1-1-1969

Structural and Stratigraphic Relations Along the Precambrian Front in Southwestern Massachusetts

Ratcliff, Nicholas M.

Trip 1

STRUCTURAL AND STRATIGRAPHIC RELATIONS ALONG THE PRECAMBRIAN FRONT IN SOUTHWESTERN MASSACHUSETTS*

by

Nicholas M. Ratcliffe
City College of C. U. N. Y.

INTRODUCTION

Gneissic rocks of the Berkshire Highlands are at present undergoing the close scrutiny of several U. S. G. S. workers. I am indebted to my colleagues David Harwood, Stephen Norton, and Robert Schnabel for helpful discussions of stratigraphic and structural problems we share. My work began as a study under R. H. Jahns, at the Pennsylvania State University in 1962. Two generous grants from the Penrose Fund, and financial support from the U. S. G. S. in the Ashley Falls and Monterey quadrangles have allowed continuation of this project to the present.

The ideas presented in this field trip guide are more in the nature of a progress report than a finished product and are subject to changes as the mapping continues. Map data from the Great Barrington, Stockbridge, Ashley Falls, East Lee, and Monterey quadrangles have been used in this compilation (Ratcliffe, 1965, and unpublished data).

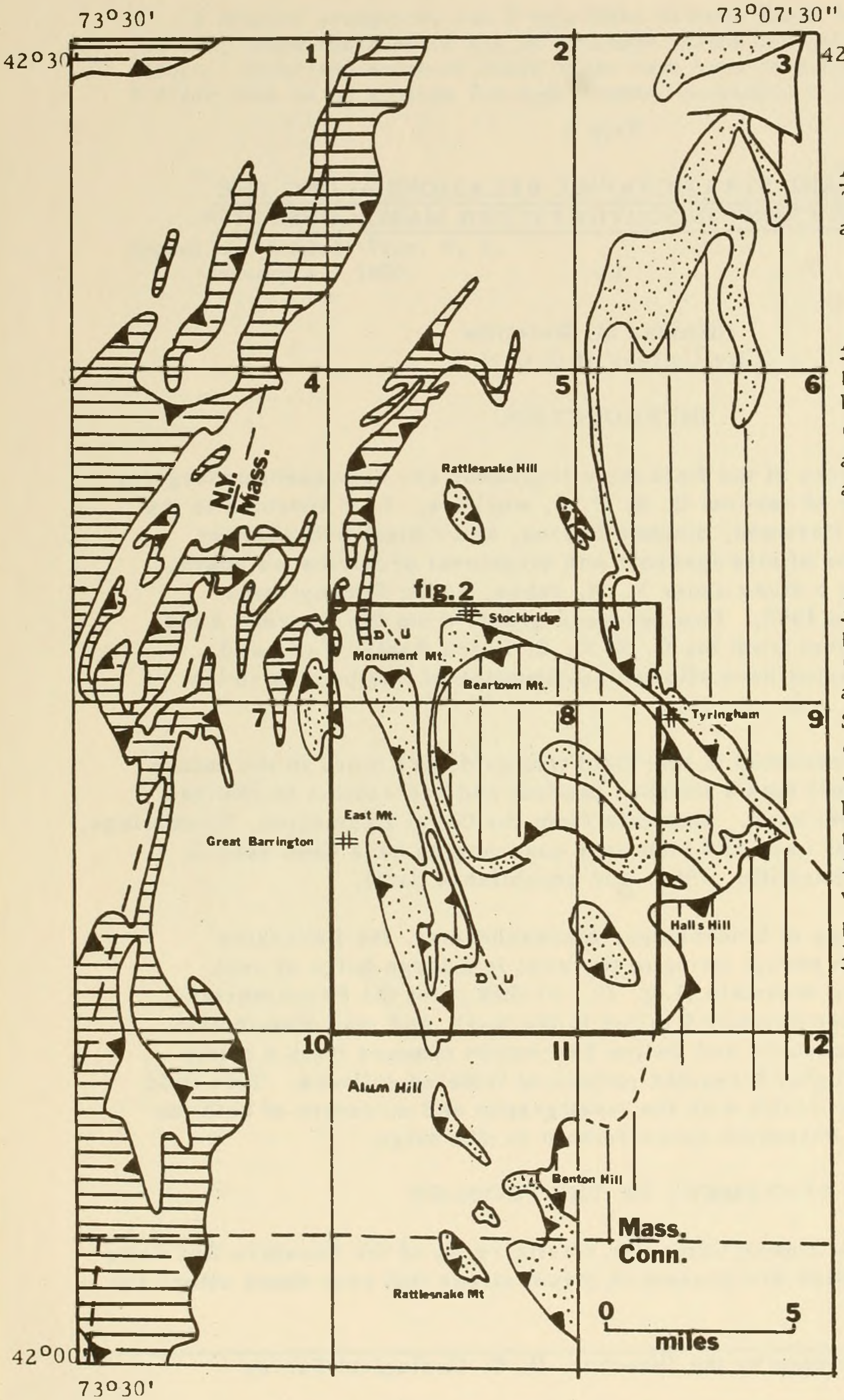
At the latitude of Stockbridge, Massachusetts, the Berkshire Highlands make an abrupt swing to the west in a large bulge of rock known as Beartown Mountain (Fig. 1). At this point the Precambrian front is offset approximately 5 miles to the west, and map distribution of the Cheshire Quartzite and Dalton Formation changes from a fairly regular belt to a highly irregular pattern of isolated outliers. This field trip will deal specifically with the stratigraphy and structure of both the Precambrian and Paleozoic rocks related to this bulge.

STATEMENT OF THE PROBLEM

The probable Lower Cambrian clastic rocks of the Cheshire Quartzite and Dalton Formation are present in thrust slices that rest above either the

---

*Publication authorized by the Director, U. S. Geological Survey



Tectonic units

Allochthonous rocks of the Taconic sequence (Chatham and Everett slices).

Autochthonous rocks, comprising Walloomsac and Stockbridge Formations or local Cheshire and Dalton Formation and Precambrian rocks that appear to be in place.

Parautochthonous rocks, comprising rootless exposures of Cheshire and Dalton Formation and Precambrian gneisses. Stippled pattern - combined Cheshire and Dalton Formation; vertical ruled pattern - Precambrian gneisses. Unstudied contacts in East Lee and Pittsfield East quadrangles are shown without fault and may be in place.

Index to quadrangles

1. Canaan
2. Pittsfield West
3. Pittsfield East
4. State Line
5. Stockbridge
6. East Lee
7. Egremont
8. Great Barrington
9. Monterey
10. Bashbish Falls
11. Ashley Falls
12. South Sandisfield

Fig. 1. Major tectonic units in southwestern Massachusetts.

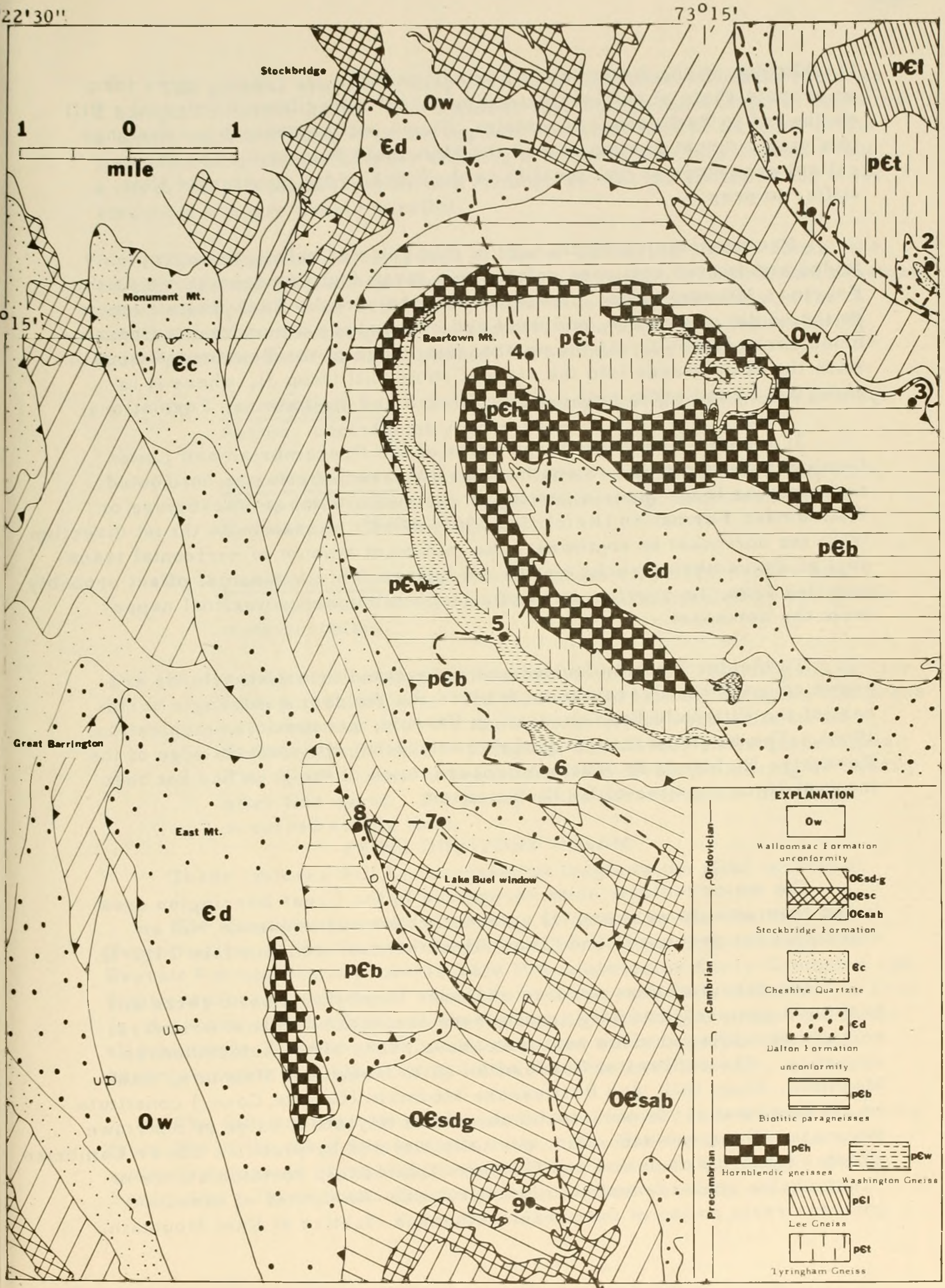


Fig. 2. Generalized geologic map of the Beartown Mountain area, showing location of stops.

Stockbridge or the Walloomsac Formation (Fig. 1). These rocks form an arcuate chain of outliers extending for 21 miles from Rattlesnake Hill southward to Rattlesnake Mountain. These outliers have been assigned to a single thrust system named the Monument Mountain slice for excellent exposures at that locality in the Stockbridge quadrangle (Ratcliffe, in prep.).

Precambrian rocks lie east of this belt and belong to a complexly folded and faulted sequence related to a large faulted nappe known as the Beartown Mountain slice. Inverted Paleozoic rocks flank this structure on the south, southwest, and west and everywhere dip under the Precambrian rocks (Stop 7). At the northeastern edge of the Beartown Mountain slice the fault passes into the air at Cobble Hill (Stop 3), where it is underlain by the right-side-up Stockbridge and Walloomsac Formations.

It appears likely that large parts of the Precambrian and Lower Cambrian clastic rocks in southwestern Massachusetts are not rooted and occur as large thrusts resting on the autochthonous Stockbridge or Walloomsac Formation (Ratcliffe, 1965, 1968). Assuming a thrust direction from the northeast to southwest, the minimum amount of horizontal transport of Precambrian rocks was seven miles. This horizontal offset probably resulted from the overthrusting of a large recumbent anticlinal nappe from the northeast.

To the north highly faulted and imbricated thrust structures are known to mark the Precambrian front in the Windsor quadrangle northeast of the Pittsfield East quadrangle (Norton, personal communication, 1969). The extent of thrusting of this kind along the western edge of the Berkshire Highlands is unknown because much of the area has not been mapped since the time of B. K. Emerson.

MAJOR TECTONIC UNITS

The major tectonic units recognized in the Great Barrington area listed from east to west are (1) a parautochthonous sequence, (2) an autochthonous sequence, and (3) an allochthonous sequence (see Fig. 1).

The parautochthon consists of Lower Cambrian clastic rocks and basement gneisses that have locally been overturned, thrust westward, and now occupy anomalous positions above rocks of the autochthonous sequence. The outliers of Rattlesnake Hill, Monument Mountain, East Mountain, Alum Hill, and Rattlesnake Mountain (Canaan, Conn.) constitute an arcuate band of the parautochthon west of the lobate bulge of Beartown Mountain. Beartown Mountain, partially rimmed by probable Lower Cambrian clastics (Dalton Formation and Cheshire Quartzite), contains a core of Precambrian gneisses and also is not rooted. An outlier of basement gneisses rests on top of the parautochthonous clastics at East Mountain.

The general synformal map pattern of Beartown Mountain requires a complex interpretation. The symmetrical map pattern (Fig. 2) indicates a single coherent fold. The Tyringham Gneiss occurs in the core of the Beartown Mountain structure, defining a synform that was rotated about a northwest-southeast axis by late folding, so that the flanks of the older structure are now nearly parallel.

The autochthon is composed of Lower Cambrian clastic rocks, the Stockbridge and Walloomsac Formations, and locally Precambrian basement rocks that appear to be overlain by right-side-up rocks. Within the autochthon a complex sequence of tectonic events is recorded involving four Paleozoic deformational phases, as summarized below.

D_0 - pre-Walloomsac: faulting, folding, and possible overturning. Angular unconformity preserved.

D_1 - post-Walloomsac: small isoclinal recumbent folds, possible slump folds related to Taconic thrusting, emplacement of Everett and Chatham slices.

D_2 - post-allochthon: regional northeast structural trends and development of major foliation (S_2) accompanied by low grade metamorphism.

D_3 - northwest-trending fold system developed, refolding all earlier folds and foliations. The intensity of this deformation increases eastward and controls the distribution of rock units in the Stockbridge, Great Barrington, and Ashley Falls quadrangles. The thermal peak of metamorphism developed during or shortly after this event. Thrusting of the parautochthon probably occurred at this time.

These features will be discussed at length in the field on Trip 2.

The allochthonous sequence (Fig. 1) occurs in the Chatham and Everett slices of the Taconic allochthon, consisting of the Nassau and Everett Formations of probable Late Precambrian or Early Cambrian age. Stratigraphic and structural relations in these rocks are discussed in Trip 2. A record of deformational phases D_1, D_2, and D_3 is preserved in the allochthonous Taconic rocks, indicating that thrusting of the Taconic sequence rocks took place early in the deformational history.

The deformation plan of the parautochthonous rocks differs markedly from that of the other two tectonic units. The Precambrian rocks were multiply deformed prior to deposition of the Lower Cambrian (?) Dalton Formation. These relations can be seen at Stops 1 and 2, where the

Precambrian-Dalton contact is nearly exposed. Paleozoic structural trends in the parautochthon are dominated by isoclinal or highly asymmetric shear folds having a strong axial plane foliation that is either subhorizontal or dips moderately steeply to the northeast. These folds commonly have a northeast over southwest rotation sense regardless of the attitude of the axial planes (gentle to the west, horizontal, or dipping moderately steeply to the east). A late set of open folds trending northwest-southeast locally arches these older features, but a foliation related to these folds is not apparent. The older folds appear to be related to thrusting of the parautochthon in a general southwesterly direction. Locally, rocks of the autochthon (Stop 10, northeast corner of Ashley Falls quadrangle) have this deformation plan as well.

The northwest-trending fold system in the autochthon and allochthon either predates or is synchronous with the peak of the metamorphism (Ratcliffe, 1965, 1968). Radiometric data (Zen and Hartshorn, 1966) indicate that the last phase of recrystallization may be as recent as Devonian. This suggests that the overthrusting of the parautochthon might be a Devonian event as well.

METAMORPHISM

Paleozoic metamorphism affected all rocks in this area. The grade increases on a regional scale toward the east-southeast. Isograds of biotite, garnet, and staurolite trend N. 15° to 20°E. approximately paralleling the New York-Massachusetts state line. Staurolite-bearing rocks are exposed near Lion's Head in the Bashbish Falls quadrangle (Zen and Hartshorn, 1966) and in the southwest corner of the Stockbridge quadrangle. The assemblage staurolite-kyanite-plagioclase-biotite-quartz is found in rocks of the Walloomsac Formation in the southwest corner of the Great Barrington quadrangle and in the western part of the Ashley Falls quadrangle. Sillimanite-bearing Walloomsac is exposed along the eastern edge of the Ashley Falls quadrangle and at Canaan Mountain in the south-central part of the same quadrangle.

The rocks shown in Figure 2 all lie on the high side of the staurolite isograd and on the low side of the sillimanite isograd. Stop 10, in the northeast corner of the Ashley Falls quadrangle probably is located close to the projected sillimanite isograd. The location of the sillimanite isograd is uncertain here owing to the lack of exposures of the schistose facies of the Walloomsac Formation that contains sillimanite at appropriate grades elsewhere.

Relict monoclinic pyroxene, largely altered to green hornblende, and strongly sheared perthitic feldspars present in some Precambrian rocks suggest that moderate to high-grade metamorphism took place in Precambrian time prior to deposition of the Dalton Formation. However, no relict mineral assemblages have been found that establish the grade of this Precambrian metamorphic event.

STRATIGRAPHY

Precambrian Rocks

Rocks of probable Precambrian age crop out at Tyringham (Fig. 1), in the core of the Beartown Mountain synform, and on East Mountain, Halls Hill, and Benton Hill. These gneisses are assigned a Precambrian age because they are overlain unconformably at many localities on a regional scale by feldspathic quartzites and conglomerates that locally contain Olenellus fragments (Walcott, 1888, p. 235-236). These unconformable relations were reported by Pumpelly and others (1894, p. 11, 100), by B. K. Emerson (1899, p. 39-40, 45), and more recently by Herz (1958, 1961) and Norton (personal communication, 1969) in the northern part of the Berkshire Highlands. Excellent exposures of the unconformity can be seen on the bed of Day Brook near Dalton, Massachusetts (Pittsfield East quadrangle) (Emerson, 1899) and at Stop 2, this trip. This unconformity is also developed in the South Sandisfield quadrangle (Dave Harwood, personal communication, 1969) and in the Ashley Falls quadrangle (Ratcliffe, unpublished data). Throughout much of the Great Barrington and Stockbridge quadrangles the Dalton-Precambrian contact is tectonically disturbed (overturned and faulted) so that unconformable relations are difficult to demonstrate.

B. K. Emerson's subdivisions of the Precambrian rocks of eastern Berkshire County (1899) were later modified in his compilation of the geologic map of Massachusetts (1917). Considerable confusion of terminology now exists because of discrepancies between Emerson's two maps, thus making difficult the correct usage of the classical formation names such as Becket Gneiss, Hinsdale Gneiss, and Lee Gneiss. Because of this uncertainty in the meaning of the classical formation names, either local names established by Emerson (1899) or informal lithologic names will be used for new map units or those of uncertain correlation.

The Precambrian rocks in the area of Figure 2 appear to belong to four major map units. Abundant lithic variation within these generalized units accounts for many members that cannot be shown at the scale of the map. The relative ages of the units are not known with certainty because of the lack of primary sedimentary structures for telling stratigraphic tops and the fact that the intense recumbent folding results in sections having opposite geometric tops. The preferred, but somewhat arbitrary, interpretation places the core rocks (the Tyringham Gneiss) of the Beartown Mountain structure at the base of the section.

Tyringham Gneiss

The Tyringham Gneiss (Emerson, 1898, p. 18; 1899, p. 34) was named for exposures in the Lee-Tyringham area (Stops 1 and 2) and

specifically referred to the rocks exposed in the core of the Beartown Mountain structure (Emerson, 1899, p. 59) (Stop 4). The unit is mainly light-gray weathering, pinkish-gray, granitic to granodioritic biotite gneiss with distinctive quartz rodding produced by multiple obliquely intersecting cleavages. The potash feldspar, in individual crystals up to 0.5 cm in diameter, is perthitic microcline that contains crosscutting veinlets or rims of granular oligoclase. The K-feldspar is strongly sheared and commonly shows a mortar structure. The type Tyringham (Stops 1 and 2) contains minor interlayers of mafic material. However, over 90 percent of the exposures are granitic gneisses.

Washington Gneiss

Washington Gneiss (Emerson, 1898, p. 20; 1899, p. 34) is named for distinct blue-quartz-bearing graphitic gneiss and biotite gneiss exposed near Washington, Massachusetts (East Lee quadrangle). The formation contains a mixture of rock types that grade into one another. The most abundant lithic type is a coarsely-ribbed, rusty weathering, blue-quartz biotite gneiss and schist (Stop 5). Layers 0.5 to 1 cm thick of bluish quartz "pebbles" are compressed in the plane of the foliation. The blue color is evidently a result of minute rutile crystals that can be detected in thin section under high magnification. Locally a white, mica-poor, plagioclase-rich blue-quartz-bearing granulite is interlayered with the more typical gneiss.

The Washington Gneiss passes laterally by interbedding of thin 2 to 3 foot mafic biotite-hornblende layers into massive amphibolites of the overlying hornblende gneiss unit.

Hornblende Gneiss

Hornblende-bearing gneisses and massive hornblende-garnet-sphene amphibolites commonly with small amounts of plagioclase (5 to 15 percent) grade into the Washington Gneiss, with which they are partially equivalent in age. The major part of the unit is either massive black-and-white-spotted hornblende-plagioclase granulite or well layered dark-gray hornblende-quartz-plagioclase-biotite gneiss. This map unit may correspond in position to that of the Lee Gneiss of Emerson (1898, p. 20; 1899, p. 33). The Lee Gneiss is also a mafic unit but differs from the amphibolites mapped on Beartown Mountain in that it contains abundant quartz grains that weather out on the surface giving the rock a distinctive quartz chaining. Both of these units (Lee and hornblende gneisses) may represent metamorphosed mafic volcanic rocks, perhaps flows interlayered with more felsic volcanic material.

Biotite Gneiss

Well layered, biotitic, quartz-rich paragneisses, feldspathic quartzites, and fine-grained magnetite-spotted granitic gneisses are exposed along the periphery of Beartown Mountain and over broad areas to the south. Locally the unit contains interlayers of calcite-chondrodite marble, diopside-hornblende calc-silicates (Stop 6), coarsely crystalline calcite-green diopside marbles, and thin biotite-rich mafic layers. The correlation of these biotite-rich gneisses, originally assigned to the Becket Gneiss (Emerson, 1899), is uncertain owing to Emerson's redefinition of the Becket (1917, p. 154) as a meta-intrusive of Precambrian age. Clearly much of what has been mapped as Becket Gneiss (Emerson, 1917) is metasedimentary; therefore the term is not used.

The abundant variation and repetition of lithic types within these biotitic gneisses makes this part of the Precambrian section the most difficult stratigraphic problem to solve. This problem is complicated by lithic similarity between some of the schistose rocks and the two-mica schists of the overlying Dalton Formation.

Cover Rocks

Dalton Formation

The Dalton Formation of probable Early Cambrian or Late Precambrian age consists of a heterogeneous sequence of tan weathering, feldspathic metaquartzites, two-mica quartz schists characterized by an abundance of black tourmaline, and less commonly schistose and quartz cemented meta-quartz pebble conglomerates. Strong lateral and vertical facies changes characterize this formation. With interbedding of clean, vitreous quartzite beds, it passes into the Cheshire Quartzite, with which it is laterally equivalent.

Within the area of Figure 2 the Dalton overlies with angular discordance the following Precambrian map units: Tyringham Gneiss, Washington Gneiss, and biotite gneiss. Where the contact can be closely located, the basal part of the Dalton is a very micaceous two-mica schist with irregular white milky quartz knots (Stop 2), or a greenish-gray two-mica gneiss with abundant detrital allanite grains. The latter member is best exposed at Umpachene Falls (Stop 10).

Cheshire Quartzite

Massive, white- to pinkish-tan weathering, vitreous meta-quartzite characterizes the Cheshire Quartzite of Early Cambrian age. Typical examples contain greater than 96 percent quartz and less than 1 percent total

feldspar. Muscovite, tourmaline, magnetite, and zircon account for the remaining percentages.

The name Cheshire is used here only for those exposures with greater than 50 percent vitreous quartzite. The Cheshire is 500 to 800 feet thick in the vicinity of Great Barrington and Stockbridge, but it thins to a feather edge in an easterly direction. The exposures at Stop 10 (Umpachene Falls) illustrate these stratigraphic relations. A rusty weathering actinolite-rich zone marks the transition from Cheshire up into the overlying Stockbridge Formation (Stops 7-10).

Stockbridge Formation

Seven lithic subdivisions of the Stockbridge Formation proposed by Zen (1966) have been mapped in the area of Figure 2. The map units are given letter designations a through g and are grouped into three members on the generalized map (Fig. 2).

For a discussion of the stratigraphy of the Stockbridge Formation see Zen, Trip 3. The lithic subdivisions are briefly summarized below.

OCsg, medium- to dark-gray calcite marble with interbeds of cream to beige weathering dolostone.

OCsf, tan to gray weathering, crossbedded, sandy-textured dolostone or calcite dolostone.

OCse, coarsely crystalline, white to light-gray, blue-gray and white mottled, and massive white calcite marble that commonly is quarried.

OCsd, beige weathering sandy dolostone, or punky weathering calcitic metasandstone locally crossbedded and with white vitreous quartzite interbeds 1 to 3 cm thick. At metamorphic grades higher than the staurolite isograd, white diopside phlogopitic calc silicates are common.

OCsc, massive, light-gray weathering, steel-gray, very fine-grained calcitic dolostone with milky-white quartz knots 1 to 2 cm thick near top of unit.

OCsb, beige to light-cream weathering non-calcitic dolostone with abundant interbeds of punky weathering quartzites and silvery-gray phyllitic partings throughout much of the unit.

OCsa, massive to bedded, white to light-gray, crystalline dolomitic marble generally free of phyllitic or siliceous impurities. Base is gradational with underlying Cheshire Quartzite.

Stockbridge units a and b (Stop 3) and c, d, and e (Stop 9) will be seen on this trip. At grades higher than staurolite grade, east of East Mountain (Fig. 2), tablets of white diopside up to 1 cm long mark unit d and the upper part of unit c.

Walloomsac Formation

The Walloomsac Formation of Middle Ordovician age (Zen, 1966) is either a black, biotite-rich quartzose schist, or an orange weathering, schistose marble within the area of Figure 2. The schistose marble forms the base of the unit and regionally thickens to 200 to 300 feet in the western parts of the Stockbridge and eastern parts of the Egremont and Bashbish Falls quadrangles. The base of the formation marks a regionally developed unconformity (see Stop 4, Trip 2). Extensive exposures of this unit appear to coincide with areas of maximum denudation on the pre-Walloomsac erosion surface, suggesting that the carbonate-rich facies of the Walloomsac was in part derived from erosion of the Stockbridge Formation.

This basal unit will be seen at Stop 3 on the northeast end of Cobble Hill, where it is found beneath a thrust of the Precambrian gneiss.

The stratigraphy of the overlying Everett Formation, part of the Taconic allochthon, is discussed in Trip 2. The unit does not crop out within the area covered by Figure 2.

MAJOR UNSOLVED PROBLEMS

At the time of this writing several important structural problems are unsolved.

1. The location of the root zone of the Beartown Mountain nappe is not known. Attitudes of minor folds thought to be related to the thrusting appear to indicate movement from the northeast to the southwest. North of the Tyringham Valley (Stops 1 and 2), however, the Precambrian-Dalton contact is right-side-up, suggesting that these rocks are not a part of the Beartown Mountain slice because the Precambrian-Dalton contact is inverted on Beartown Mountain. Perhaps the root zone lies covered by rocks moved southwest on the fault north of Tyringham known as the Tyringham fault (Emerson, 1899).

2. It is now known that the Beartown Mountain slice is only one of a series of low angle thrusts that involve Precambrian rocks. The Precambrian front at this latitude appears to be marked by several overlapping thrust slices. These overlapping thrusts, such as the one at Halls Hill in the Monterey quadrangle, further complicate the geology by covering critical exposures of the underlying Beartown Mountain slice. Mapping in progress in the South Sandisfield quadrangle by David Harwood and in the Monterey and East Lee quadrangles by the writer should shed some light on this problem.

REFERENCES

Emerson, B. K., 1898, The geology of old Hampshire County, Massachusetts, comprising Franklin, Hampshire and Hampden Counties: U. S. Geol. Survey Mon. 29, 790 p.

___ 1899, The geology of eastern Berkshire County, Massachusetts: U. S. Geol. Survey Bull. 159, p. 13-102.

___ 1917, Geology of Massachusetts and Rhode Island: U. S. Geol. Survey Bull. 597, 289 p.

Herz, Norman, 1958, Bedrock geology of the Cheshire quadrangle, Massachusetts: U. S. Geol. Survey Geol. Quad. Map GQ-108.

___ 1961, Bedrock geology of the North Adams quadrangle: U. S. Geol. Survey Geol. Quad. Map GQ-139.

Pumpelly, Raphael, Wolff, J. E., and Dale, T. N., 1894, Geology of the Green Mountains in Massachusetts: U. S. Geol. Survey Mon. 23, 206 p.

Ratcliffe, N. M., 1965, Bedrock geology of the Great Barrington area, Massachusetts: The Pennsylvania State Univ., Ph. D. thesis, 213 p.

___ 1968, Structural geology and deformational history of the Taconic Range in southwestern Massachusetts near Great Barrington [abs.]: Geol. Soc. America Spec. Paper 101 (Abstracts for 1966), p. 274.

___ in prep., Bedrock geology of the Stockbridge, Massachusetts, quadrangle: U. S. Geol. Survey Geol. Quad. Map.

Walcott, C. D., 1888, The Taconic System of Emmons, and the use of the name Taconic in geologic nomenclature: Am. Jour. Sci., v. 135, p. 229-242, 307-327, 394-401.

Zen, E-an, 1966, Stockbridge Formation; Walloomsac Formation; Egremont Phyllite; Everett Formation, p. 30-32 in Cohee, G. V., and West, W. S., Changes in stratigraphic nomenclature by the U. S. Geological Survey, 1965: U. S. Geol. Survey Bull. 1244-A, 60 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.

ROAD LOG

Field trip stops and route will be in the East Lee, Stockbridge, Monterey, Great Barrington, and Ashley Falls quadrangles.

From Albany take Exit 2 of Massachusetts Turnpike at Lee, Massachusetts. Head south on Rte. 102 toward South Lee-Stockbridge. Immediately turn left (0.1 mile) onto Tyringham Road. Log starts from this point.

Mile

0.0 Intersection Rte. 102-Tyringham Road, Lee, Mass., East Lee quadrangle. Head southeast toward Tyringham.

0.9 Discontinuous outcrops of Dalton Formation and Cheshire Quartzite left side of road. Right-side-up west-dipping sequence; valley to right exposes units a, b, and c of Stockbridge.

0.5 Intersection Meadow St., view to right of north slopes of Beartown Mt.

2.0 Stop 1. Exposure left side road of type Tyringham Gneiss (Emerson, 1899) with interlayered dark-gray, well-layered biotite gneiss. In field well-layered dark-gray biotite gneiss strikes N. 35°E. and dips steeply northwest. Two later foliations, N. 30°E. 45°S. E. and N. 25°W. 30°N. E., cut this layering. At east edge of field large crops of massive granitic gneiss typical of the bulk of the Tyringham. Note the indistinct banding and well developed foliation. Rock is a microcline-plagioclase-quartz-muscovite-biotite gneiss. Compositional layering is intruded by K feldspar quartz pegmatites, and that is cut by the N. 20° E. 45°S. E. -dipping foliation. The foliations and pegmatites are thought to be of Precambrian age because the Dalton (Stop 2) unconformably overlies rocks showing these features.

Continue southeast on Tyringham Road.

3.4 Pass house of Hansel and Gretel on left; slow down for hidden drive.

3.6 Turn left on George Canon Road.

3.8 Stop 2. Park at cabin on left. Walk up hill to stream crossing. Tyringham-Dalton contact relations (unconformity) and lithology of basal Dalton. We will hike up the hill to first outcrop, then view the rocks on our descent, walking up section.

Stop 2-a. Outcrop of Tyringham Gneiss, compositional layering N. 20°E. 80°S. W., oblique intersecting foliations N. 20°W. 45°S. W. and N. 40°E. 15°S. E.
Stop 2-b. Small outcrop of Tyringham in stream. Compositional

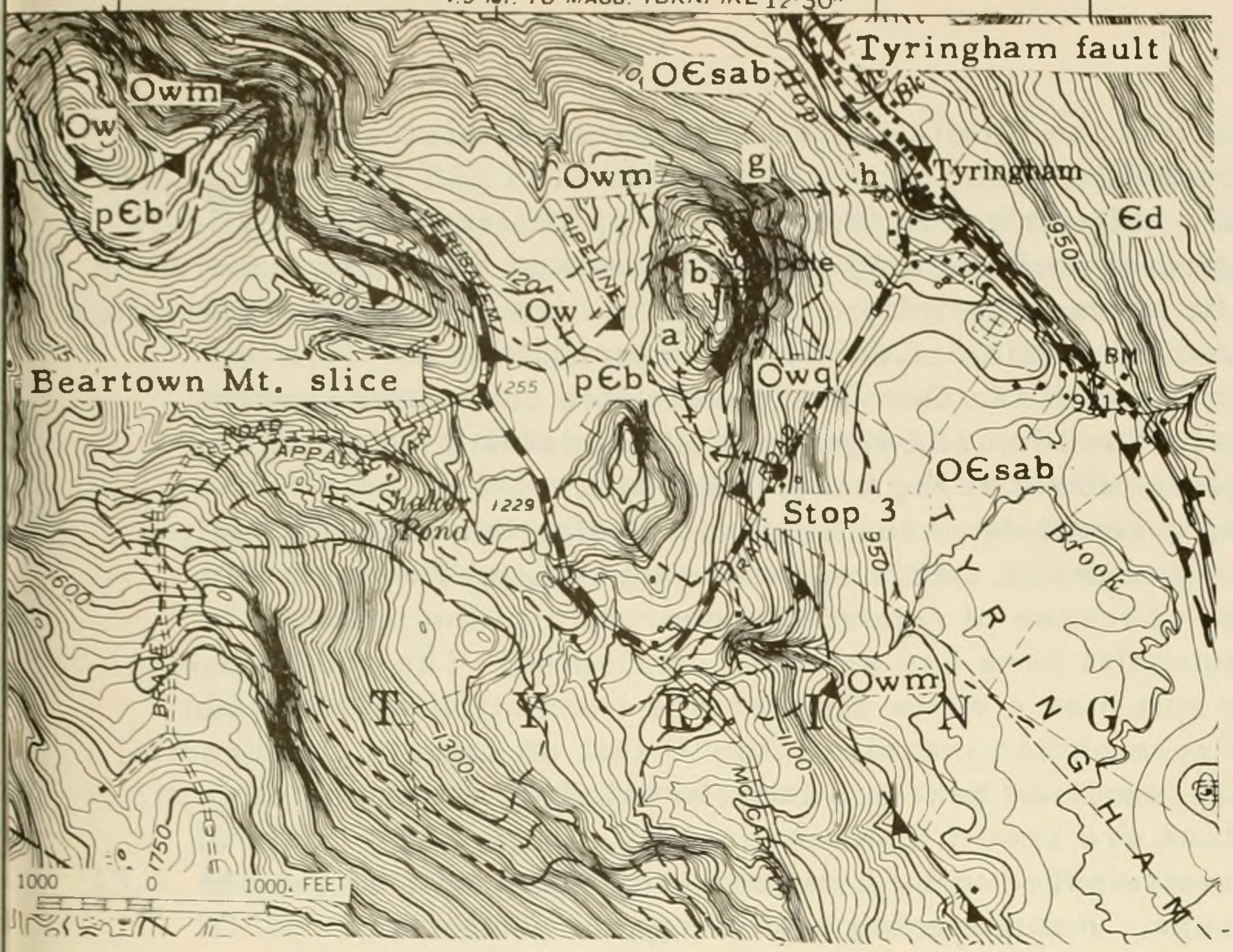
layering still trending northeast-southwest; note linear structure.
Stop 2-c. Small waterfalls by well house. Dark biotite-rich schist with muscovite and white quartz knots and black tourmaline. Bedding and parallel foliation, N. 50°W., 25°S. W., is folded by late folds that plunge S. 15°W. The unconformable relations seen here are duplicated along the entire Dalton-Tyringham contact north of Tyringham. Conglomerates are locally developed, but characteristically not right at the unconformity. The basal unit is commonly a schistose rock, although locally thin (10 to 20 feet thick) beds of arkosic quartzites may mark the base of the Dalton. Black tourmaline is a never-failing accessory mineral.
Stop 2-d. In stream, flaggy, impure quartzites typical of the Dalton. Note well developed bedding and highly feldspathic layers. Continue downstream to road and cross into brook below road.
Stop 2-e. Interbeds of vitreous quartzite, tentatively assigned to the Cheshire. Return to bus.

4.0 Return to intersection of George Canon Road and Tyringham Road. Turn left. View to right of Cobble Hill (Stop 3).

4.7 Town of Tyringham; turn right on Jerusalem Road (no signpost).

4.8 Bear right at Y; head up hill. View of Cobble Hill at right (west). Stockbridge at base, overlain by Walloomsac, and finally gneiss caps the hill.

5.2 Stop 3. Cobble Hill traverse - Precambrian biotite gneisses of Beartown Mountain slice resting on Walloomsac. We will walk to the top and look at the rocks on the way down the steep northeast slope, and will rejoin bus at the town of Tyringham (see Fig. 3).
a. Outcrops in field of rusty weathering, well-layered biotite gneiss with minor amphibolite layers. These gneisses are believed to belong to the youngest of the Precambrian units. Note the differences and similarities with the schistose rocks of the basal Dalton.
b. Walk to crest of hill; note late southeast-plunging folds that fold the early foliation.
c. At base of cliff on northeast edge of the Cobble. Overhanging cliff of gneiss exposing a large nearly recumbent fold in gneiss. The fold plunges S. 20° E. at 5° with a northeast over southwest rotation sense (clockwise). Note an earlier set of folds with a counterclockwise rotation sense and folded lineation. The large recumbent folds probably formed at the time of emplacement of the Beartown Mt. nappe.
d. Walk carefully along cliff to an infold of epidote-actinolite-quartz pebble conglomerate. This could be basal Dalton or Walloomsac infolded at the base of the gneiss; but age assignment of this lithology is uncertain, as the rock has not been found elsewhere.
e. Walk down cliffs to northeast to exposures of Ow (schist and schistose



Explanation

Ow
Walloomsac Fm. (schist)

Owm
Schistose marble of Walloomsac Fm.

Owq
Quartzite in Owm

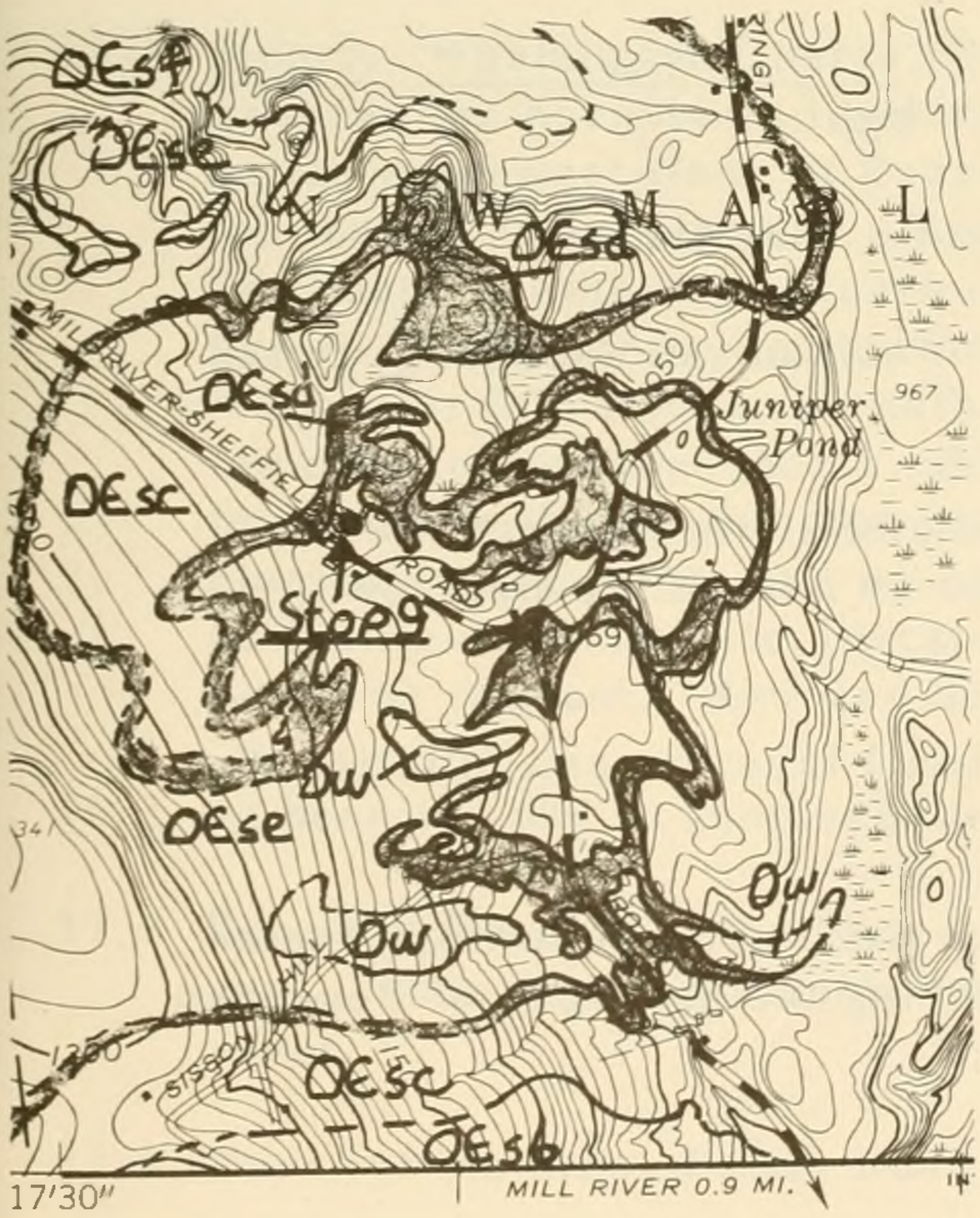
OEsab
Stockbridge Fm., units a and b

Ed
Dalton Fm.

pEb
Biotite gneiss

Thrust fault, teeth on upper plate

Fig. 3. Geologic map showing Stop 3 (Cobble Hill traverse), Monterey quadrangle. Contacts within Beartown Mt. slice are members of the Biotite gneiss unit and are not described individually here. Letters a, b, g, and h denote stops along traverse.



Explanation

Ow
Walloomsac Fm.

OEsf
OEse
OEsd
OEsc
OEsb
} Stockbridge Fm.

1000 0 1000 FEET

Fig. 4. Geologic map showing the location of Stop 9, Great Barrington quadrangle. Unit d of the Stockbridge Fm. is shaded.

marble) that underlies the biotite gneiss. Pasture contains scattered outcrops of Owm and Ow.
f. At edge of hill quartzite bed in Owm. Beds of quartzite are relatively rare in the Walloomsac and are only found in areas of maximum erosion on the Middle Ordovician unconformity. Perhaps the quartz in these quartzites was locally derived by erosion of the Cheshire or Dalton.
g. Continue down the cliffs in Owm and finally into dolomitic marbles of the Stockbridge. The impure beige weathering dolostones of unit b of the Stockbridge are found at the base of the hill.
h. At Hop Brook, a small exposure of calcitic dolostone with tourmaline and golden yellow phlogopite. This exposure was called Precambrian by Emerson (1899) because of reported chondrodite in the marble. However the condrodite here has not been confirmed. The rock closely resembles either unit b or c of the Stockbridge Formation and does not resemble other Precambrian marbles (Stop 7) that do contain chondrodite. Marbles in the Precambrian here are largely calcitic, although dolomitic chondrodite marbles are known from several localities. The floats of chondrodite marble referred to by Emerson (1899) can still be seen at the base of the crops. Return to bus at Tyringham center.

5.7 Turn left on Tyringham Road. Re-enter East Lee quadrangle.

8.4 Turn left onto Meadow Street and cross broad Tyringham Valley underlain by Stockbridge units c. b, and a. Enter Stockbridge quadrangle.

9.3 Turn right on Fernside Road. Hill to left duplicates Cobble Hill relations: Stockbridge a, b at base; Walloomsac overlain by biotite gneisses at top of first cliff.

10.3 One of Berkshire's scenic dude ranches. Ugh!

10.6 Turn right after crossing railroad track into Pine Street.

10.9 Bear left at Y onto Beartown Mt. Road. Walloomsac exposures to the west.

11.2 Feldspathic quartzites of the Dalton Formation, dip to south toward Beartown Mt. and overlie the Walloomsac as part of the Beartown Mountain slice.

11.4 Precambrian biotite gneisses, compositional layering and foliation dip south, thrust over the Dalton.

12.1 Marvelously dirty pig sty on left. We are driving on the biotite gneiss and the hornblendic gneiss units, approaching the hingeline of Beartown Mt. nappe.

12.5 Stop 4. At BM 1363 (Stockbridge quadrangle). Roadcut and cliffs of Tyringham Gneiss in the core of the Beartown Mt. nappe. East-west nearly vertical compositional layering is intersected by two cleavages that dip gently north and south, producing rhombic cleavage fragments and a strong east-plunging lineation. Zircons from this exposure and from the next are being dated by Robert Zartman of the U. S. G. S. At the time of this writing, the data are not yet available. When completed, these will be the first ages from the gneisses of the Berkshire Highlands. To the east the map relations indicate this unit closes as a west-plunging synform, thus ruling out a simple anticlinal structure.

LUNCH STOP

Continue south on Beartown Mt. Road; enter Great Barrington quadrangle.

13.2 Intersection on left of road to Mt. Wilcox. We are crossing the hingeline of the nappe; the section repeats going south.

13.6 Low exposure to right of schistose rock of the Washington Gneiss, and associated hornblende amphibolites, massive hornblende garnet amphibolites are exposed south of this point on the hill to the west.

14.4 Small bridge; everybody out if necessary. This point marks the axis of the late southeast-plunging synform that folds the early anticlinal nappe.

15.8 Stop 5. Washington Gneiss (Great Barrington quadrangle). We have crossed the hornblendic gneiss and the Tyringham gneiss, and now are on the southwest flank of Beartown Mt. in a section that is thought to top toward the southwest. Exposures on left (east) side of dirt road are rusty weathering, blue-quartz, plagioclase, biotite gneiss. Interlayers of thin biotite-rich amphibolite layers are isoclinally folded. Walk west into woods to weathered exposures of the same rock showing the distinctive blue-quartz ribbing and the white granulite lithology. Minerals in the Washington include muscovite, biotite, hornblende, plagioclase, quartz, and scapolite. Locally graphite-rich schists and actinolite-bearing calc silicates are found. Note muscovite-biotite schist at roadcut. Reboard bus. Continue south on Beartown Mt. Road.

16.2 At bend in road to southeast and steep decline, contact biotite gneiss unit.

17.3 Benedict Pond on left. Fine-grained granitic gneiss of the biotite gneiss unit. Turn right at Y onto new road that follows A. T. on topographic sheet.

17.7 Turn left on Stony Brook Road.

17.8 Stop 6. Calc silicates in biotite gneiss unit on southwest flank of Beartown Mt. Please DO NOT HAMMER at rocks in outcrop. There is enough float of everything to go around. Walk east from field into woods. Cliffs of well layered hornblende-plagioclase and biotite plagioclase quartz gneiss with minor layers of calcite-chondrodite marble, diopside-hornblende calcite marble and minor layers of plagioclase granulite with large blotches of green hornblende and 1/4-inch chocolate-brown sphene crystals. In the vicinity of crosscutting pegmatites, chlorite pseudomorphs after hornblende or diopside can be seen. This distinctive unit is thin but does not appear to be stratigraphically persistent, although rocks of this kind are good marker horizons in gneisses at Benton Hill (Fig. 1) and in the South Sandisfield quadrangle, according to David Harwood. Note dips to the northeast. The distant view to the southwest looks over the Lake Buel window (underlain by Stockbridge) to East Mountain, where biotite gneisses with calc silicates like this and the hornblendic gneiss unit rest with thrust contact on the Dalton Formation marking the southwest edge of the Beartown Mt. slice.

Continue southeast on dirt road.

19.4 Turn right on Brett Road.

19.9 Turn right on Rte. 23. Exposures of recumbently folded Stockbridge units c, d, e. Rocks that are beneath the Beartown Mt. slice. Note large tablets of white diopside.

21.0 Intersection of Rte. 57. Continue west on Rtes. 23 and 57.

21.1 Stop 7. Overturned Stockbridge and Cheshire at base of Beartown Mt. slice. Walk up from road to yard by small house. Massive Cheshire overlies Stockbridge unit a, with thin, rusty weathered actinolite zone marking the contact. Note northeast over southwest rotation sense of folds.

Continue west on Rte. 23 and 57 past low road cuts of flat lying Stockbridge in the Lake Buel window.

22.2 Turn left on Lake Buel Road.
Stop 8. Dalton Formation of Monument Mt. slice at northeast face of East Mt. Walk into woods to large cliffs of isoclinally recumbently folded feldspathic quartzites of the Dalton Formation. Rotation sense northeast over southwest. Precambrian gneiss like those at Stop 6 overlies these rocks farther up the hill.

Continue southeast on Lake Buel Road.

24.9 Turn right at Y onto Mill River Road.

26.8 Take right. Turn at Y onto Sheffield Road.

27.0 Turn right into yard of yellow farmhouse by burned barn.
Stop 9. Exposures of extremely folded and refolded carbonates, units c, d, e of the Stockbridge. Lake Buel window. You will walk from the house, starting in white calcite marbles of unit e, to rusty weathering diopside, calc silicate rock with interlayers of white quartzite exposed behind the barn (unit d), and finally fissil dolostones of unit c in pasture past the fence. Note the complex fold patterns. This type of deformation is characteristic of the rocks in the Lake Buel window. Please don't expect your leader to explain the folds; have fun for yourself. The overall map pattern at this locality can be seen in Fig. 4.

Return to bus, head east (left turn) onto Sheffield Road.

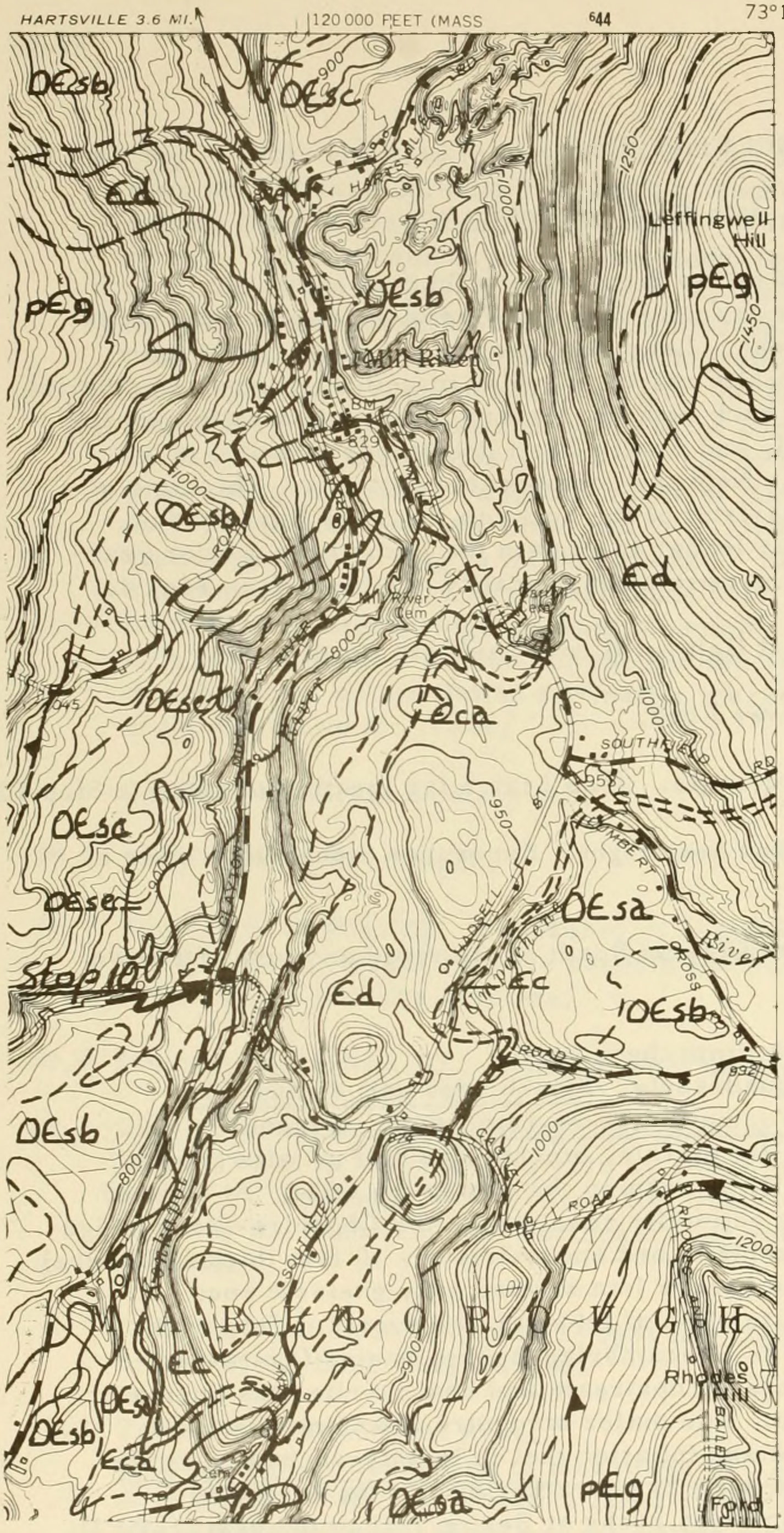
27.4 Turn right onto Mill River Road.

28.0 Enter Ashley Falls quadrangle. (See Fig. 5 for location of route to Stop 10.)

28.9 Cross Konkapot River and bear right. Exposures Stockbridge units a and b in river.

29.2 Mill River; turn right on Clayton Road; cross river and turn left down Clayton Road.

30.5 Turn left on dirt road to Umpachene Falls.
Stop 10. Ashley Falls quadrangle. Stockbridge unit a, Cheshire Quartzite, and Dalton Formation of the autochthon. Exposures of white crystalline dolomitic marble, Stockbridge unit a, with gentle east-dipping foliation will be seen on the way to the falls. At base of falls a rusty weathering actinolite zone marks the Cheshire-Stockbridge contact, overlain by a quartzite bed approximately 10 feet thick (Cheshire). Up stream this quartzite passes into silvery gray gneissic rock containing irregular white clots of feldspar and quartz. This rock was previously mapped as Precambrian Becket Gneiss (Emerson, 1917). The Cheshire returns upstream and now overlies the gneissic rock in a small syncline. The major structure is an anticline with nearly horizontal axial plane foliation that is locally warped in gentle folds. This deformation style is characteristic of the overlying parautochthonous Precambrian rocks at Benton Hill to the east (Fig. 1). This exposure illustrates several important stratigraphic relations:
a) The Cheshire Quartzite that measures 500 to 800 feet in thickness in the Great Barrington quadrangle, is here only 10 feet thick, suggesting very rapid thinning of the quartzite facies eastward. Locally in the



Explanation

Ow

Walloomsac Formation

OЄse

OЄsd

OЄsc

OЄsb

OЄsa

Stockbridge Formation

Єca

Rusty weathering actinolite rock

Єc

Cheshire Quartzite

Єd

Dalton Formation

pЄg

Precambrian gneisses, here not differentiated

1 ½ 0

MILE

Fig. 5. Geologic map showing the location of Stop 10, Umpachene Falls (northeast corner of the Ashley Falls quadrangle).

area around Umpachene Falls, the Cheshire is absent altogether and schistose rocks of the Dalton are in contact with unit a of the Stockbridge.
b) The Umpachene type of Dalton seen here differs markedly from the typical orange-tan weathering feldspathic quartzites of the Dalton (Stops 2 and 8).
Evidently the Dalton Formation is marked by rapid vertical as well as lateral facies changes. The relations seen here indicate the feldspathic and gneissic facies of the Dalton are lateral equivalents of the clean quartzite facies (Cheshire). In areas to the east Cheshire-equivalent rocks may be gneissic or schistose rocks previously assigned to the Becket or other Precambrian map units.