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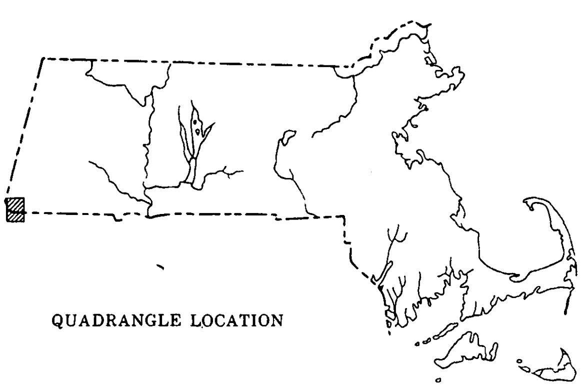
GEOLOGIC QUADRANGLE MAPS OF THE UNITED STATES

GEOLOGIC MAP OF THE BASHBISH QUADRANGLE MASSACHUSETTS, CONNECTICUT AND NEW YORK

By
E-an Zen and J. H. Hartshorn



QUADRANGLE LOCATION

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GEOLOGY OF THE BASHBISH FALLS QUADRANGLE, MASSACHUSETTS, CONNECTICUT, AND NEW YORK

By E-an Zen and Joseph H. Hartshorn[1/]

STRATIGRAPHY

Except for the surficial deposits, the Bashbish Falls quadrangle is underlain by metamorphosed lower Paleozoic sedimentary rocks. Early mapping in the area was done by Dana (1873) and Hobbs (1893a, 1893b). Dale (1923) mapped the marble in the general area of the Housatonic valley as the Stockbridge Limestone and subdivided it into a lower dolomitic and an upper calcitic member; he mapped the schist units as Berkshire Schist.

Stockbridge Formation

The Stockbridge Formation (Zen, in press[a]) is a sequence of impure dolomitic and calcitic marbles with local beds of arkose and phyllite. It differs from the Stockbridge Limestone as used by Dale (1923) in that limestone interbedded with schist, occurring at the top of the Stockbridge Limestone is assigned to the overlying Walloomsac Formation (Zen, in press[b]) and excluded from the Stockbridge Formation. The suggested correlations of the rock units with formations in adjacent areas are based largely on lithology; however, these correlations are consistent with the ages of various dated units.

The Stockbridge Formation is divided into seven lithostratigraphic units, tentatively referred to by the letters A through G (see correlation chart, p. 2). These seven units of the Stockbridge Formation constitute a single sedimentological sequence. Where observed, the contacts between units are conformable and commonly are gradational. The sporadic distribution of units D and F probably is primary, as the abrupt changes in thickness and lateral facies intercalations can be demonstrated even in single outcrops. Estimates of average thickness from areas of good outcrop and simple structure are given in the correlation table. The total thickness for the Stockbridge Formation is about 3000 feet; in the Pine Plains area (Knopf, 1962) it is 4000 feet, and in west-central Vermont (Doll and others, 1961) it is 5000 feet thick.

The age of the Stockbridge probably ranges from Early Cambrian to late Early Ordovician. In the Egremont quadrangle to the north, unit A overlies the Cheshire Quartzite with transitional contact; the Cheshire, as well as the unit A-correlative Dunham Dolostone of Clark (1934) contains Early Cambrian fossils in northwestern Massachusetts and in Vermont. The lithic and sequential equivalents of many of the other units, in the Pine Plains area and in Vermont, are also fossiliferous and agree in the indicated ages. The top of the Stockbridge is truncated by an unconformity whose angularity is displayed in a cliff in Wildcat Hollow in the Sharon quadrangle to the south. Above the unconformity is black schist of the Middle Ordovician Walloomsac Formation (Zen, in press[b]). By the gate to the Berkshire Downs racetrack west of Pittsfield, Mass. (about 25 miles NNE of Bashbish Falls quadrangle) is an outcrop of limestone correlated with the basal part of the Walloomsac Formation. This outcrop yielded rugose corals, fragmentary brachiopods, pelmatazoan stems, and gastropods. The corals are no older than Black River, and may be Trenton (probably Wilderness Stage) according to Helen Duncan (written communication, 1963). These fossils, the first found in the "lime belt" of Massachusetts and Connecticut, establish an upper age limit for the carbonate section.

Walloomsac Formation

The Walloomsac Formation (Zen, in press[b]) is composed of gray to black phyllite and schist; interbedded gray to white limestone at or near the base was assigned to the Stockbridge Limestone by Dale (1923). The phyllite and schist were called Berkshire Schist by Emerson (1917) and Dale (1923); they are the main body of the Riga Schist of Hobbs (1893a), although the type Riga of Hobbs is now mapped as part of the Everett Formation. The name Walloomsac is applied because these rocks are on strike with, occupy the same relative position as, and may prove to be continuous with the type Walloomsac Slate of Prindle and Knopf (1932, p. 274), but of higher metamorphic grade.

Gray-green schist occurs locally near the base of the Walloomsac (for example, NNW of knob 889, 3000 feet east of the Salisbury-Giberson road junction); such gray-green beds are common within the Walloomsac immediately above the unconformity and were not mapped separately.

At the upper contact of the Walloomsac is the Everett Formation. This contact is based on color differences and locally is gradational; it is particularly uncertain wherever extensive recrystallization has occurred.

Egremont Phyllite

The Egremont Phyllite (Zen, in press[c]), is a black and gray phyllite that includes sporadic lenses of phyllitic limestone. Good examples of the rock are seen in Wright Brook in the present area.

Despite locally intricate contact relations caused by folding (visible, for example, in Wright Brook), the map pattern shows that on the whole the contact between the Egremont and the Everett Formation must be nearly planar. Both in its lithic features and in its geometric relations to the Everett, the Egremont resembles the Walloomsac Formation on the east slope of the Taconic Range; the limestone lenses in the Egremont also correspond to the limestone lenses at the base of the Walloomsac. In cross-section A-A', an Egremont - Walloomsac equivalence is assumed.

Everett Formation

Hobbs (1893a, p. 728) applied the name Everett Schist for the mass of green schist occupying the Taconic Range of the map area. In order to include

[1/] Surficial geology by J. H. Hartshorn.

Chart showing correlation with adjacent areas

AGE	Pine Plains area, New York (Knopf, 1962; Zen, 1963)	Bashbish Falls quadrangle and vicinity, this report		Western Vermont (Brace, 1953; Doll and others, 1961; Zen, 1964)	Northwestern Massachusetts (Herz, 1958)
UNKNOWN		Everett Formation O€ev O€ea	2000'?		Greylock Schist
MIDDLE ORDOVICIAN	Normanskill Shale	Walloomsac Formation (= Egremont Phyllite?) Ow Owm	1500'?	Ira Formation	Berkshire Schist
	Balmville Limestone	Oeg Limestone interbedded with schist	0-200'	Whipple Marble Member	
EARLY ORDOVICIAN	Copake Limestone	Stockbridge Formation: Unit G O€sg	400'	Chipman Formation	Stockbridge Group: Bascom Formation
	Rochdale Limestone			Bascom Formation	
	Halcyon Lake Formation	Unit F O€sf	0-150'	Cutting Dolostone	Shelburne Marble
		Unit E O€se	400'	Shelburne Formation	
		Unit D O€sd	0-150'		
MIDDLE AND LATE CAMBRIAN	Briarcliff Dolostone	Unit C O€sc	700'	Clarendon Springs Dolostone	Clarendon Springs Dolomite
				Danby Formation	Danby(?) Formation equivalents
EARLY CAMBRIAN	Pine Plains Formation	Unit B O€sb	600'	Winooski Dolostone	Kitchen Brook Dolomite
	Stissing Dolostone			Monkton Formation	
		Unit A O€sa	700'	Dunham Dolostone	
	Poughquag Quartzite	Cheshire Quartzite	300'?	Cheshire Quartzite	Cheshire Quartzite
CAMBRIAN(?)		Dalton Formation	>200'	Mendon Formation	Dalton Formation

rocks of different metamorphic grades, the designation has been changed to formation (Zen, in press[d]).

The limestone layers in the Everett Formation are readily seen in City Brook under the West Street bridge. Arkosic lenses (O€ea) in the Everett are best seen along the Appalachian Trail south of Bear Mountain; lithically, these beds resemble the Lower Cambrian(?) Zion Hill Quartzite of Vermont as that name was used by Zen (1964, p. 15-16). Laminated quartzite can be seen on the west slope of Cedar Mountain. Small, isolated masses of gray schist that lithically resemble the Walloomsac or the Egremont, but appear to be interbedded with the Everett, are provisionally mapped as a lithic variant of the Everett, and designated O€eb on the map.

The problem of correlation is not yet resolved. The Everett occupies the same relative position as the green schist elsewhere in the Taconic Range. In southwestern Vermont, Dale (1912), MacFadyen (1956), and Hewitt (1961) referred these latter rocks to Middle Ordovician or younger age. On the basis of regional relations and lithic comparison with the fossiliferous rocks of the Taconic sequence, Prindle and Knopf (1932) and Doll and others (1961) assigned the rocks to the Lower Cambrian. Based on local lithic and stratigraphic evidence, Potter (1963) referred the rocks to an inverted sequence of Early Cambrian to Middle Ordovician age.

METAMORPHISM

In the Bashbish Falls quadrangle, the metamorphic grade increases from northwest to southeast, at an angle to the nearly north-south structural trend in the area. The rocks of lowest grade are phyllites, but become coarse schists southeast of Lions Head. Kyanite was reported by Agar (1932, p. 38) in the southern part of the area; in the same area pegmatitic quartz-feldspar veins are present.

Typical mineral assemblages of the Everett Formation, approximately in order of increasing grade, are given below; minerals in parentheses are not everywhere present in the assemblages.

1. Chlorite-muscovite-ilmenite-quartz (biotite, albite, paragonite)

2. Chlorite-muscovite-chloritoid-ilmenite-quartz (paragonite, albite, biotite)

3. Chlorite-muscovite-almandine-ilmenite-quartz (chloritoid, oligoclase, paragonite, biotite)

4. Chlorite-staurolite-almandine-muscovite-oligoclase-quartz (chloritoid, ilmenite)

Other assemblages, approximately isogradic with (4) above, show

4a. Hornblende-biotite-almandine-plagioclase-quartz

4b. Almandine-biotite-chlorite-cummingtonite-muscovite-quartz (ilmenite?)

4c. Almandine-biotite-staurolite-oligoclase-quartz (ilmenite).

Assemblage (4a) occurs on the ridge south of Hammertown, in a calcareous schist of unit B of the Stockbridge Formation. (4b) is from a dense quartzite in the Walloomsac, south of Lions Head and just outside the quadrangle. (4c) is a typical schist of the Walloomsac Formation near Lions Head. Noteworthy, apparently stable associations are biotite-chloritoid, paragonite-oligoclase, and staurolite-almandine-chloritoid.

The lowest grade Stockbridge Formation in the area is isogradic with assemblage (2). Colorless tremolite, several centimeters long, is abundant in unit A just east of the mapped area; phlogopite is found in many dolostone beds throughout the area.

Although crushed and partially chloritized porphyroblasts of almandine and biotite occur locally, enough unaffected mineral assemblages exist in all areas to show that the westward decrease in metamorphic grade is primary. There is no evidence to support Agar's (1932, p. 42, 43) conclusions of a regional, westward increase in retrograde metamorphism (diaphthoresis), or of igneous activity responsible for the metamorphism and for the divergence of metamorphic and structural trends.

Porphyroblasts of coexisting muscovite and biotite from the Walloomsac Formation at an altitude of 1200 feet, 4000 feet southeast of Lions Head, were isotopically analysed by C. E. Hedge and R. F. Marvin of the U.S. Geological Survey. The Rb/Sr ratio in biotite gave an apparent age of 355 m.y., and the K/Ar ratio in muscovite gave 390 m.y. These most likely are ages of the last important episode of progressive metamorphism. The crushing and local retrogression of the minerals indicate that the formation of the porphyroblasts was a late though not the last event in the diastrophic history. The isotopic ages agree with those of similar rocks from Dutchess County, N. Y. (Long 1962).

STRUCTURE

Structure in the Housatonic valley

A major structure in the Stockbridge Formation is a recumbent fold, here called the Foley fold, that extends the length of the quadrangle. Although the geometry of this fold at depth is not established, the structure probably is a true recumbent fold instead of a fan fold because the bedding attitude passes through the horizontal rather than the vertical, from one limb of the fold to the other across the axial region. The inverted stratigraphy in the underlimb of the Foley fold is visible in the breached core of a superimposed anticline; this inversion, as well as other structural relationships, can be seen in an abandoned marble quarry (see map) 2000 feet due west of the Berkshire School Road-Giberson Road intersection. Here unit E underlies unit D, and bedding is flat. On the east and west slopes of the hill that adjoins the quarry, unit C dips gently away from the hill.

The oldest exposed unit in the Foley fold is unit B. The western or leading edge of the structure must have travelled west for about a mile along the latitude of section A-A'. The reconstructions of sections B-B' and C-C' suggest that the degree of recumbency diminishes southward.

The broad fold around New Guinea Swamp is considered an open normal syncline east of the axial region of the Foley fold; this syncline extends south at least to the Twin Lakes area (sections A-A', B-B', C-C'). The open fold may have been formed during the same episode as the formation of the Foley fold, or later.

The chronologic relation of the Foley fold and deposition of the Walloomsac Formation is not clear. Regional truncation of the Stockbridge by the Walloomsac, and the relations at Wildcat Hollow indicate an episode of diastrophism following the deposition of unit G of the Stockbridge but preceding the deposition of the Walloomsac. This is in accord with relations in Vermont and in the Hudson valley area (Zen, 1963; 1964, p. 58-67). The Foley fold may have formed during this deformation or it may have formed after deposition of the Walloomsac. A post-Walloomsac age for the Foley fold is supported by the fact that the Walloomsac in the Bashbish quadrangle everywhere rests on right-side-up Stockbridge; however, there is lack of evidence that the Walloomsac was affected by large-scale intense deformation that is expected from such recumbent folds. A post-Walloomsac age for the Foley fold has been adopted as a working hypothesis and was followed in drawing the hypothetical relations shown at depth on the cross sections.

The post-unconformity Walloomsac Formation is itself deformed; locally the deformation involves flowage and isoclinal folding of the carbonate units, though on a scale too small to map individually. Along a railroad cut southeast of Tom's Hill in the Ashley Falls quadrangle (referred to by Hobbs, 1893b, p. 792), the isoclinal folds in the basal Walloomsac are refolded, but the two foldings are coaxial and probably belong to the same episode. This post-Walloomsac deformation appears to be no younger than the regional metamorphism, because the metamorphic textures generally are preserved. There is also no noticeable break in the metamorphic grades of rocks above and below the unconformity.

Despite the local severity of this deformation, the folds are shallow and relatively open on a regional scale. This late deformation produced most of the folds visible in individual outcrops, and is the cause of the most conspicuous cleavage in the schists. The relation between different sets of cleavages and specific systems of folds, and the relation of these structures to the pre-Walloomsac deformation, however, remains to be determined.

Much of the patchy distribution of rock units on the map is caused by the pre-Walloomsac unconformity. The large area of units D and E of the Stockbridge southeast of Mount Race, however, is of particular interest because on its east side almost flat-lying Stockbridge occurs topographically above the Walloomsac. Although an abrupt reversal of bedding attitude in the Walloomsac at the contact could explain the patch as a simple erosional inlier, the favored explanation is that the eastern boundary of the patch is a high-angle fault with a relatively small downdrop to the east. The fault has the same trend as the fault along Schenob Brook near Salisbury Road. The continuation of the fault is conjectural; it may die out abruptly within the Walloomsac Formation.

Structure in the Taconic Range and problem of the Taconic allochthon

The schists of the Taconic Range (western half of the quadrangle) lie in a broad, open synclinorium. If, however, the Egremont Phyllite proves to be the same as the Walloomsac, as proposed here, instead of a separate unit as suggested by Hobbs (1893a, p. 725), then there exists a broad anticline along the axial part of the synclinorium. The development of this gentle flexure may have been a relatively late event.

Where bedding is visible locally within the Everett Formation, it commonly shows isoclinal and recumbent folds on the scale of tens of feet. In the areas of nearly continuous outcrop between Brace Mountain and Alander Mountain, and between Mount Everett and Sages Ravine, faults are common, each with displacement of a few inches. Lacking key beds, unfortunately, it is impossible either to decipher these doubtlessly complex structures, or to determine whether the Everett is structurally conformable with the underlying units.

The tectonic relation of the schist mass of the Taconic Range is part of the Taconic controversy. Some geologists (for example, Prindle and Knopf, 1932) suggested that at least the higher parts of the schist are part of a klippe, and may be of Early Cambrian age. Other workers, impressed by the gradational contact and the synclinal shape, advocated a sedimentary succession, while allowing the possibility of one or more intervening unconformities (for example, Dale, 1923; Hewitt, 1961).

Should pre-Middle Ordovician fossils be found in the Everett Formation, or should this rock be shown to contain large-scale recumbent folds having trailing edges projecting into the air and not related to the underlying structures, then a Taconic allochthon would be demonstrated. However, while the establishment of a pre-Middle Ordovician age for the Everett would prove an allochthon, a post-Middle Ordovician age would not uniquely demonstrate an autochthon.

SURFICIAL GEOLOGY

The last major event in the geologic history of the area was the advance of a late Wisconsin glacier from the northwest. Till, almost entirely derived from the local bedrock, covers most of the upland area west of the mountain front. The till ranges from light olive brown, with a sandy or silty-sandy matrix and many stones, to olive gray, with a compact, less stony, silty-clayey texture.

During glacial retreat, tongues of ice occupied the lowlands east of the mountain front, and the water-laid ice-contact stratified drift on the west side of the valley of Moore Brook was deposited at altitudes as high as 250 feet above valley floor. In other parts of the major north-south valley, collapsed deposits, the result of melting of ice blocks beneath and beside the stratified drift, also indicate the presence of ice until late in the depositional history. Two areas of north-facing, ice-contact slopes probably represent the headward limits of extensive deposits of sand and gravel derived from the glacier front. The collapsed and kettled ice-contact head south of the State line grades southward past Fisher Pond into proglacial outwash having very few kettleholes. The ice-contact head north of Salisbury Road also has an extensively collapsed area at its northern limit and the debris extends southward as a narrow kame terrace along the west side of the valley. The adjacent outwash deposits, which occupy the low areas around and perhaps beneath the swamps, are like those in the Housatonic valley, just east of the quadrangle, which is filled with stream or lake deposits breached and terraced by the modern river.

ECONOMIC RESOURCES

The Bashbish Falls quadrangle contains marble quarries, both in calcite marble and in dolomite marble; these quarries are now abandoned. Dale (1923) gave accurate locations of all of the significant quarries existing in 1918; no more have been opened since then.

In the adjacent Sharon and Copake quadrangles, iron ores had been mined (and exhausted) along the base of the Walloomsac Formation; the ore may represent saprolitic deposits below the unconformity. Comparable bodies might be expected at a similar stratigraphic position in the Bashbish Falls quadrangle; the pond at an altitude of 840 feet, 1800 feet west of the northwest tip of Fisher Pond, might be the site of such a mine.

About 15 pit areas have been opened to exploit the extensive sand and gravel deposits. Pebble counts in several pits show approximately 50 percent gneiss and schist; 15 percent limestone, dolomite, and marble; 15 percent quartzite; 10 percent sandstone and conglomerate; and 10 percent vein quartz. Pebbles of deeply weathered schist and ferruginous conglomerate occur locally. Sand and gravel in the water-laid ice-contact deposits and in parts of the outwash are adequate for any foreseeable need.

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_____ 1966d, Everett Formation, <u>in</u> Cohee and West, 1966.