarse schistosity formed during the F_2 event concurrently with metamorphism that produced lepidoblastic muscovite, biotite, and ubiquitous quartz layering. Relationships in adjacent quadrangles (Zen and Ratcliffe, 1971) indicate this schistosity postdated emplacement of the Taconic allochthon.

Low angle synmetamorphic thrust faults and related F_3 folds.--The structure of the eastern half of the map is dominated by a series of overlapping low angle overthrusts that have displaced rocks toward the west. These faults clearly postdate a period of deformation and metamorphism in the Paleozoic as metamorphic F_2 fold structures and the coarse schistosity is folded and cataclastically deformed near the faults. Near faults a second generation of metamorphic minerals are aligned in the new foliation in rocks that range from mylonite schist, mylonite gneiss to blastomylonite and have abundant isoclinal and recumbent folds of schistosity or of gneissic layering. Because new lepidoblastic minerals crystallized in the blastomylonite that accompanied F_3 fold formation, the faults are classed as synmetamorphic, and may have formed during the culmination of the early metamorphic event (see Table 1).

The lowest fault, the Brush Hill-Umpachene Falls-Leffingwell Hill fault is exposed as the result of F_4 and F_5 foliation antiforms and interference domes. Stratigraphic separation on this fault is at least 450 m, but displacement on the detachment surface could be much greater. Excellent exposures of blastomylonite and mylonite gneisses can be found in p€gg at the south-plunging end of the Brush Hill window, and again at the north-plunging end of the window in the bed of the Konkapot River immediately below the Mill River Dam. Similar blastomylonite and mylonite gneiss zones dip west, south, and southeast off the Umpachene Falls antiform. The excellent exposures at Umpachene Falls show a contact between Cheshire Quartzite and underlying greenish-gray blastomylonite that is so conformable with the quartzite as to appear sedimentary. Upstream from the quartzite exposures of the sheared

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
887-100

gneiss change imperceptibly over a distance of 120 m into normal granitic gneiss. Ratcliffe (1968) originally interpreted the blastomylonite, mylonite gneiss as a basal conglomerate unit of the Dalton Formation. Petrographic study of the small pebble-like inclusions indicates that they are porphyroclasts rather than pebbles of gneiss.

The Bow Wow Road fault extends into the map from the Egremont quadrangle where the fault dies out northward in a major overturned syncline (Zen and Ratcliffe, 1971). A sliver of Cheshire Quartzite and unit a of the Stockbridge is locally juxtaposed against Stockbridge units c and b north of Miles Hill. The fault has been extrapolated through Robbins Swamp to the south and may connect with a northwest-trending, northeast-dipping fault shown by Gates (personal communication) at Cobble Hill in the South Canaan quadrangle that separates the Housatonic Highlands on the south from Canaan Mountain on the north. This fault thrusts Precambrian rocks and Dalton Formation over the northern end of the Housatonic Highlands. If this interpretation is correct, the gneisses of the Housatonic Highlands may project beneath Canaan Mountain and could reappear in the Brush Hill and Umpachene windows, or at the next lower structural level.

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

In sections A-A' and B-B' the Bow Wow Road fault has been connected with the Umpachene-Brush Hill detachment surface as a single fault. No exposures at the surface demonstrate this connection, but the gentle dips and general synformal or basinal geometry of the surface rocks in the Canaan and Sheffield valleys suggest this connection. An alternate interpretation would place the detachment surface below the base of section A-A' and B-B' and have the Bow Wow Road fault as an upward splay thrust from a buried west-dipping fault. If the faults are correctly shown in the section, displacement north of latitude 42°07'30" is small and taken up by rock flowage on the inverted limb of the overturned syncline shown by Zen and Ratcliffe (1971) in the Egremont quadrangle. The net slip could increase significantly to the south.

No major thrust faults are recognized at the surface in the Stockbridge units to the west in the Bashbish Falls quadrangle (Zen and Hartshorn, 1966). However, examination of core data in 1968 from a boring near Bear Rocks Stream (west end of section C-C' of Zen and Hartshorn, 1966) contains a gently dipping, intensely sheared zone in unit e that apparently thrusts unit c of the Stockbridge over unit e. This may indicate that other low angle buried thrusts may extend westward as minor splays from the Brush Hill-Umpachene Falls detachment surface. Recumbent folding such as the Foley Fold (Zen and Hartshorn, 1966) may have been cuased by boundary disturbances in blocks related to such dislocations. The north-plunging antiformal structure east of the Bow Wow Road fault (section A-A') is interpreted as an F_3 overturned fold formed by drag on the fault.

Low angle faults have moved the Precambrian rocks of Benton Hill westward over imbricate slices of Dalton Formation and across a detached sliver of Walloomsac that is tectonically the lowest slice. The slice of Walloomsac may be the same as the Lake Buel slice exposed in the Monterey quadrangle (Ratcliffe, 1975a).

The Alum Hill-East Mountain-Rattlesnake Hill and Clayton faults are equated as shown in sections A-A' and B-B'. These faults probably connect with the Monument Mountain-East Mountain, and Dry Hill slices exposed to the north that underly or form the brow of the west-facing Beartown Mountain nappe (Ratcliffe, 1975a, Fig. 1). Recumbent isoclinal folds are abundantly developed in the Dalton-Cheshire sequence at Alum Hill and northeast of Clayton. At Alum Hill F_2 folds are isoclinally refolded by isoclinal F_3 folds, resulting in the contorted map pattern. Similar refolded F_2 folds are shown on Rattlesnake Hill. The Dalton beneath the overlying Benton Hill fault contains numbrous F_3 folds with distinctive zones of cataclasis along detached limbs of isoclinal recumbent folds. A small sliver of hornblende gneiss (pꞒbh) between the Walloomsac and the Clayton fault west of Benton Hill (section B-B') is recumbently folded with the Dalton beneath the Benton Hill fault.

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

The Benton Hill fault has transported Precambrian rock westward across the imbricate slices of Dalton and autochthonous Walloomsac and across the autochthon. The sequence of rocks above Benton Hill fault can be traced northeastward in the South Sandisfield quadrangle (Harwood, personal communication) into rocks of the Beartown Mountain slice, although several relatively minor faults intervene. These relations indicate the Benton Hill fault is essentially the base of the Beartown Mountain slice at latitude $42^{\circ}05'$ north. Therefore, it projects upwards to the northwest to connect with the thrust fault of Precambrian rocks shown on Warner Mountain in the Great Barrington quadrangle (Ratcliffe, 1975b).

Exceptional exposures of the Benton Hill fault, F_3 folds, and extensive blastomylonite-mylonite gneiss can be seen in the cliffs west of Benton Hill. Extensive zones of black to gray-green zones of blastomylonite up to 1 m thick dip eastward subparallel to the fault surface. For description of the blastomylonites and their regional significance, see Ratcliffe and Harwood (1975).

Slip line determinations using the rotation sense and separation angle of F_3 minor folds (after the technique of Hansen, 1971) have yielded slip lines of north 64° E. and N. 84°E., and S 77° E. from three different localities (Fig. 1, and illustrated on the map) on the folded thrust. At each locality prominent lineations produced by the intersection of the blastomylonitic foliation and the Precambrian gneissosity approximate the slip direction, although the distributions are skewed. When the effects of rotation F_4 and F_5 folding is considered, the slip lines are consistent with thrusting from the east. These determinations are consistent with seven slip line determinations from the Beartown slice in the Monterey quadrangle to the north (Ratcliffe, 1975a).

The Canaan Valley fault is shown as truncating the Benton Hill slice. This interpretation is suggested by the relationship in the adjacent South Sandisfield quadrangle (Harwood, personal communication, 1975).

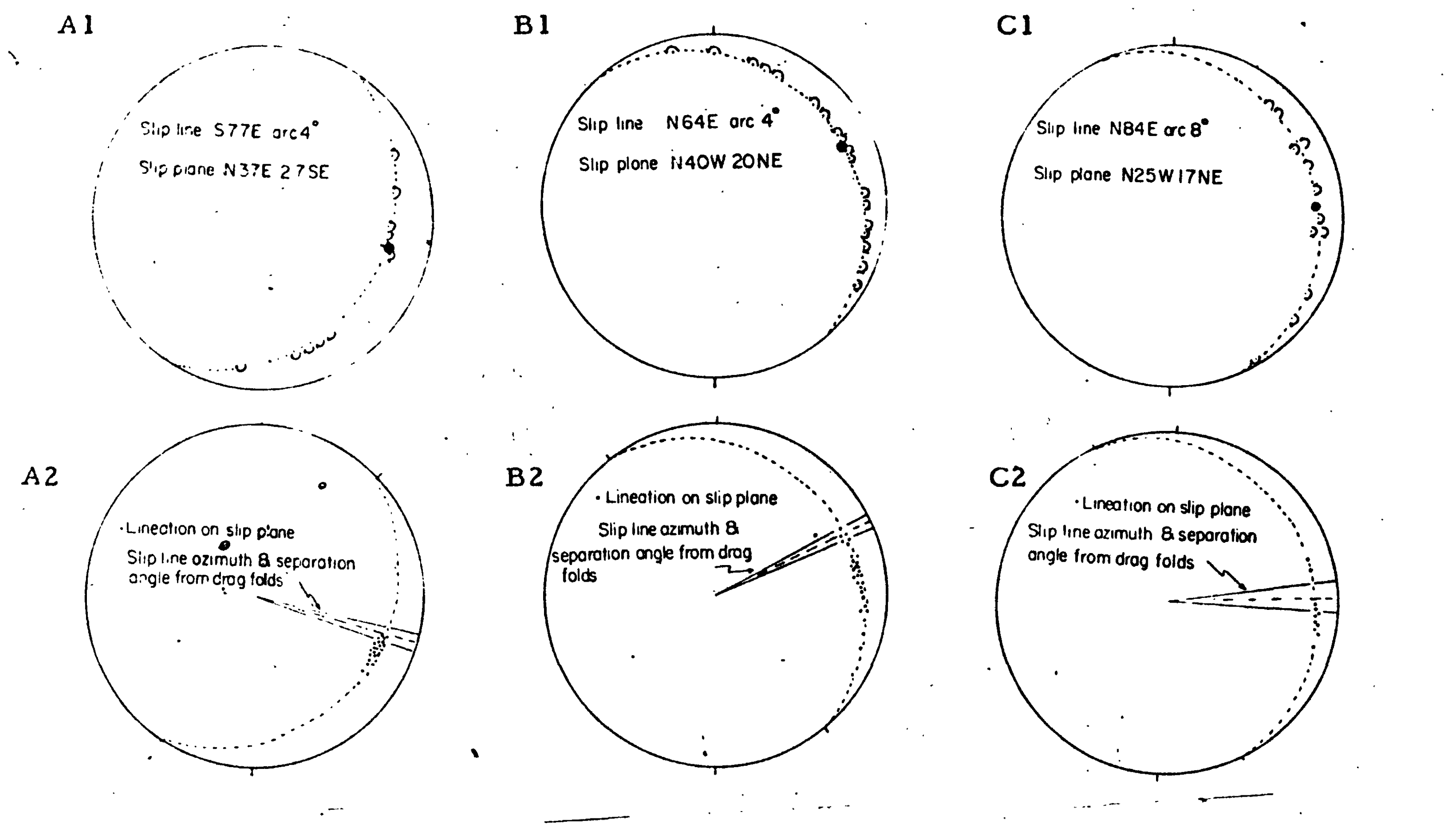


Figure 1. Slip line determinations from rotation sense of F_3 minor folds and lineations in blastomylonite from three localities just above the Benton Hill fault arranged A, B, C, from north to south. See map for location. Diagrams A2, B2, and C2 show lineations measured on blastomylonite surfaces at localities where drag folds were measured. Lower hemisphere stereographic projection.

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171

Thrusts beneath allochthonous rocks.--Sillimanitic schist and granulites of the Canaan Mountain schist (Rodgers and others, 1957) appear to concordantly overlie schist of the Walloomsac Formation in the Church Hill F_4 synform, but three different map units of the upper plate are exposed at the contact with the Walloomsac and suggest a fault contact. Excellent exposures of the contact can be seen for 500 feet southeast and southwest of the prow of the synform where abundant isoclinal recumbent folds of schistosity parallel the fault, dipping parallel to the contact with the Walloomsac. The Canaan Mountain Schist contains lithologies similar in part to Lower Cambrian rocks of the Hoosac Formation east of the Berkshire massif, as well as schistose and feldspathic rock in the late Precambrian(?) and Lower Cambrian Dalton Formation of the parautochthon, and also bears in part a striking resemblance to the Everett Formation of the Taconic allochthon. The lithologic data suggests that the Canaan Mountain rocks may have been deposited in a sedimentary environment intermediate between that of the Dalton (western facies) and the Everett facies Formation on the east. If this correlation is correct, the Canaan Mountain Schist may be part of an extensive slice of Taconic allochthonous rocks that lagged behind to be tectonically bypassed by the gravity emplaced allochthonous rocks of the main Taconic allochthon.

 U. S. GOVERNMENT PRINTING OFFICE: 1959 O - 511171
887-100

Rocks of the Everett Formation(?) on June Mountain in the Great Barrington quadrangle (Ratcliffe, 1975b) are in thrust contact with and involuted into the Dalton Formation of the Monument Mountain-East Mountain slice and are interpreted as allochthonous Taconic rocks that were retransported westward during the F_3 thrust faulting and recumbent folding (Ratcliffe, 1975b).

Post-thrust deformation and metamorphism.--F_4 and F_5 cross folds commonly have upright axial surfaces and are marked by a late crenulation slip cleavage or true foliation. Staurolite, garnet, and biotite porphyroblasts locally include microfolds of crenulated schistosity, but new minerals such as biotite and second generation muscovite are aligned on the F_4 axial surface cleavage locally producing a new foliation. Mineral textures and the lack of offset of the sillimanite isograd suggest that the high grade staurolite-kyanite-sillimanite Barrovian type metamorphism postdated the overthrusting but may have been synchronous with F_4 folds.

 U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

At the contact between Owm and the overriding Precambrian rocks at Benton Hill, a zone of tremolite-diopside calc-silicate rock 10 cm thick is developed that shows no evidence of cataclasis. This calc-silicate zone may represent a tectonically produced dolomite-quartz gouge zone that was recrystallized during the later metamorphism. Similar vuggy diopside-albite calc-silicate rocks are developed in a F_3 fault at Hop Brook in the Monterey quadrangle (Ratcliffe, 1975a), attesting to significant post-thrust metamorphism that is consistent with the mineral textures and distribution of isograds cited above.

Tectonic history

Following high grade regional dynamothermal metamorphism (F_1 folds) in the Precambrian at about 1 b.y. (Ratcliffe and Zartman, 1971), the gneisses of the Berkshires were exposed to erosion, and a transgressive sequence of coarse clastic rocks of the Dalton Formation and Cheshire Quartzite was deposited unconformably on the basement rocks. Sedimentation continued with stabilization of a shallow water carbonate depositional basin in which the Stockbridge rocks were deposited from the Early Cambrian to the Lower Ordovician. A major bathymetric reversal in the Middle Ordovician, coupled with block faulting, preceded the deposition of the exogeosynclinal Walloomsac Formation (Zen, 1967, p. 40-44, 71; Ratcliffe and Zen, 1971), and was the precursor to gravity gliding of the Lower Taconic slices in the Middle Ordovician (Zen, 1967). Rocks of the Everett slice were emplaced by hard rock thrusting before development of the regional foliation (Zen and Ratcliffe, 1966), the F_2 folds, and the first regional metamorphism.

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

Either synchronous with or slightly later than this event, intense recumbent folding and low angle thrusting of the Berkshire massif and its cover rocks (Dalton Formation and Cheshire Quartzite) took place under metamorphic conditions, although the cover rocks were metamorphosed prior to thrusting (Ratcliffe, 1972). During this period of overthrusting, the miogeosynclinal section locally became detached from the basement rocks.

Slip line determinations from the overthrust slices from the Monterey quadrangle (Ratcliffe, 1975a) and from Benton Hill indicate a general east to west thrust direction. The overthrusting may be Ordovician in age based on preliminary zircon ages from a granitic stock that crosscuts rocks above Canaan Valley fault and overlying fault slice of Precambrian rocks just east of the quadrangle boundary at 42°02'30" north latitude (Harwood, 1972). The F_2 and F_3 folding and metamorphism are therefore regarded as phases of the Taconic orogeny.

Additional deformation and northwest F_4 and northeast F_5 trending folds postdate the thrusts, and were in part synchronous with staurolite-kyanite-sillimanite and muscovite Barrovian metamorphism. The later event may be Acadian. The high angle thrust fault and normal fault are postmetamorphic and may be Late Devonian or younger.

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

Applied geology

Numerous marble quarries have been opened in unit a of the Stockbridge Formation, which is a massive, glistening white coarse grained dolomite marble suitable for crushing for pigment or agricultural lime. Where finer grained, west of the sillimanite isograd, this marble may be suitable for monumental stone or as white ships for terrazo flooring. The large quarry east of Church Hill and several smaller ones east of Alyndale Road are still active. Local zones rich in fibrous tremolite and quartz knots in unit a could release asbestosform tremolite needles into the air if processed improperly and could constitute a hazard to health. The local deposits of OGse in the western part of the map could be processed for high calcium lime, and mixed with the high magnesian lime of unit a for agricultural purposes.

Karst features, including sink holes, disappearing streams, caves, and solution enlarged joints are common in Owm east of Benton Hill. Solution enlarged joints and disappearing streams are developed in the Stockbridge on the southeast flank of the Brush Hill window. This area may be an important recharge area for potentially high volume artesian wells in the adjoining valley of the Konkapot River. If the connection of the Brush Hill fault and Bow Wow Road faults is correct, significant amounts of deep groundwater reserves may be expected about the projected Brush Hill fault in the Sheffield area, although the aquifer may be at too great a depth to provide economibal sources of water.

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

References cited

Hansen, Edward, 1971, Strain facies, Mon. 2, Minerals, rocks and inorganic materials: New York, Springer-Verlag, 207 p.

Harwood, D. S., 1972, Tectonic events in the southwestern part of the Berkshire anticlinorium, Massachusetts and Connecticut /abstr./: Geol. Soc. America abstr. 1972, v. 4, no. 1, (Northeast Sect.), p. 19.

MacFadyen, J. A., Jr., 1956, The geology of the Bennington area, Vermont: Vermont Geol. Survey Bull. no. 7, 72 p.

Norton, S. A., 1969, Unconformities at the northern end of the Berkshire Highlands: p. 21-1 to 21-20 in Guidebook for field trips in New York, Massachusetts and Vermont (J. M. Bird, ed.), New England Intercoll. Geol. Conf., 61st Ann. Mtg., Albany, New York, 1969: Albany, New York, SUNY-A Bookstore.

Ratcliffe, N. M., 1972, Revised polyphase structural chronology in western Massachusetts and problems of regional correlation /abstr./: Geol. Soc. America Abstr. 1972, v. 4, no. 1 (Northeast Sect.), p. 40.

______1975a, Bedrock geologic map of the Monterey quadrangle, Massachusetts: U. S. Geol. Survey open file rept.

______1975b (in press), Bedrock geologic map of the Great Barrington quadrangle, Massachusetts: U. S. Geol. Survey Geol. Quad. Map GQ-1141, and open file rept., U. S. Geol. Survey

______1975c (in press), Bedrock geologic map of the Stockbridge quadrangle, Massachusetts: U. S. Geol. Survey Geol. Quad. Map GQ-1143.

Ratcliffe, N. M., and Harwood, D. S., (in press), Blastomylonites associated with recumbent folds and overthrusts at the western edge of the Berkshire massif, Connecticut and Massachusetts: a preliminary report: in Tectonic studies of the Berkshire massif, Massachusetts, Connecticut and Vermont, U. S. Geol. Survey Prof. Paper 888, Ch. A.

Rodgers, John, and others, compilers, 1956, Preliminary geological map of Connecticut: Hartford, Conn., Geol. and Nat. History Survey, scale 1: 253,440.

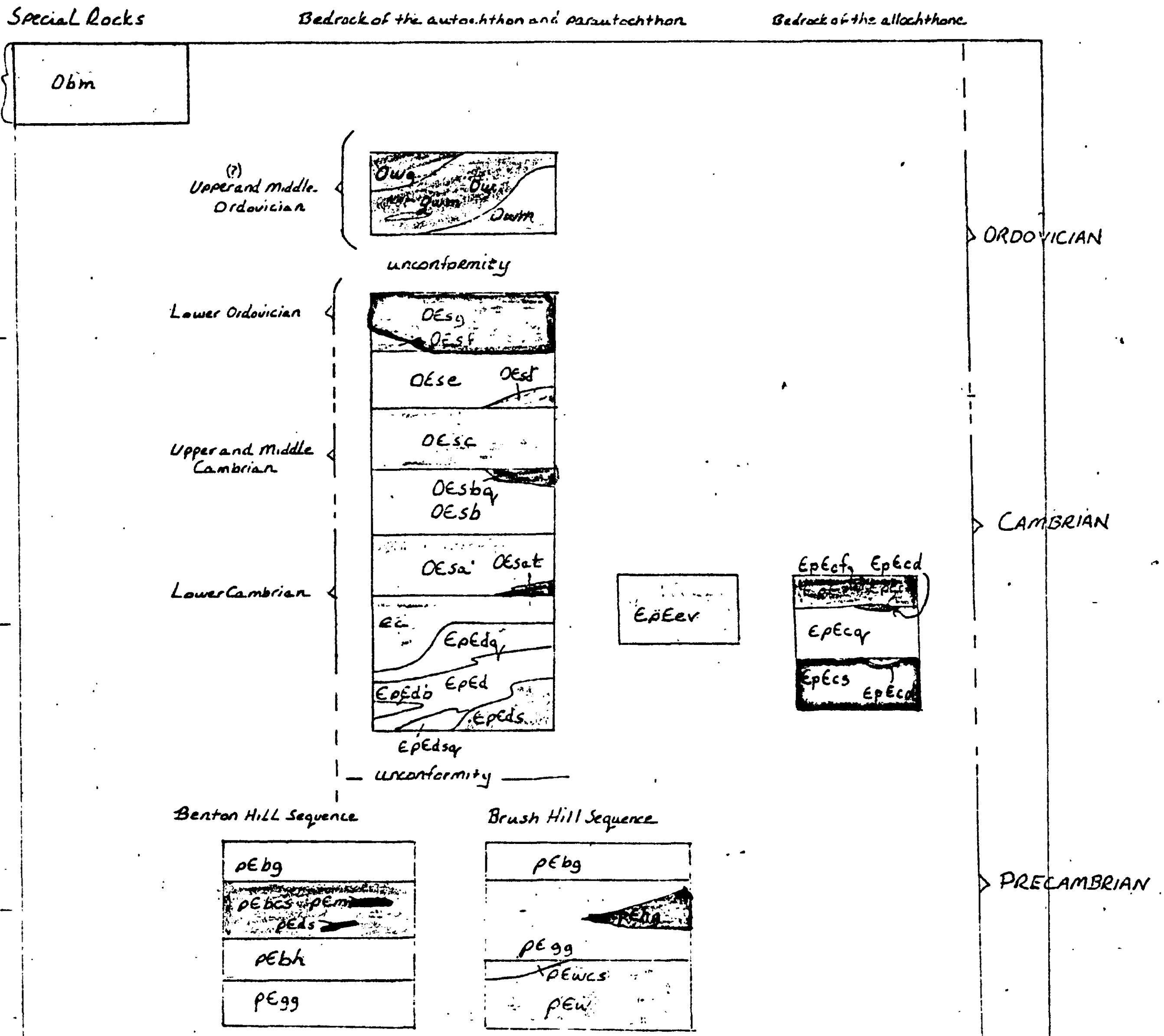
Zen, E-an, 1967, Time and space relationships of the Taconic allochthon and autochthon: Geol. Soc. America Spec. Paper 97, 107 p.

Zen, E-an, and Hartshorn, J. H., 1966, Geology of the Bashbish Falls quadrangle, Massachusetts, Connecticut, and New York: U. S. Geol. Survey Geol. Quad. Map GQ-507.

Zen, E-an, and Ratcliffe, N. M., 1966, A possible breccia in southwestern Massachusetts and adjoining areas, and its bearing on the existence of the Taconic allochthon, in Geological Survey research 1966: U. S. Geol. Survey Prof. Paper 550-D, p. D39-D46.

______, 1971, Bedrock geologic map of the Egremont quadrangle and adjacent areas, Berkshire County, Massachusetts and Columbia County, New York: U. S. Geol. Survey Misc. Geol. Investigation Map I-628.

Correlation of rock units



U. S. GOVERNMENT PRINTING OFFICE : 197? O - 511171
867-100

DESCRIPTION OF MAP UNITS

(Major minerals are listed in order of increasing abundance)

BEDROCK OF THE AUTOCHTHON AND PARAUTOCHTHON

(Parautochthon includes all gneisses of the Berkshire massif above the Benton Hill slice as well as the Dalton Formation and Cheshire Quartzite above the East Mountain, Alum Hill, Rattlesnake Hill, Canaan Valley, and Clayton faults. Autochthonous rocks include the Dalton Formation, Cheshire Quartzite, Stockbridge and Walloomsac Formations west of the Bow Wow Road fault, in the detached Paleozoic sequence above the Brush Hill, Umpachene Falls and Leffingwell Hill faults, as well as Precambrian and Precambrian(?) and Cambrian rocks in the Brush Hill, Umpachene Falls and Leffingwell Hill windows.)

WALLOOMSAC FORMATION (UPPER(?) AND MIDDLE ORDOVICIAN)

Owg

Dark-gray to silvery-gray, lustrous staurolite-garnet-biotite-plagioclase-muscovite-quartz schist, that locally contains milky white quartz pods and stringers 1 to 5 cm thick parallel to the prominent schistosity. Plagioclase-rich varieties are deeply pitted with 3 to 5 mm porphyroblasts of staurolite and deep-red garnet raised in positive relief. At the Bears Den Owg contains minor chlorite, with staurolite, biotite, garnet, plagioclase,

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
847-100

muscovite, and quartz and has a slight greenish cast. The contact with Ow at Toms Hill and Little Johnny Mountain appears conformable and locally ismarked by thin, 0.5 m thick layers of biotite-plagioclase hornblende amphibolite. Owg has been tentatively assigned to the Walloomsac Formation. It resembles staurolite-rich schists of the Walloomsac at Lions Head in the Bashbish Falls quadrangle (Zen and Hartshorn, 1966). Owg is up to 400 ft. thick on Miles Mountain

Ows

Dark-gray to dull gray, well-foliated, muscovite-plagioclase-biotite quartz schist and schistose metaquartzite with interbeds of silvery-gray graphitic muscovite-rich quartz schist, massive dull gray pitted cummingtonite-plagioclase-biotite-quartz calc-silicate rock up to 2 m thick, on Canaan Mountain and similar calcite biotite-quartz rock on Tom's Hill. At Benton Hill and Canaan Mountain Ows locally contains dark-gray to silvery-gray sillimanite-garnet muscovite-biotite-plagioclase quartz schist and a distinctive beds of medium dark gray biotite quartz schist and schisotse quartzite up to 5 m thick marked by clots of black biotite up to 1 cm in diameter that forms elongated spears up to 10 cm long in the prominent schistosity. Ows grades laterally and vertically into Owm through the addition of calcitic schist interbeds. The thickness of Ows is variable, ranging from a

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

feather edge up to 60 m

Owm

Massive, dark-rusty-brown to orangish-tan weathering, medium to coarse grained, light-gray to yellow-gray, microcline-plagioclase-phlogopite-quartz-calcite marble and schistose marble. Weathered exposures are deeply pitted, with porphyroblasts of black albitic plagioclase and irregular clots of phlogopite and quartz standing out in positive relief. Interbeds up to 2 m thick of strongly mottled, blue-gray and white calcite marble with boudinaged interbeds of beige-weathering, fine grained dolomite marble 3 to 6 cm thick are common near the base. Irregular lenses of Ows 0.5 m to 10 m are found throughout. At Canaan Mountain and east of Konkopot Village massive beds of grayish to faintly grayish-green diopside calc-silicate rock up to 3 m form irregular nonpersistent lenses of metadolomitic quartzite. Thin beds of white to yellow-gray weathering well laminated meta-quartzite and metaquartz pebble conglomerate are found in Owm on the small, 980 foot knob 3200 ft. southwest of the intersection of Route 44 and Old Turnpike Road. The thickness of Owm is variable but is in excess of 152 m at Tom's Hill. Owm unconformably overlies unit a of the Stockbridge in a small quarry exposure 1400 ft. south of the intersection of Trescott Hill Rd. and Route 44

STOCKBRIDGE FORMATION (LOWER ORDOVICIAN TO LOWER CAMBRIAN)

OЄsg

Massive, light-gray weathering, white to gray calcite marble with steel-gray weathering calcitic dolomite marble as north of Tom's Hill (dolomitic marble previously assigned to unit c by Zen and Hartshorn, 1966). Less than 20 m thickness is exposed in the quadrangle

OЄsf

Gray-weathering calcareous metasandstone and quartzose calcitic marble with quartz grains raised in positive relief, and rare thin interbeds of cream-weathering dolomitic marble up to 1 m thick. Thickness varies from a feather edge to 5 m

OЄse

Light-gray- and white-banded, calcite marble with a distinctive mottled appearance owing to contorted and irregular layering. Exposures north of Konkopot are coarsely crystalline, calcite marble with calcite grains as much as 1 cm in diameter, but more commonly from 0.25 to 0.5 cm in diameter. Irregular blotches of white granular calcite, and darker areas of swirled blue-gray finer grained calcite marble produce a distinctive mottled appearance. Ocse is less than 30 m thick west of the Bow Wow Road fault where the entire Stockbridge may be tectonically thinned.

OCsd

Discontinuous, light-gray phlogopitic, quartzose calcite marble and quartzose dolomitic marble, with interlayers of silvery-gray muscovitic schistose calcite marble. North of Konkopot OCsd consists of interbedded rusty-yellow gray-weathering massive diopside calc-silicate rock and tan-weathering phlogopitic tremolite-diopside metaquartzite in beds up to 1 m in thickness. The unit is up to 25 m thick but locally is absent

OCsc

Massive, light-gray to dark-steel-gray weathering, fine grained calcitic dolomite marble with thin phlogopitic partings, locally well bedded with laminations 2 to 5 mm thick of dark blue-gray and medium blue-gray dolomitic marble, and massive white-weathering calcitic dolomite marble. Exposures on the south flank of Brush Hill have abundant solution enlarged joints. North of Konkopot siliceous dolomite marble beds near the top of the unit contain large rectangular porphyroblasts of white diopside up to 3 cm long randomly scattered throughout the rock. The unit is approximately 200 m thick

OCsb

A heterogeneous unit consisting mainly of gray, beige, and cream weathering dolomitic marble, with distinctive ubiquitous phlogopite-quartz partings. Interbeds of rusty-weathering tremolite-phlogopite-dolomite marble with small amounts of secondary metamorphic calcite are common north of Konkopot and near

Mill River. Discontinoous beds of feldspathic metaquartzite up to 1 m thick but more commonly 1 cm to 5 cm thick are common throughout. A distinctive quartzite and tremolite calc-silicate unit OCsbq is discontinuously developed near the top of unit B in the western part of the map. Outcrops are massive, to ireegularly pitted and knotted with coarse growths of quartz and bladed tremolite. Excellent exposures of OCsbq can be seen at Bartholomew's Cobble, 500 ft. south of the intersection of Wheatogue and Andrus Roads

OЄsbq

OЄsa

A massive, white to light gray, medium grained, dolomitic marble commonly lacking siliceous impurities or the heterogeneous character of OCsb. Exposures at Canaan contain tablets of white diopside and sprays of white magnesian tremolite-actinolite. Dolomite marble with large curved sprays of fibrous tremolite 3 to 10 cm long is exposed at the large quarries at the eastern foot of Canaan Mountain. Virtually all of the numerous quarries in the quadrangle are opened in unit a. At the contact with the Cheshire quartzite around the Umpachene Falls window, a thin light-green, rusty-weathering tremolite-actinolite calc-silicate unit OCsat, up to 2 m thick is developed

OЄsat

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

CHESHIRE QUARTZITE (LOWER CAMBRIAN)

Massive, white- to tan-weathering, vitreous metaquartzite in exposures up to 4 m thick, locally thinly bedded and cross laminated. Cheshire Quartzite is composed predominantly of metaquartzite with less than 5 percent feldspar or mica, although feldspathic metaquartzite is interbedded. Rocks composed predominantly of more feldspathic metaquartzite and muscovitic flag stones are assigned to the Cdq unit of the Dalton Formation. On Alum Hill vitreous quartzite 3 m thick forms the core of numerous isoclinal recumbent folds and is in normal sedimentary contact with flaggy metaquartzites of the Dalton Formation (CpCdq). Excellent exposures of Cc can be seen at Umpachene Falls, north of Route 44 1,000 ft. east of Trescott Hill Rd. A complete section of Cc is not exposed in the quadrangle, but the thickness exceeds 270 m

DALTON FORMATION (LOWER CAMBRIAN AND PRECAMBRIAN(?))

Mainly yellow-tan-weathering, black-biotite-spotted, muscovitic, feldspathic metaquartzite containing scattered metacrysts of black tourmaline, commonly finely laminated on a mm scale but massive appearing in large outcrops. Feldspar, largely microcline, exceeds 5 percent, and commonly ranges from 51 to 25 percent; red-brown pleochroic biotite ranges from 2 to 25 percent; and

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

muscovite from 2 to 27 percent. This lithology represents the bulk of the Dalton. However, with loss of quartzose interbeds and increase of micaceous and feldspathic impurities, several other rock types have been mapped separately

ЄpЄdq Yellow-gray to buff-weathering, tourmaline-rich flaggy meta-quartzite with beds 1 to 4 cm (0.4 to 0.6 in.) thick or as massive out crops as much as 5 m (16 ft.) thick of yellowish-gray-weathering feldspathic metaquartzite containing black spots of magnetite and small weathered-out pits of kaolinite that results in a porous, easily crumbled rock where deeply weathered. Deeply weathered feldspathic CpCdq forms a saprolite at least 3 m thick on the cleared slopes east of the new dam at Canaan Valley. A lens of feldspathic metaquartzite found in schistose Dalton (CpCds) above the East Mountain fault may be at a different stratigraphic horizon than the bulk of CpCdq

ЄpЄds Silvery-gray to dark-gray, biotite-plagioclase-quartz-muscovite schist with irregular pods and stringers 1 cm to 5 cm thick composed of granular white quartz-microcline and black tourmaline. Locally CpCds is yellowish-tan-weathering, microcline-biotite quartz muscovite schist with large 0.5 to 1 cm scales of lustrous muscovite. C pcds above the East Mountain fault locally contains beds of garnet-biotite-plagioclase-quartz-muscovite. CpCds

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

exposed above Canaan Valley fault locally contains white knots of sillimanite and scattered garnets. Overall, CpCds contains abundant muscovite and significant microcline but rarely contains garnet in contrast to similar but distinctly different sillimanite-garnet muscovite-biotite-plagioclase quartz schists on Canaan Mountain

€p€dsq

Light-yellow-tan-weathering, biotite-microcline-plagioclase quartz muscovite schist spotted with abundant accessory black tourmaline and with thin beds of well bedded, gray to yellow-gray vitreous quartzite 0.25 to 0.5 m thick and rare beds up to 1 m thick of conglomerate containing small pebbles of blue-gray quartz. This unit is restricted to the Brush Hill area, where lack of continuous exposure and abundant interlayering of rock types restricts further subdivision

€p€db

Massive, dark-gray to black biotite metaquartzite with interbeds of greenish-gray quartzose biotite schist, and rare beds of quartz pebble metaconglomerate. Locally the unit is finely foliated and laminated on a centimeter scale, resulting in a pin-striped appearance produced by alternation of dark-gray biotite-rich layer and lighter-gray biotite-plagioclase-quartz layers. The unit is exposed only on Rattlesnake Hill, where it has normal sedimentary contact with Tan-weathering feldspathic metaquartzites of CpCd

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

GNEISSES OF THE BERKSHIRE MASSIF (ABOVE BENTON HILL FAULT) AND IN THE BRUSH HILL, UMPACHENE FALLS AND LEFFINGWELL HILL WINDOW

BENTON HILL SEQUENCE

pЄbq

BIOTITE QUARTZ PLAGIOCLASE PARAGNEISS--light- to dark-gray-weathering, fine grained, boitite-quartz-plagioclase gneiss, commonly well layered on a cm to m scale, produced by alternation of white-weathering quartz and plagioclase-rich granulite with jet black biotite and/or hornblende-rich layers. Relatively massive, tan- to gray-weathering biotite-plagioclase quartz granulite is locally present. Unit grades into pCbcs through addition of hornblende plagioclase quartz and hornblende-diopside plagioclase quartz granulite. The unit is at least 100 m thick

pЄbcs

CALC-SILICATE GNEISS--A heterogeneous unit consisting of rusty-weathering, sulphidic, hornblende-plagioclase diopside calc-silicate, gray-weathering well layered hornblende gneiss with irregular knots up to 10 cm in diameter of dark-green diopside rimmed with medium-dark-green hornblende, and massive beds of leek-green diopside rock up to 2 m thick. Beds of coarsely crystalline white calcite marble up to 2 m thick with large dark-green crystals of diopside up to 5 cm long, and disseminated

U. S. GOVERNMENT PRINTING OFFICE: 1959 O - 511171
887-100

small dark-green hornblende are mapped separately as pCm. Massive, white-weathering, block jointed, fine-grained, diopside-hornblende-plagioclase granulite (pCds) with abundant large 1 cm wedge-shaped crystals of chocolate-brown sphene is scattered throughout but is extensively developed on Rhodes Hill. The unit is approximately 60 m thick

HORNBLENDE QUARTZ PLAGIOCLASE GNEISS--Dark-gray, finely layered, hornblende-biotite-quartz-plagioclase gneiss with beds up to 1 m thick of biotite-rich hornblende amphibolite or biotite schist, with addition of diopside and hornblende plagioclase granulite the unit grades into pCbcs. Excellent exposures of pCbh can be seen on Ford Hill

BIOTITE GRANITIC GNEISS--Massive, light-gray to white-weathering, biotite-plabioclase-microcline-quartz granitic gneiss locally with augen of pink microcline up to 3 cm in length and 1 to 2 mm spots of black magnetite and small amounts of ferro-hastingsite. The rock is commonly exposed in massive, glacially smoothed exposures commonly showing of only a faint layering on a centimeter scale produced by varying concentrations of biotite. This unit resembles in massive nonlayered character and mineralogy the Tyringham Gneiss exposed in the Great Barrington (Ratcliffe, in press) and Monterey quadrangles (Ratcliffe, 1975a) to the north, and may be intrusive

BRUSH HILL-UMPACHENE FALLS AND LEFFINGWELL HILL SEQUENCE

pЄbg

BIOTITE-QUARTZ PLAGIOCLASE PARAGNEISS--Light-gray to dark-gray biotite-quartz-plagioclase gneiss with accessory muscovite and thin beds up to 1 m thick of biotite-rich white plagioclase spotted hornblende amphibolite. Unit exposed at the north end of Brush Hill resembles pCbg of the Benton Hill sequence and may be correlative

pЄhg

HORNBLENDE GARNET AMPHIBOLITE--Massive, dark-green hornblende or hornblende garnet amphibolite with minor beds of sulphidic leek-green diopside calc-silicate rock and plagioclase blue quartz granulite

pЄgg

BIOTITE GRANITE GNEISS (for description see pCgg under Benton Hill sequence above)

pЄw

WASHINGTON GNEISS AND ASSOCIATED CALC-SILICATE ROCK

A heterogeneous unit consisting of the following rock types interlayered on a meter scale: dark-colored, well-layered biotite gneiss with coarse crystals of microcline-perthite or plagioclase up to 10 cm in diameter irregularly interlayered with beds up to 7 cm thick of lavender quartz pebble conglomerate and blue quartz plagioclase granulite. Locally blue quartz conglomerates

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

are graphitic and yellow-gray- to rusty-weathering. Beds of massive plagioclase-hornblende-biotite spotted granulite with scattered blue quartz laterally replaces the more layered varieties

pЄwcs

Rusty-weathering graphitic muscovite-quartz schist and deeply weathering, rusty, fine grained pale-green diopside calc-silicate rock

ALLOCHTHONOUS ROCKS

(Includes rocks tentatively assigned to the Everett Formation above the June Mountain fault, and Canaan Mountain Schist above the Canaan Mountain fault.)

ЄpЄev?

EVERETT FORMATION(?) (LOWER CAMBRIAN(?) AND (OR) UPPER PRECAMBRIAN(?))--Coarse-grained light-gray to greenish-gray lustrous muscovite-biotite-staurolite-garnet-plagioclase-chlorite-quartz schist, marked by irregular segregations of milky white nongranular to granular quartz seams parallel to prominent foliation. Rugged surfaces result from differential weathering of resistent large garnet and staurolite and nonresistent plagioclase megacrysts. Contains local beds of kyanite-bearing schist and amphibolite. Unit is confined to June Mountain area but grossly resembles rocks of the Everett slice in the Egremont, Bashbish Falls, and State Line quadrangles, as well

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

as schistose beds in CpCcs immediately above the Canaan Mountain thrust on the northwest limb of the Church Hill synform

CANAAN MOUNTAIN SCHIST (CAMBRIAN(?) AND PRECAMBRIAN(?)

€p€cs

Light-silvery-gray to dark-gray lustrous, garnet-biotite-plagioclase-muscovite-quartz schist marked by thin 1 to 3 cm thick stringers of granular milky-white quartz parallel to the prominent schistosity that is isoclinally folded. Thin amphibolitic interbeds 0.5 m to 0.1 m thick are scattered throughout. Locally coarse garnet, sillimanite-plagioclase muscovite biotite quartz schist and granulite is interlayered on a meter scale. The unit is not strongly sillimanitic and contains relict armoured grains of staurolite included in plagioclase or muscovite. CpCcs resembles most closely rocks of the Everett Formation (CpCev) at June Mountain, although chlorite and staurolite , relatively abundant at June Mountain, are largely absent on Canaan Mountain

€p€ca

Lenticular biotite-hornblende-plagioclase and biotite plagioclase hornblende amphibolite up to 3 m thick interlayered with dark-gray biotite quartz plagioclase granulite. Amphibolite CpCa appears in two stratigraphic positions

ЄpЄcq

Massive, light-gray to light-yellow-tan-weathering, magnetite-biotite-muscovite-plagioclase-quartz granulite with interbeds of tan-weathering plagioclase-microcline-metaquartzite 2.5 to 15 cm thick. Locally the unit is flecked with black biotite and contains small 1 to 2 mm pale-red garnet and small knots of sillimanite and magentite. Overall CpCcq resembles feldspathic meta-quartzites and feldspar granulites of the Dalton Formation CpCd and may represent interfingering Dalton-like sediments in the Canaan Mountain Formation

ЄpЄcf

Knubby, slightly rusty-weathering, gray to dark-gray, sillimanite-magnetite-garnet-muscovite-biotite-plagioclase-quartz schist and granulite marked by distinctive large knots up to 1 cm long of sillimanite and quartz and large up to 1 cm deep-red garnets. More schistose beds resemble some of the schistose and silli-manitic CpCds of the Dalton Formation above the Canaan Valley fault

SPECIAL ROCK TYPE

Obm

BLASTOMYLONITE AND MYLONITE-GNEISS (indicated as map unit where extensively developed, shown by symbol only elsewhere)--Dark-gray to silvery-gray-green, fine-grained muscovite-biotite-clinozoisite-microcline-plagioclase-quartz mylonite gneiss and blastomylonite with subrounded porphyroclasts of granitic gneiss

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

and calc-silicate rocks. Porphyroclasts resemble small pebbles in outcrop, but exhibit all degrees of milling in thin section. The matrix of blastomylonite contains finer grained minerals than the porphyroclasts aligned on a well developed fluxion structure with a strongly preferred planar orientation of biotite and muscovite parallel to the fluxion bands. Blastomylonite and mylonite gneiss is found at the sole of the Brush Hill, Umpachene and Benton Hill faults and beneath the fault slice of CpCds at Leffingwell Hill. Excellent exposures of the blastomylonite in contact with unit a of the Stockbridge can be seen in the east wall of the Knokopot River below the dam at Mill River, where microcline-rich granitic gneiss ~~porphyroclastic blastomylonite~~ is isoclinally folded with the marble.

The exposures of blastomylonite at Umpachene Falls were originally regarded as a sedimentary pebble conglomerate (Ratcliffe, 1968b) and used incorrectly as evidence for a sedimentary contact between the Cheshire Quartzite and the Precambrian gneisses (Ratcliffe and Zartman, 1971). The blastomylonite passes gradationally into normal pCgg above Umpachene Falls and at the southwest end of Brush Hill window

CONTACT--Long dashed where approximately located; short dashed where inferred beneath thick glacial cover; dotted in water

FAULTS--Long dashed where approximately located; short dashed where inferred beneath thick glacial cover; dotted in water

Synmetamorphic--Sawteeth on overthrust plate, inclined and overturned. Formed synchronous with foldset 3, folded by foldsets 4 and 5 locally overturned in foldset 3. Irregular zones of blastomylonite (Obm) may parallel fault traces

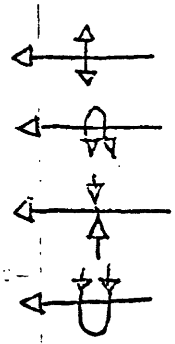
U
D
Steep fault--Postmetamorphic-- upthrown side, D, downthrown side

MAJOR FOLDS--Showing approximate trace of axial surface. Arrows show direction of dip of limbs, barbs show dip direction of axial surface. Folds are classed by age of formation based on superposition of folds and lepidoblastic mineral textures from 2 the oldest to 5 the most recent. Foldset 1 are Precambrian folds, not recognized in the quadrangle but mapped in the Monterey quadrangle to the north. For a discussion of fold characteristics and tectonic chronology, see the text of the Monterey quadrangle (Ratcliffe, 1975, open file report)

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

Foldset 2--Folds of bedding in Paleozoic rocks with strongly developed axial planar cleavage, or coarse schistosity.

The dominant schistosity in the metapelitic Paleozoic rocks that is defined by coarse micaceous and quartzo-feldspar layering or by coarse plates of mica is axial planar to these folds



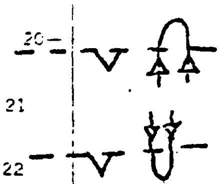
Anticline

Overturned anticline

Syncline

Overturned ~~anticline~~ syncline

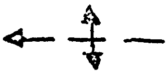
Foldset 3--Folds of foliation (schistosity) in Paleozoic rocks and of gneissic layering in Precambrian rocks, related to episode of low angle synmetamorphic overthrusting of Berkshire massif and detachment along the Brush Hill-Umpachene Falls-Leffingwell Hill faults. Folds are strongly overturned and locally recumbent. A blastomylonitic axial surface foliation is strongly developed, particularly in the Precambrian rocks. Barbs show dip direction of axial surface



Overturned to recumbent antiform

Overturned to recumbent synform

Foldsets 4 and 5--Open to tight folds of schistosity and second blastomylonitic foliation affecting rocks above and beneath overthrusts. Axial surfaces are largely upright to mildly overturned with axial planar slip or crenulation cleavage locally well developed. Folds are identified by superscript 4 or 5


Antiform of older foliation


Synform of older foliation


Folded fold axis--Showing approximate orientation and direction of plunge as seen in outcrop

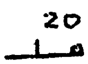
PLANAR FEATURES--Where two symbols for planar features are combined, the younger feature is shown by a solid triangle or rectangle; their intersection marks point of observation

Strike and dip of bedding--Ball indicates top of beds known from sedimentary features

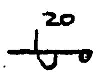
Inclined


Vertical


Horizontal



Right-side-up, tops known from sedimentary features



Up-side-down, tops known from sedimentary feature

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

Strike and dip of parallel foliation (or schistosity) and bedding

Inclined


Vertical


Horizontal

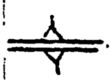
Strike and dip of gneissic foliation in Precambrian granitic gneisses produced by faint variations in biotite or hornblende concentrations or by foliation not accentuated by parallel compositional zoning. Feature may have formed in the Precambrian

Inclined


Vertical

Strike and dip of foliation and parallel gneissic layering in Precambrian rocks, resulting from alternating quartzo-feldspathic and micaceous or hornblendic layers 1 cm to several meters in thickness. Feature may have formed in the Precambrian

Inclined


Vertical

Strike and dip of slip or crenulation cleavage or of second cleavage in Precambrian rocks

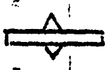
Inclined


Vertical

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100

Strike and dip of axial surface of isoclinal fold in bedding (Paleozoic rocks) or of gneiss layering in Precambrian rocks. In Paleozoic rock axial surface has strongly developed coarse schistosity or foliation

Inclined

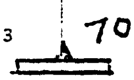

Vertical

Strike anddip of blastomylonitic foliation that is axial planar to isoclinal to tightly appressed folds of schistosity or gneissic layering (foldset 3). In both Paleozoic and Precambrian rocks the folded surface is an older axial-surface foliation; folds are concentrated near synmetamorphic thrust faults and have axial planar foliation in which biotite, hornblende, muscovite are aligned parallel to zones of crushing and shearing spaced 1 mm to centimeters apart. Shear zones are composed of gray fine-garined seams of blastomylonite. The intensely developed axial planar blastomylonitic foliation is expressed in thin section by minute 0.5 mm thick zones of cataclasis marked by granulation of feldspar, quartz, biotite, and hornblende and by recrystallization of a second generation of finer grained biotite and muscovite. Stringers of crushed rock rich in newly crystallized clinozoisite and magnetite are

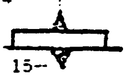
U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
887-100

aligned along the shear zones. This new foliation is both cataclastic, as shown by the milling of preexisting minerals, and metamorphic, as shown by the crystallization of new lepidoblastic and (retrograde) mineral assemblages in the sheared zones. This feature is widespread and is uniquely associated with deformation along the soles of the basement overthrusts throughout the Berkshires (see Ratcliffe and Harwood, 1975)

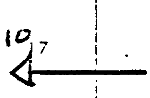
Strike and ip of axial surface of late (post-thrust) upright to slightly overturned F_4 or F_5 folds of schistosity or foliation with axial planar slip or crenulation cleavage

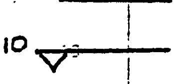


Inclined

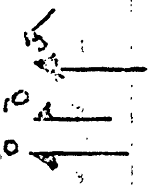

Vertical

LINEAR FEATURES (may be combined with planar features)

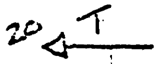




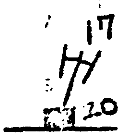
Bearing and plunge of axis of minor fold in bedding in Paleozoic rocks, or fold of compositional layering in Precambrian rocks (first foldset). Half arrow indicates side that moved up for drag sense



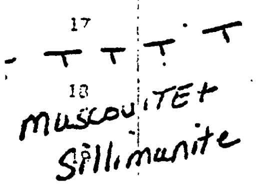
Bearing and plunge of minor fold in foliation or schistosity in Paleozoic rocks, or in gneissic layering in Precambrian rocks formed in F_3, F_4, or F_5 folding event. Half arrow indicates side that moved up for drag sense



Tourmaline lineation on schistosity in rocks of the Dalton Formation



Linear symbol shows direction and plunge of slip line on plane of blastomylonitic foliation as determined from analysis of drag sense and separation angle of F_3 minor folds. Slip line approximates thrust direction and agrees closely with slickensides and lineation on surfaces of blastomylonite seams. Slip line determined from 3 localities at the base of the Benton Hill slice near section B-B' indicate thrusting from the east-northeast (See Fig 1)



Isograd--Approximate location of the sillimanite and muscovite isograd; tick marks on the high grade side

 U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171
867-100