1-1-1969

Unconformities at the Northern End of the Berkshire Highlands

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Trip 21

UNCONFORMITIES AT THE NORTHERN END OF THE BERKSHIRE HIGHLANDS[1]

by

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Quadrangle required: Windsor, Massachusetts, 1960, 7½ minute.

NOTE: Stops 4 and 5 will require moderately strenuous traverses.

INTRODUCTION

The Windsor quadrangle straddles the axis of the Berkshire Highlands of Massachusetts. Cambrian and Ordovician miogeosynclinal clastic and carbonate rocks (henceforth called the "western sequence") are exposed in the western third of the quadrangle. The eastern third of the quadrangle is underlain by Cambrian and Ordovician eugeosynclinal volcanic rocks, pelites, and graywackes. All of the Paleozoic rocks have mineral assemblages consistent with the garnet or kyanite zone (Norton, 1967). The central part of the quadrangle is underlain by feldspathic gneisses and minor amounts of calc-silicate gneiss, amphibole gneiss, graphitic gneiss, and quartzite; all of probable Precambrian age. These Precambrian rocks were subjected to at least sillimanite (+muscovite) grade metamorphism. Radiometric ages on correlative rocks in Vermont date this event as being equivalent to the late Precambrian Grenville orogeny (0.9 b.y.; Faul and others, 1963; Lyons and Faul, 1968). Relict evidence for this earlier metamorphism has been partially obscured by mid-Paleozoic (Acadian) metamorphism which retrograded the Precambrian mineral assemblages. The metamorphic discontinuity between the Precambrian and Paleozoic rocks is best seen in the calc-silicate gneiss.

[1]Publication authorized by the Director, U. S. Geological Survey

The dominant Paleozoic structure of the quadrangle is the Hoosac nappe. This Acadian recumbent anticline is overturned to the west and has three large amplitude satellitic syncline on its inverted limb. The term Hoosac nappe is restricted to those rocks to the east of the Savoy Hollow Brook thrust (Figure 1) although structures to the west of the same thrust suggest that nearly the entire quadrangle is involved in the nappe. In the northwestern part of the quadrangle, the western sequence of rocks is inverted in the overturned limb; in the southwestern part of the quadrangle, the western sequence is upright in what may be the normal limb of a major syncline overturned to the west. This fold is probably related to the Hoosac nappe. Syn- and perhaps post-folding thrust faults are major features which have complicated the structure of the nappe.

The Windsor quadrangle is three miles south of the northernmost exposures of the Precambrian core of the Berkshire Highlands and thus is one of the best areas to study the stratigraphic relationships between the eastern and western rock sequences. Furthermore, the structural relationships in the quadrangle bear strongly on the problem of a source area or root zone for the large mass of Taconic allochthonous rocks that make up Mount Greylock to the west. If Zen (1967) is correct in proposing that the Taconic rocks were originally deposited on the site of the presently exposed Precambrian rocks, a problem arises in the Windsor area and adjacent areas in that the proposed source area is too small to yield the quantity of known Taconic rocks. Furthermore, miogeosynclinal facies rocks (in particular the Cheshire Quartzite; see Figure 2) are now within 2 miles of eugeosynclinal rocks in the eastern extension of the Savoy Hollow Brook syncline and the Taconic rocks to the west of the quadrangle that would have been derived from this area are more than 10

miles wide. Clearly, there is not sufficient room from which to derive the Taconic rocks in this area. The answer to this dilemma must lie in extensive east-west shortening of the crust, which must have been accomplished in large part by overfolding and intraformational east-over-west shear and in part by thrusting.

The purpose of Trip 21 is to:

1. Look briefly at the rocks exposed in the area, primarily from a stratigraphic viewpoint.
2. Examine the Precambrian-Cambrian contact and the basal rocks of the Paleozoic section. This is relevant to the problem of east-west correlation and also has bearing on the source area for the Lower Paleozoic clastic rocks.
3. Examine the relationships between the Berkshire Schist of Middle Ordovician age (Figure 2) and the various units upon which it rests unconformably. The Berkshire is a clastic unit deposited during the time that the area now underlain by the Precambrian rocks was apparently emergent. Just prior to the emplacement of the Taconic Mountains, extensive erosion of the western sequence occurred in the vicinity of the Windsor quadrangle; then followed an onlap of the Berkshire facies onto the erosion surface. This relationship is clearly shown in the Windsor quadrangle.

ACKNOWLEDGMENTS

The field work for this report was carried out while the writer was a student at Harvard University and was supported by the U. S. Geological Survey. I greatly appreciate the many helpful discussions, comments, and constructive criticisms stemming from conversations with M. P. Billings,

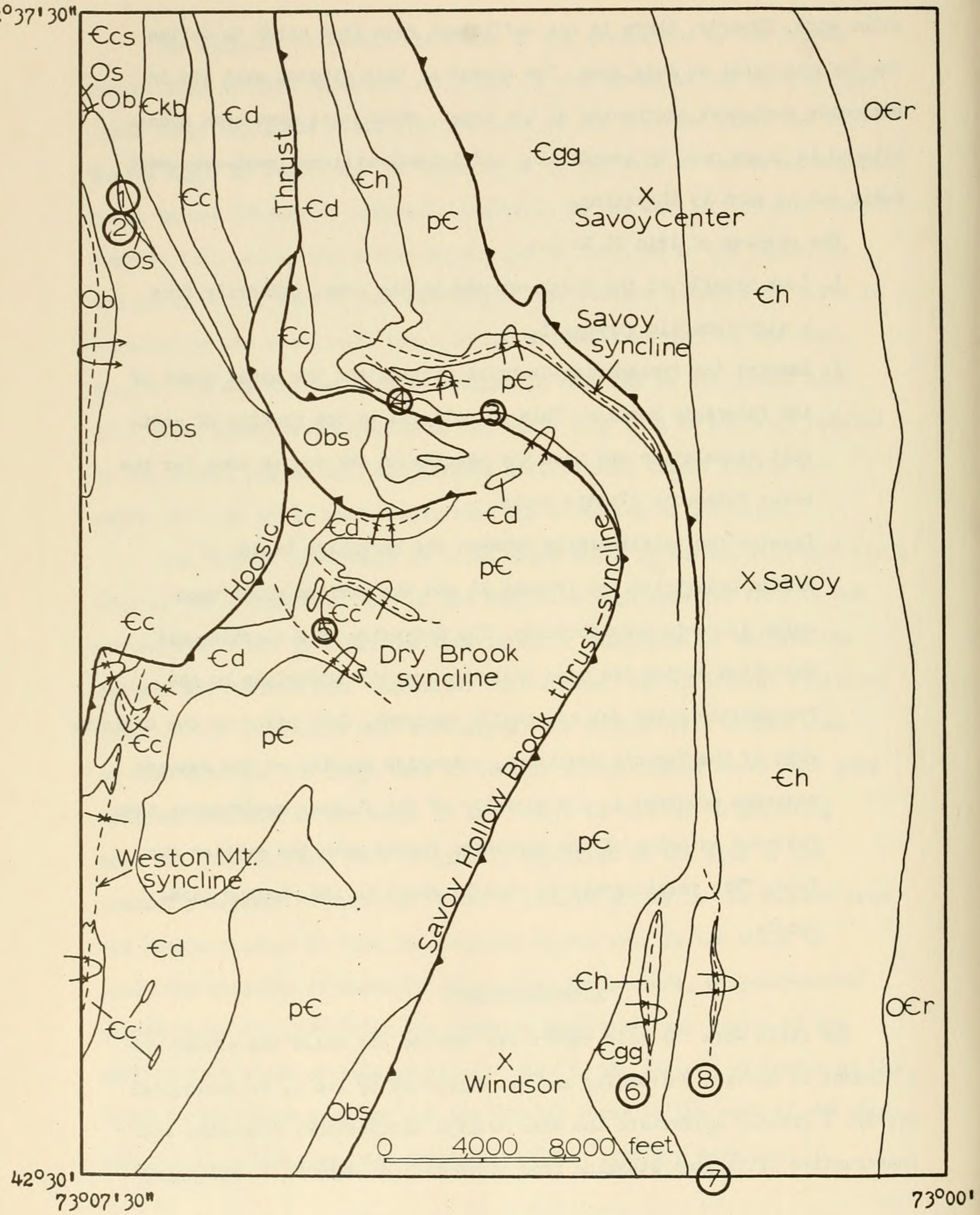

Figure 1. Generalized geologic map of the Windsor quadrangle, Massachusetts.

Explanation of symbols on facing page.

Western Sequence			Eastern Sequence	
Formation	Map Symbol	Age	Formation	Map Symbol
Berkshire Schist	Obs	Middle Ordovician	Not exposed in the Windsor quadrangle	
Bascom Formation	Ob	Lower Ordovician		
Shelburne Marble	Os			
Clarendon Springs Dolomite	€cs	Upper Cambrian	Rowe Schist	O€r
Kitchen Brook Dolomite	€kb	Lower and Middle Cambrian		
Cheshire Quartzite	€c	Lower Cambrian		
Dalton Formation	€d			
basal conglomerate	€dc			
Hoosac Formation	€h	Lower Cambrian or older	Hoosac Formation	€h
			Granitic Gneiss	€gg
		Major Unconformity		
Gneiss	p€	Precambrian	Gneiss	p€

Trace of fold axial surface

Trace of thrust fault, teeth on upper plate

④ Stop on itinerary. Dotted line indicates foot traverse.

Figure 2. Explanation for Figures 1, 3, and 4 and stratigraphic column for the Windsor quadrangle, Massachusetts showing the rock sequences west and east of the Precambrian core of the Berkshire Highlands.

L. M. Hall, N. L. Hatch, Jr., P. H. Osberg, L. R. Page, N. M. Ratcliffe, J. B. Thompson, Jr., and E-an Zen. A. K. Gibbs served as a very capable assistant during 1968.

STRATIGRAPHY

Figure 2 gives the stratigraphic column for the rocks of the Windsor quadrangle. The Kitchen Brook Dolomite, Clarendon Springs Dolomite, Bascom Formation, and Rowe Schist will not be seen on this trip and will not be described here. For descriptions of the western sequence the reader is referred to Herz (1958, 1961) and Norton (1967) and for descriptions of the eastern sequence the reader is referred to Hatch and others (1966, 1967, 1968), Norton (1967), and Osberg and others (in press). A brief description of the units to be seen at Stops 1 to 8 follows:

Precambrian Gneiss

The Precambrian rocks are composed predominantly of equigranular, fine-grained quartz-feldspar(normally both plagioclase and microcline)-biotite gneiss. Accessory minerals may include epidote, garnet, and an opaque mineral. Muscovite is typically absent or very sparse. The rock is typically well-banded, both compositionally and texturally. Amphibole gneiss, calc-silicate gneiss, quartzite, and graphitic gneiss locally may predominate.

Hoosac Formation (western sequence)

In the northwestern part of the quadrangle, the Hoosac Formation of Lower Cambrian (?) age or older forms the base of the Paleozoic section. Two different lithologies have been distinguished. A medium-grained, graphitic quartz-muscovite-albite-garnet-biotite(or chlorite, or chlorite and chloritoid) schist forms the lowest unit. Outcrops typically

weather rusty-brown or black. Bedding is indistinct, but may be marked by discontinuous lenses of quartz that constitute 5 to 10 percent of the rock. A fresh specimen has a somewhat greasy appearance; locally the rock is conspicuously graphitic. In places (e.g. STOP 4) a few feet of quartz-pebble conglomerate are present at the contact with the Precambrian gneiss. The unit is nowhere more than 150 feet thick.

A brown-weathered quartz-albite-muscovite-biotite-microcline granular schist overlies the garnet schist. Beds range from a few inches to several feet in thickness. The contact with the garnet schist is sharp. The upper unit in the Hoosac has a maximum thickness of 150 feet. Both units thin southward and are not present south of Route 116 (Savoy Road).

Dalton Formation

In the northwestern part of the quadrangle the Hoosac Formation is stratigraphically overlain (but structurally underlain) by the Dalton Formation. The Dalton is typically a fissile to flaggy quartz-microcline-muscovite-biotite-albite granular schist or gneiss. Beds are conspicuous, of consistent thickness, and are marked by mica-rich partings. The rock weathers light tan to brown. Clean quartzites, much like those of the Cheshire Quartzite, are locally interbedded with the feldspathic Dalton rocks. These clean quartzites range in thickness from a few inches to as much as 20 feet. In the vicinity of STOP 3, the Dalton and the upper unit of the Hoosac appear to be interbedded and grade laterally into one another. However, to the northwest the Dalton is in sharp contact with the older Hoosac and there is no interbedding of the two lithologies.

South of Route 116, the Dalton lies with angular unconformity on the Precambrian rocks. Here, in addition to the granular schist and gneiss, the Dalton also contains a basal quartz-pebble conglomerate. Both

the grain size and the thickness of the conglomerate increase to the south.

The maximum thickness of the Dalton is probably about 500 feet in the Windsor quadrangle; it thins eastward, having thicknesses of 20 feet at STOP 3, and about 2 feet half a mile east of STOP 3.

Cheshire Quartzite

The Cheshire Quartzite is a massive white, pink-weathered or buff-weathered quartzite. Generally it is at least 99 percent quartz. Bedding is recognized only locally where it is faintly indicated by the presence of mica-rich partings. The maximum thickness of the Cheshire is about 100 feet; it thins eastward. At STOP 3 it is about 30 feet thick and where last seen in the eastern extension of the Savoy Hollow Brook syncline (Figure 1), it is 2 feet thick.

Shelburne Marble

The Shelburne Marble is a medium-grained, white-weathered calcite marble. Beds range from 1 inch to more than a foot in thickness, are pronounced, and are marked by thin layers rich in muscovite. Calcite constitutes as much as 99 percent of the rock. Accessory minerals concentrated along bedding planes include quartz, albite, and muscovite. The Shelburne is estimated to be less than 100 feet thick in the Windsor quadrangle.

Berkshire Schist

The Berkshire Schist lies unconformably on all the older rocks of the western sequence in the quadrangle. At several localities within the quadrangle, the Berkshire rests directly on Precambrian gneiss. The predominant lithology is either a quartz-albite-muscovite-biotite-garnet granular schist (STOP 2) or a muscovite-quartz-garnet-chlorite phyllite. Chloritoid and paragonite may be locally abundant in the more aluminous

phyllite. All of the rocks of the formation are gray to black because of abundant graphite.

Locally predominant lithologies include sulfidic rusty-weathered quartz-albite-muscovite-biotite-sulfide mineral schist (STOP 4), graphitic quartzite (STOP 4), and black graphitic marble which contains appreciable quartz, albite, and muscovite. Bedding is conspicuous in all rocks except the phyllite. Berkshire rocks are distinguished from the mineralogically similar upper unit of the Hoosac (western sequence) by the presence of more distinct bedding and by a generally rustier appearance on weathered surfaces.

Granitic Gneiss

Granitic gneiss constitutes the lowest unit of the eastern Paleozoic sequence. This unit is apparently in fault contact with Precambrian rocks in the northern part of the quadrangle; this contact has not been observed in either the northern or southern part of the map area. However, the writer believes this body of rock in the Windsor quadrangle and the southern part of the North Adams quadrangle (Herz, 1961) has been incorrectly correlated with the Stamford Granite Gneiss at Stamford, Vermont. There the Stamford is unconformably overlain by the Dalton Formation and is clearly Precambrian.

The granitic gneiss in the Windsor area is a microcline-quartz-biotite-plagioclase augen gneiss. Garnet and muscovite are rare accessory minerals but are more common in the southern part of the quadrangle (STOP 6). The augen texture is locally obscured by intense crushing, the feldspar augen being drawn out to several inches in length. Uncrushed augen commonly are as much as one inch long. The contact with the overlying rocks is sharp; interbedding of the granitic gneiss and the basal rocks

of the Hoosac Formation (eastern sequence) is everywhere restricted to an interval of only a few feet.

Hoosac Formation (eastern sequence)

The granitic gneiss is overlain on the east by a sequence of rocks assigned to the Hoosac Formation. In the northeastern part of the quadrangle, the granitic gneiss is overlain by a few tens of feet of quartz-pebble and polymictic-pebble conglomerate. The conglomerate grades upward by transition and interbedding to quartz-albite-muscovite-biotite-chlorite medium-grained schist. In the southeastern part of the quadrangle, the granitic gneiss is overlain by quartz-microcline-albite-biotite gneisses with accessory epidote, muscovite, magnetite, and garnet. Locally, quartz-feldspar quartzites predominate.

The basal gneisses are overlain at STOP 7 by quartz-albite-muscovite-biotite granular schist, typical of much of the Hoosac Formation. This schist unit pinches out northward. Above the albite schist is a thin (200 feet) unit of coarse-grained quartz-muscovite-paragonite-garnet-chlorite-chloritoid schist (STOP 8). This lithology is correlated with the basal garnet schist of the Hoosac in the western sequence although it is slightly more aluminous.

The garnet schist of the eastern sequence is overlain by 4,000 feet of quartz-albite-muscovite-biotite(or chlorite, or biotite and chlorite) schist that is typical of the Hoosac Formation in Massachusetts.

ROAD LOG AND STOP DESCRIPTIONS

Assemble at 8:30 A.M. in the parking lot of the Adams Market, diagonally opposite the U. S. Post Office at the intersection of Routes 8 and 116 at the south end of Adams, Massachusetts.

NOTE: Coordinates for stops are based on the Massachusetts coordinate system.

Mileage

0.0 Proceed east up hill on Route 116 (Savoy Road).

0.4 Small outcrops on left of Clarendon Springs Dolomite in inverted position.

0.9 The house across the gully to the right (west) is built on a large kame terrace.

1.2 STOP 1 (58.93N - 16.44E) Enter the woods on the east side of the road about 100 feet north of the hydrant. The outcrop is about 200 feet east of the road.

Here is exposed a series of ledges of well-bedded, fine- to medium-grained calcite marble of the Shelburne Marble. Beds range from 1/10 inch to 2 feet in thickness. In the lower part of the outcrop is a large open fold with an east-over-west shear sense. An earlier lineation is present and wraps around the axis of this later fold that refolds isoclinal folds that are related to the formation of the Hoosac nappe. The axial surfaces of the early folds are nearly everywhere parallel to the bedding. They strike north and dip 20 to 30° east. The axes plunge gently to the north. Locally this attitude is slightly disturbed by the later folding.

Return to cars and continue on Route 116.

1.4 STOP 2 (58.75N - 16.44E) Roadcut on right (southwest) side of Route 116.

Here is exposed gray quartz-albite-muscovite-biotite graphitic schist of the Berkshire Schist. At the north end of the outcrop are recumbent isoclinal folds related to the Hoosac nappe. Schistosity parallels the axial surface of these folds. Twenty feet south of the prominant isoclinal folds are more open folds that fold schistosity. The later folds in the Berkshire are normally chevron in style. Both the bedding and the schistosity project beneath the rocks at STOP 1. Here the Berkshire is interpreted to lie with stratigraphic unconformity on the Shelburne Marble, both formations being upside down in the overturned limb of the Hoosac nappe. Thus, in this area, the unconformity beneath the Berkshire

has cut down through the Bascom Formation. The contact between the Berkshire and Shelburne is not exposed. One half mile to the west, the Bascom and Berkshire are in contact

Continue on Route 116.

1.7 Cheshire town line.

3.2 The washed bank to the left (north) of the road consists of brecciated Cheshire Quartzite with a ferruginous cement. This breccia zone marks the trace of the Hoosic thrust (Herz, 1961; Norton, 1967).

3.4 Roadcut on left (north) side of road of Berkshire Schist slightly above the Hoosic thrust and below the Savoy Hollow Brook thrust (Figures 1 and 3).

3.6 Start up windy road with brook along left (north) side of the road. Berkshire Schist is exposed in the lower part of the brook.

3.8 Berkshire Schist in brook below Savoy Hollow Brook thrust is overlain by Cheshire Quartzite above thrust. The Cheshire is in turn structurally overlain by the Dalton Formation in inverted sequence.

3.9 Outcrops of Cheshire may be seen on the north bank of the brook.

4.2 Long roadcut of Berkshire Schist. We are below the Savoy Hollow Brook thrust at this point.

4.3 Savoy town line. Still in Berkshire Schist.

4.8 Scattered outcrops on both sides of the road of Precambrian gneisses. Trace of Savoy Hollow Brook thrust is about 100 feet north (left) of the road.

5.2 Outcrop on left side of road of flaggy Dalton feldspathic gneiss.

5.4 STOP 3 (58.00N - 17.91E) Large roadcut at the height of land between Adams and Savoy.

Exposed on the road is pink, white, and buff Cheshire Quartzite. This outcrop, along with other similar exposures in the town of Cheshire, was originally a source of glass sand. The west end of the outcrop consists of friable quartzite whereas the eastern end is tough vitreous quartzite. The cause of this difference is not known. Neither tectonic crushing nor the presence of accessory minerals appear to explain the relative cohesion of the rock. Although the Cheshire is generally unbedded, bedding may be recognized with difficulty at the west end of the outcrop on the south side of the road. One hundred and fifty feet east of this exposure, on the north side of the road, is an outcrop of rock that most closely resembles the massive albite schist of the Hoosac Formation of the western sequence. Less than 1,000 feet to the west this rock type is interbedded with and passes laterally into flaggy rocks typical of the Dalton Formation. About 100 feet

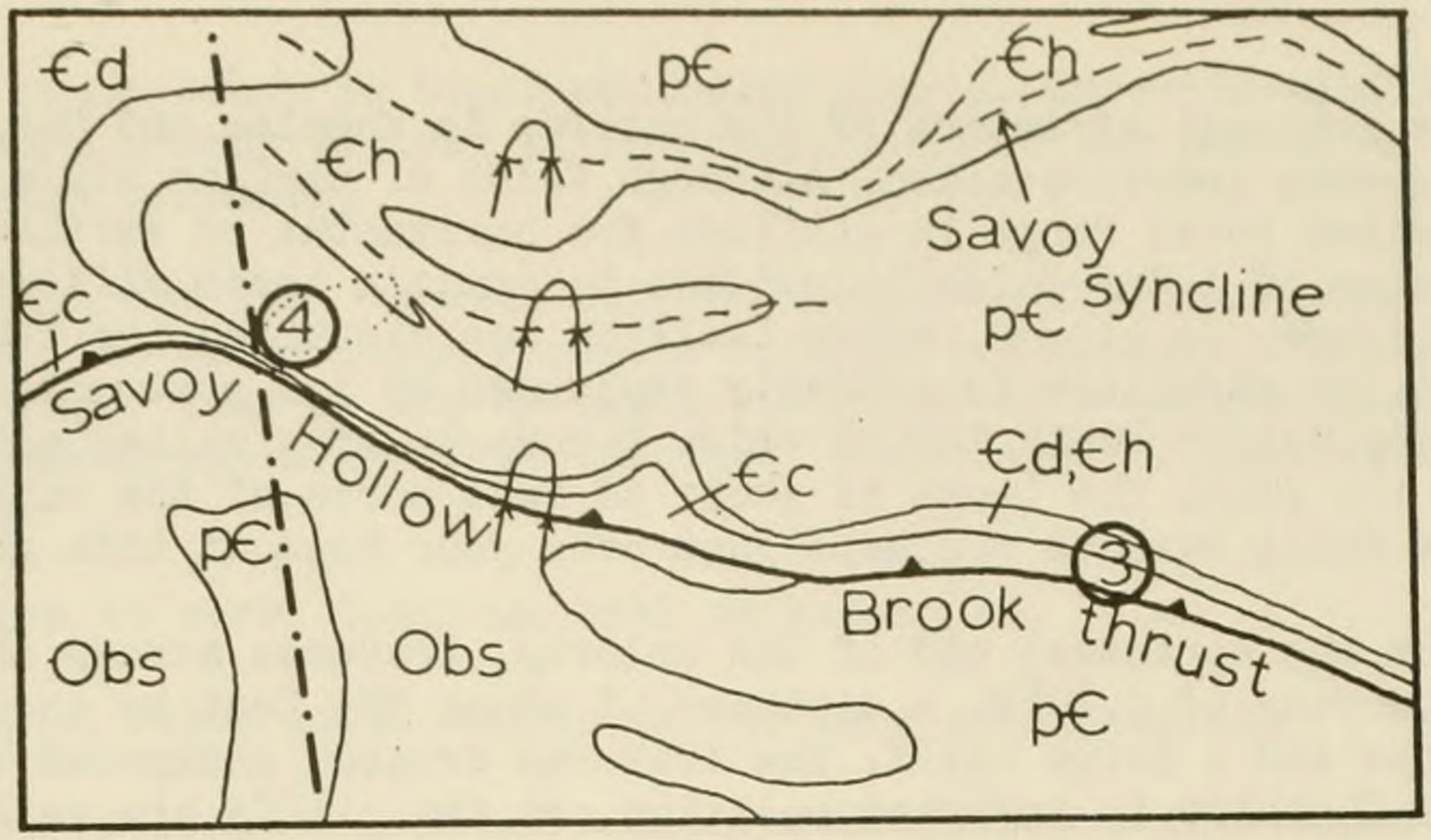

Figure 3. Generalized geologic map in the vicinity of STOPS 3 and 4. Route 116 is nearly coincident with the thrust fault. Dashed and dotted line is the town line between Savoy (east) and Cheshire (west), Massachusetts. Symbols are the same as those used for Figure 1.

north of this outcrop of Hoosac is an outcrop of well banded Precambrian gneiss, similar to that seen at the next stop. In this area the Precambrian-Cambrian contact unfortunately occurs in a swale and can not be seen. South of the road, the Cheshire is apparently in fault contact (the Savoy Hollow Brook thrust) with the Precambrian gneisses. This same inverted sequence may be followed southeastward for 8,000 feet.

Continue on Route 116.

5.5 The outcrop on the right (south) side of the road may be a sliver of Berkshire beneath the thrust. These rocks resemble those seen at STOP 2.

5.6 Large driveway. Turn cars around and head west on Route 116.

5.8 Pass by STOP 3.

6.9 <u>STOP 4</u> (58.12N - 17.37E) Just before Cheshire town line and roadcut in the Berkshire Schist. We shall look at the roadcut and then traverse up the steep hill to the north.

A variety of rocks within the Berkshire Schist are exposed on the road. They include quartzites, quartz-albite-muscovite-biotite schist, and quartz-muscovite schist. All the rocks are graphitic and contain abundant sulfide minerals, predominantly pyrite and pyrrhotite, which cause rusty yellowish-brown to black weathering.

The internal structure of the outcrop is complex and has defied rigorous interpretation. Although folds of similar style in similar rocks range in attitude fro horizontal to vertical, no system of later folds is evident to explain these differences in attitude. In places, minor faulting has disrupted the beds. The complex structure is probably explained by the presence of the Savoy Hollow Brook thrust which trends up this valley parallel to the road. The trace is about 50 feet north of the outcrop and the fault surface projects just over your head at this point.

From the northeast end of the outcrop, traverse across the field on a bearing of N.20°E. a distance of about 375 feet to the break in slope and a large cliff. The traverse crosses unexposed Dalton and Cheshire in inverted position. At the cliffs are well-banded Precambrian quartz-feldspar-biotite gneisses. The general absence of muscovite in these Precambrian gneisses distinguishes them from the Dalton and Hoosac gneisses with which they may be confused. Minor, gray-weathered, somewhat feldspathic quartzites and massive feldspar-quartz-biotite gneissic granulites will be seen on the traverse up the hill. At the base of the cliff, two styles of folding may be seen:

1. Isoclinal recumbent folds with a gentle northerly plunge. These are presumably related to the formation of the Hoosac nappe. Schistosity is axial planar to these folds.

2. More open folds of small amplitude with a consistent east-over-west shear sense fold the schistosity. The axial planes of these later folds strike northerly and dip about 30° east; the axes plunge gently to the north.

These two fold generations correspond to the two sets of folds seen at STOP 1. The later folds are nearly coaxial with the isoclinal folds and appear also to be related to the nappe but they must have formed after the emplacement of the nappe because their shear sense is consistently east-over-west, regardless of position with respect to the larger recumbent syncline we shall see at the top of the traverse (Figure 3). In places, the compositional layering can not be followed for more than a few tens of feet. The gneissosity in those rocks which are generally more micaceous is interpreted to have formed from the transposition of earlier compositional banding during the formation of the nappe.

Continue up the cliffs of Precambrian gneiss until a break in slope is reached with a broad plateau. On the southwesternmost corner of the plateau is a low 30 feet long outcrop which exposes quartz-pebble conglomerate resting unconformably on the Precambrian gneisses. The contact may be traced from outcrop to outcrop and has itself been folded in a left handed sense with east-over-west transport. At this outcrop, the contact trends N.25°W. and dips 33°NE. The stretched pebbles have their maximum dimension oriented about N.15°E. which is essentially parallel to the axes of both the early recumbent isoclinal folds and the later open, east-over-west shear folds. The rocks exposed to the northeast and north

are rusty-brown to black weathered quartz-muscovite-albite-garnet-biotite schist typical of the basal unit of the Hoosac of the western sequence.

If time permits, we will walk northeast to the next break in slope where the Precambrian gneisses rest on the Hoosac in inverted sequence. Thus we are on the normal limb of a southwest-facing recumbent syncline. This syncline closes about 2,000 feet to the east.

Return to cars. Continue west on Route 116.

7.7 Left on Fales Road. Poorly marked turn - be careful.

7.8 Small outcrop on left of Berkshire Schist. The hill 4,000 feet to the west is all Berkshire Schist.

8.7 Left on Sand Mill Road.

8.8 Bear left on dirt road.

8.9 Cross trace of Hoosic thrust onto upper plate. Breccia of Cheshire Quartzite is exposed in brook to left.

9.2 Join Windsor Road. Gorge on left in Cheshire Quartzite. Cross Dry Brook - so named because in the lower reaches, this brook flows over Bascom Formation carbonate rocks and solution channels cause a loss of surface water to subterranean channels.

9.4 Small unnamed brook on left contains an outcrop of Berkshire Schist occupying the core of Dry Brook syncline (Figures 1 and 4), an isoclinal recumbent fold, overturned to the southwest. We will see rocks higher in the brook at STOP 5A.

9.6 STOP 5 (57.11N - 17.14E) At the break in the fence line. This stop will involve a 5,000 feet long traverse. Bring your lunches. We will eat at the outcrops with a fine view of the Hoosic Valley and Mount Greylock. From the break in the fence, proceed northerly across the small field to an old woods road and follow it uphill. About 600 feet from Windsor Road, branch left on an obscure path and continue another 150 feet to a brook. Proceed up the brook. About 320 feet upstream are slumped outcrops of Dalton. Five hundred feet upstream the stream bed steepens through a jumble of boulders, most of which are Dalton. Directly above the boulders is a large outcrop of Precambrian gneiss (STOP 5A), the base of which is highly sheared and marks the position of the inverted unconformity. Note the angularity of the contact. About 100 feet northwest of this point, the contact is clearly exposed in a slumped outcrop. Note the quartz pebbles as much as 6 inches in diameter in the loose boulders.

Walk north about 750 feet across small scattered outcrops of Precambrian gneisses to the ridge on the high meadows. You may follow the traverse on Figure 4.

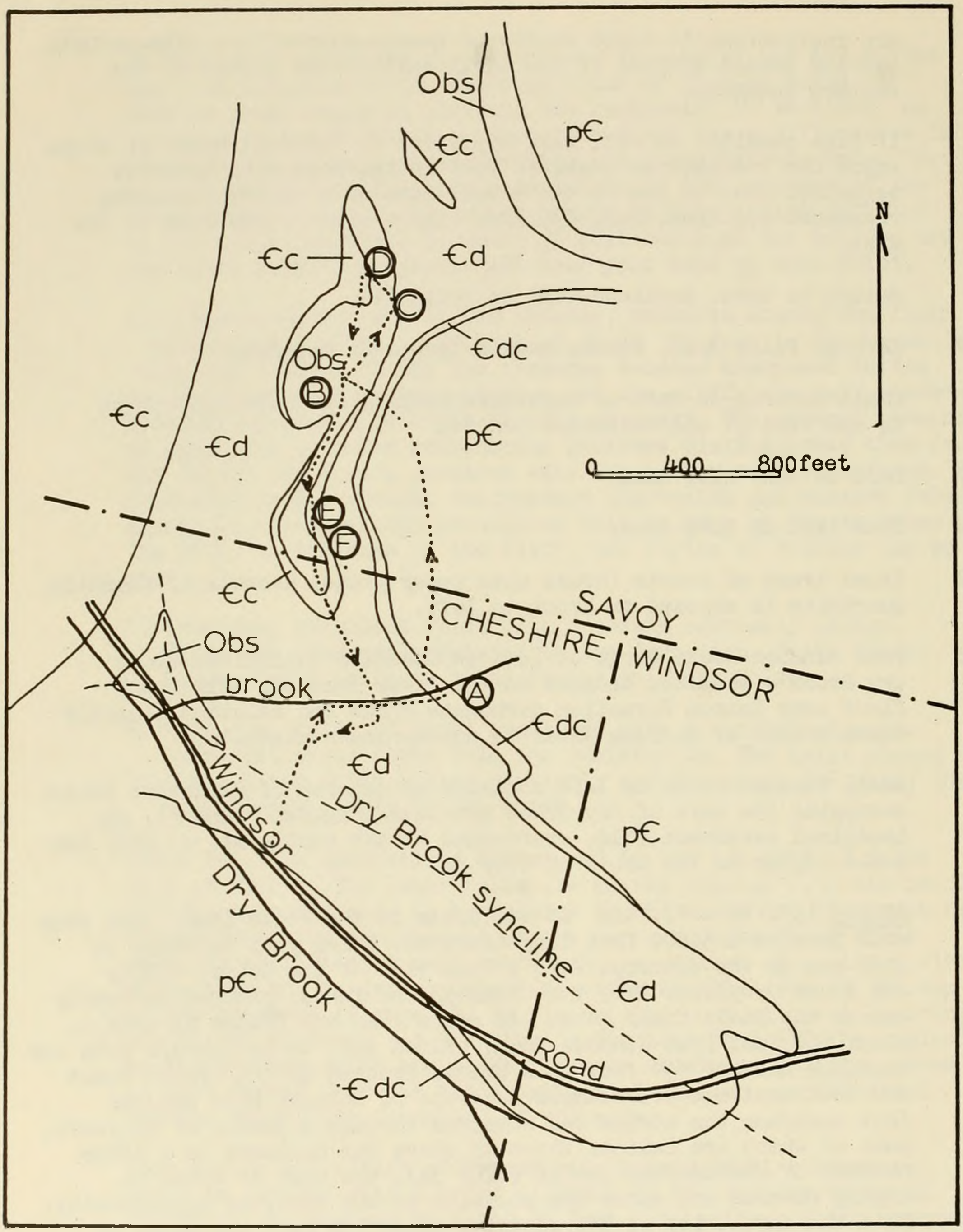

Figure 4. Geologic map in the vicinity of the Dry Brook syncline, Windsor quadrangle, Massachusetts. Circled letters indicate outcrops of particular interest discussed in the text under STOP 5. Symbols are the same as those used for Figure 1.

LUNCH

Points of Interest

1. The valley to the southwest is occupied by the recumbent Dry Brook syncline, overturned to the southwest. Our traverse has brought us through the inverted limb.

2. Mount Greylock, composed of allochthonous Taconic rocks, may be seen across the Hoosic Valley on a bearing of N.35°W.

3. Stafford Hill, composed of Berkshire Schist, is the nearest hill on a N.65°W. bearing. The valley beyond Stafford Hill is occupied by the western carbonate sequence.

4. The bench 300 feet to the northwest is occupied by an open syncline, overturned to the west. See Figure 4 for the plan of our traverse.

STOP 5B Center of syncline. Berkshire Schist occupies the core of this syncline throughout its entire length. Here the rock consists of brown-weathered quartz-albite-muscovite-biotite-tourmaline schist.

STOP 5C Here Berkshire Schist is in contact with medium-grained quartzites of the Dalton Formation. Some of the beds contain quartz pebbles as large as ½ inch. This locality is on the overturned limb of the syncline.

STOP 5D This outcrop, 175 feet northwest of STOP 5C, is on the normal limb of the syncline. Here, Berkshire is in contact with the Cheshire Quartzite.

STOP 5E S.15°W. 450 feet from STOP 5B, the contact between the Cheshire and the Dalton is clearly exposed. At this point we are on the overturned (eastern) limb of the fold. The Dalton is somewhat atypical here in that it is non-rusty weathered. The outcrop about 125 feet northwest of this point is Dalton. Thus either the Berkshire is very thin through this part of the fold, or it is not present at all.

STOP 5F Two hundred and fifty feet S.5°W. is the contact between the Berkshire and the Cheshire on the nearly (at this point) flat lying, overturned limb of the fold.

Proceed S.25°E. following a series of outcrops of Berkshire which occupy the core of the syncline. The hinge line beneath the Berkshire emerges before the brook is reached (about 650 feet from STOP 5F) and projects into the air over the brook. Cross the brook and continue about 100 feet to old woods road and proceed down to cars.

Continue on Windsor Road.

9.8 Windsor town line. Road becomes Cheshire Road.

10.0 Small outcrop of Precambrian gneiss on left.

10.2 Large outcrop of Precambrian gneiss on left, 100 feet off road.

10.4 Home of Al Chamberlain on right, handcrafted from the ubiquitous glacial boulders of Cheshire Quartzite.

12.3 Intersection with paved Savoy Road (Route 8a). Turn right (south).

14.1 Intersection with Route 9 at the center of Windsor, Massachusetts. Turn left (east) on Route 9.

14.6 Whaleback outcrop off road to right exposes granitic gneiss of the eastern sequence. Microcline augen in this outcrop are as large as $2\frac{1}{2}$ inches in length.

14.8 Cross Savoy Hollow Road (on left)-Humes Road (on right).

15.0 STOP 6 (55.35N - 18.35E) Pull cars to right. Roadcut on left (north) side of road.

This outcrop is located within what is mapped as granitic gneiss. It consists of a microcline-quartz-biotite-plagioclase gneiss with accessory garnet, muscovite, and magnetite. The augen of microcline which are characteristic of this unit are crushed and drawn out into lenses at this locality. The unit, aside from the texture, is very homogeneous, both perpendicular and parallel to strike. The unit is believed to be correlative with the Bull Hill Member of the Cavendish Formation of Doll and others (1961) which forms the base of the Paleozoic section in several areas in Vermont.

Continue east on Route 9.

15.8 STOP 7 (55.04N - 18.65E). Roadcut on right side of road.

Here, the basal Hoosac gneisses, composed of albite, quartz, muscovite, biotite, and epidote, are in contact with the overlying quartz-albite- and albite-quartz-muscovite-biotite schist of the Hoosac Formation. The schist is slightly graphitic and weathers a characteristic brown or rusty-brown. Bedding in the schist is obscure, but is well-displayed in the light colored gneisses. Both of the rock types present here pinch out northward between the granitic gneiss (STOP 6) and the overlying garnet schist member of the Hoosac Formation (STOP 8) and are not present at the north edge of the quadrangle.

The pronounced schistosity in the schist is axial plane to isoclinal steeply plunging folds that are best seen on the top of the weathered outcrop. The numerous quartz lenses that outline these folds are interpreted as quartz-rich lenses in the original sediment. Late southwest plunging open reverse drag folds may be seen in the fresh roadcut surface. These folds fold schistosity and only rarely display a weak axial plane cleavage.

Continue east on Route 9.

16.1 Reverse direction on Route 9.

16.5 Pass by STOP 7.

17.5 Turn right (north) on Savoy Hollow Road (dirt).

17.7 Turn right (east) on Shaw Road.

17.8 Whaleback outcrop in road of granitic gneiss.

17.9 Whaleback outcrop in road of granitic gneiss.

18.4 STOP 8 (55.37N - 18.63E) Top of rise in road. Outcrop extends up ridge to north of road.

This exposure is in the garnet schist member of the Hoosac Formation and directly overlies the albite schist seen at STOP 7, an outcrop of which may be seen 100 feet west of STOP 8. The rock is a coarse-grained quartz-muscovite-paragonite-garnet-chlorite-chloritoid schist. Minor amounts of albite may be present in some beds. The rock has a very strong schistosity which is folded unsystematically by folds that only locally display a weak slip cleavage. The rock here is correlated with the basal garnet schist of the Hoosac of the western sequence (STOP 4). To the north, it is tentatively correlated with the garnet-mica schist member of the Cavendish Formation of Doll and others (1961) in the Rowe, Massachusetts quadrangle (Chidester and others, 1967), with the Heartwellville Schist of Skehan (1961) in southern Vermont, and with the Gassetts Schist Member of the Cavendish Formation in central Vermont (Doll and others, 1961).

END OF TRIP

To rejoin Route 9, continue on dirt road to

19.4 Outcrop of typical albite schist of the Hoosac Formation.

20.1 Intersection of High Street (formerly Shaw Road) and High Street Hill Road. Turn right. Outcrop at the corner is the basal graphitic schist of the Rowe Schist (Figure 2).

20.2 High tension lines.

20.6 Rejoin Route 9. For Connecticut, eastern Massachusetts, New Hampshire, and Maine, turn left and proceed to Northampton and Interstate 91. For Vermont, turn right and return to Windsor. Take Route 8a north. For New York, turn right and follow Route 9 to Pittsfield.

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