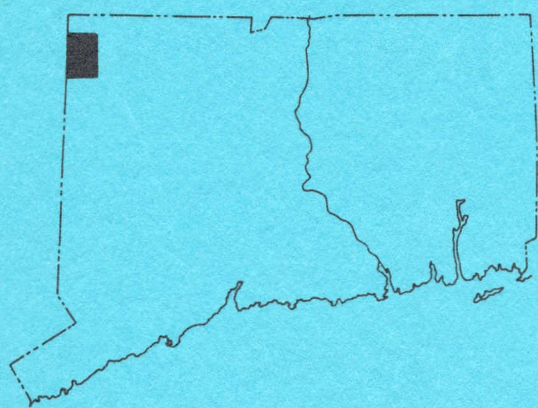
The Bedrock Geology of the Sharon Quadrangle

WITH MAP

Open Plate 1

Open Plate 2

ROBERT M. GATES



STATE GEOLOGICAL AND NATURAL HISTORY SURVEY
OF CONNECTICUT

DEPARTMENT OF ENVIRONMENTAL PROTECTION

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QUADRANGLE REPORT NO. 38

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University of Wisconsin-Madison

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TABLE OF CONTENTS

ILLUSTRATIONS

The Bedrock Geology of the Sharon Quadrangle

by

Robert M. Gates

ABSTRACT

The bedrock of the Sharon quadrangle includes the southern end of the Taconic Range in the northwestern quarter and the western edge of the quadrangle, and the northwestern end of the Housatonic Highlands massif in the southeastern quarter. Between the Taconic Range and the Housatonic massif are the Cambro-Ordovician autochthonous sediments of the Dalton-Cheshire, Stockbridge, and Walloomsac formations.

The Precambrian Housatonic Highlands massif, with its discontinuous carapace of the Dalton-Cheshire Formation, occurs as a block thrust northwestward over the autochthonous sediments and, locally, on Red Mountain, in a nappe of overturned Dalton and the Housatonic massif. The root zone of the nappe is not known.

The Stockbridge Formation outcrops sparsely from border to border in a series of NNW-trending folds, overturned to the west. It is overlain unconformably by the Walloomsac Formation.

The Walloomsac Formation is separated into a lower, impure, calcitic marble unit and an upper unit of interlayered and intergradational black quartzitic schists and garnet-staurolite-muscovite-quartz schist. The garnet-staurolite-muscovite-quartz schist is strikingly similar to a prominent lithology in the Everett Formation.

Of particular interest is the relationship of the Walloomsac to the Everett Formation, which is generally considered (Zen, 1967, 1972) to be an allochthonous hard-rock thrust slice. In many places in the Sharon and Bashbish Falls quadrangles, the contact between the formations appears to be interlayered or gradational, with scant structural indication of thrusting. Locally, large exotic blocks of the Stockbridge Formation occur in the Walloomsac Formation. Some blocks are near the Walloomsac-Everett contact where the contact is exposed; elsewhere the blocks are remote from it unless the present erosion surface approximately coincides with the contact. The similarity of the garnet-staurolite-muscovite schists in the two formations suggests the intriguing possibility that they are related by a sedimentary interfingering.

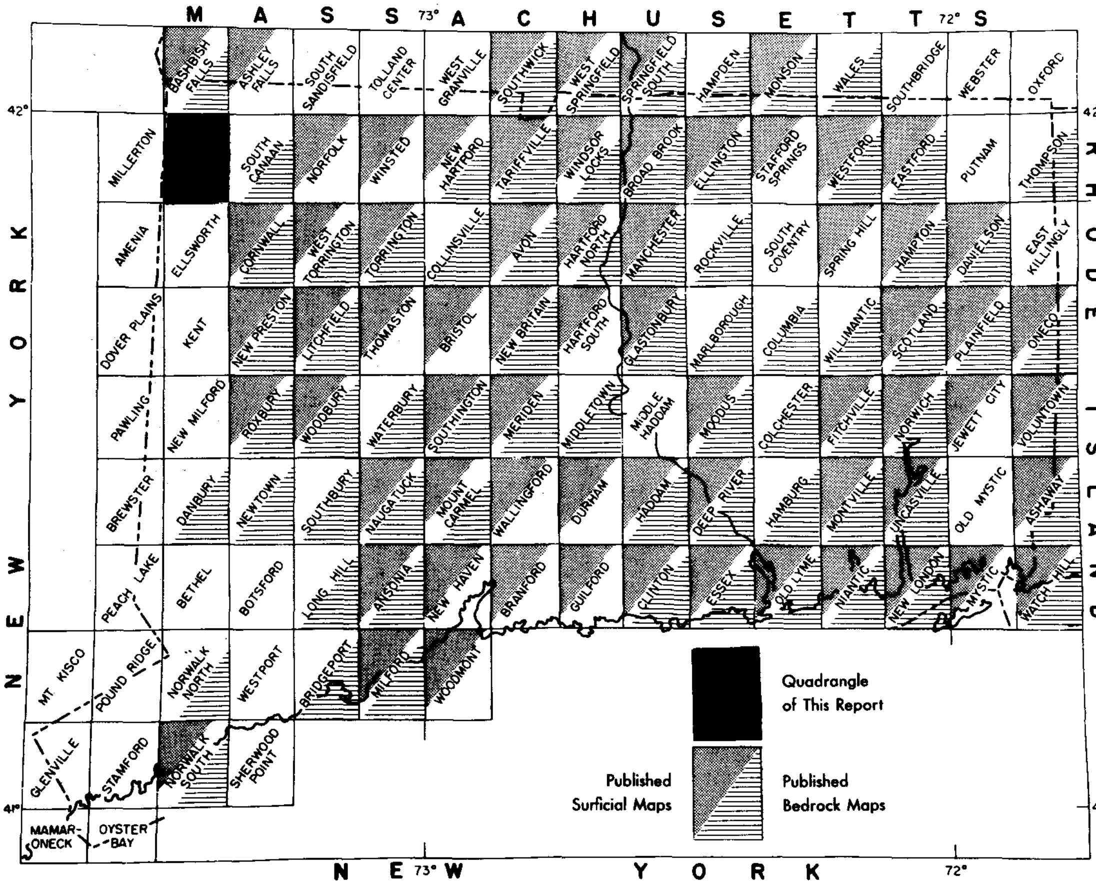

Fig. 1. Index map of Connecticut showing the location of the Sharon quadrangle and of other published quadrangle maps

INTRODUCTION

Location

The Sharon quadrangle lies in the extreme northwestern corner of Connecticut (fig. 1); its rocks bridge the area between the Housatonic massif in the southeastern corner and the Taconic klippe to the northwest. The population centers of Sharon, Lakeville, and Salisbury lie in the carbonate valley on Highway 41, the major N-S route through the quadrangle. The primary E-W traffic routes, highways 44 and 112, connect with highways 7 to the east and 22 to the west.

Physical features

The valley trending NNE between Sharon and Salisbury is dominated by Mudge Pond and Wononpakook lakes. Elevations range from approximately 700 ft (213 m) near Salisbury to 500 ft (152 m) at Sharon. The valley is flanked to the west and northwest by Indian Mountain, Thorpe Mountain, and Mt. Riga, which rise 900-1100 ft (175-335 m) above the valley floor, and on the east by an arcuate series of hills and knobs, known as Wetawanchu, and by Falls, Forge, and Red mountains.

Acknowledgments

The quadrangle was mapped under the sponsorship of the Connecticut Geological and Natural History Survey. Grants to support this project were received from the Wisconsin Alumni Research Foundation in 1971 and 1977.

E-an Zen graciously gave me a copy of his field map of the northwestern part of the quadrangle, made during the mapping of the Bashbish Falls quadrangle (Zen and Hartshorn, 1966).

I greatly appreciate the critical review by David Harwood.

Previous work

The classic work in this area was done by Percival (1842) and by Rice and Gregory (1906) and Gregory and Robinson (1907). Much of Rice and Gregory's report was based on the unpublished Litchfield Folio of W. H. Hobbs. Knopf's (1927) reconnaissance studies and Agar's (1929, 1932, 1933) more detailed studies of the region provided a background for future work and showed unusual insights into the problems of the area. Moore (1935) integrated and summarized much of the information on the limestones of the area. Zen and Hartshorn (1966) and Zen (1966) established many stratigraphic and structural relationships in the Bashbish Falls quadrangle to the north. Zen's (1967, 1972a) and Bird and Dewey's (1970) regional syntheses have contributed significantly to the understanding of the regional geology. Zen (1967, 1972a) has given an excellent overview of the western edge of the New England section of the Appalachians.

GENERAL GEOLOGY

The Sharon quadrangle is near the western edge of the Appalachian Mountain belt, where the Precambrian Housatonic massif has been thrust westward over the miogeosynclinal assemblage of metamorphosed sandstone, carbonate rocks, and shale. The miogeosynclinal assemblage is overlain by the allochthonous phyllitic schist of the Taconic klippe. East of the quadrangle, generally east of the belt of Precambrian massifs extending from the Green Mountains in Vermont to the Hudson Highlands in Connecticut and New York, are lower Paleozoic eugeosynclinal rocks. A few kilometers to the west are the relatively unmetamorphosed foreland rocks equivalent to the miogeosynclinal rocks.

The Housatonic massif is an en-echelon segment of the Precambrian Green Mountain, Berkshire, and Hudson massifs that are presumed to mark the eastern edge of the continent during Cambro-Ordovician time (Rodgers, 1968). The Housatonic massif is composed of granitic to granodioritic gneisses, quartz-plagioclase gneisses of metavolcanic origin, and subordinate metasedimentary and amphibolitic gneisses. The regional gravity high, spatially coincident with the Green Mountains and Berkshire massifs, lies to the east of the Housatonic massif and may indicate that the Housatonic massif is allochthonous (Zen, 1972a).

The miogeosynclinal sedimentary assemblage of sandstone, carbonate, and shale, represented here by the Dalton-Cheshire, Stockbridge, and Walloomsac formations, is the correlative of similar rock sequences occurring west of the line of Precambrian massifs extending from Vermont to New York. The Dalton-Cheshire is present only as discontinuous remnants on the Housatonic massif. The Stockbridge and Walloomsac formations underlie the major portion of the quadrangle in a series of folds overturned westward. The Everett Formation, the southernmost extension of the Taconic klippe, overlies the Walloomsac Formation principally in the northwestern corner of the quadrangle and on the crest of Indian Mountain along the western border. The relations of the Everett and Walloomsac formations in this region are equivocal.

The quadrangle was mapped during the summers of 1971-1976.

HOUSATONIC HIGHLANDS MASSIF

General statement

The Housatonic massif is offset to the west of the Berkshire massif by less than 6 km. It is composed largely of granitic gneiss, metavolcanic granitic to trondhjemitic gneisses, muscovite-biotite-quartz-plagioclase paragneisses, and amphibolitic to mafic gneisses. The biotite granite gneiss and the biotite-quartz-plagioclase (trondhjemite) gneiss are by far the most abundant. The paragneisses are minor and there are only two mappable areas of amphibolite to mafic gneiss. However, essentially all the rocks contain very subordinate layers of mafic gneisses and amphibolite.

Almost all the rocks exhibit a cataclastic texture that is shown mainly as fluxion structure, as defined by Higgins (1971). Most rocks are protomylonitic, with only a few areas of thin mylonite zones. The rocks of the allochthonous slice of Red Mountain which has overridden the Walloomsac and Stockbridge formations are undifferentiated because of the small-scale interdigitation of the various rock types. The map units in the Housatonic massif are: biotite-granite gneiss (p€hb), trondhjemitic gneiss (p€ht), muscovite-biotite-quartz-plagioclase paragneiss (p€hp), and mafic to amphibolitic gneiss (p€ha).

Lithology

BIOTITE-GRANITE GNEISS (p€hb)

This highly variable biotite-granite gneiss is the dominant rock type on Sharon and Mine mountains. It is a light- to dark-gray, locally tan or reddish-tan, medium- to coarse-grained gneiss, composed of microcline, quartz, plagioclase, and biotite, with subordinate muscovite and accessory epidote, magnetite, sphene, zircon, allanite, and apatite. Epidote is especially abundant and occurs in aggregates and euhedral crystals, 1-2 cm across. The heterogeneity of the granitic gneiss is due primarily to variations in grain size and to the distribution of the biotite, both features probably related to cataclasis. The biotite forms fine, uniform folia in the fine-grained gneiss and is in coarser, discontinuous streaks or clots in the coarse-grained gneiss. Some of the coarse-grained gneiss is an augen gneiss with feldspar augen, 1-5 mm. Microscopically, most of the granite gneiss is protomylonitic, with angular porphyroclasts of microcline in a partially crushed and recrystallized matrix of quartz, plagioclase, and biotite. Myrmekitic embayment of the microcline is particularly common in the zones of crushed material. The biotite ranges from fine grained to coarse grained, and occurs in pronounced planar folia, in irregular, discontinuous folia, and in clots or folia around large porphyroclastic augen of microcline.

The biotite-granite gneiss is not distinctly different lithologically from the other gneisses of the massif. However, it is characterized by an abundance of microcline, relatively coarse grained. None of the other rocks in the massif has a microcline/plagioclase ratio greater than 1.

Locally, as adjacent to the small fault on Sharon Mountain, (pl. 1), the granite gneiss is mylonitic. In some places it is more mylonitic near contacts with the Dalton or Walloomsac formations.

The distribution and associations of the granite gneiss do not allow a definitive correlation with any of the granitic gneisses reported by Ratcliffe (1974) in the Great Barrington quadrangle.

TRONDHJEMITIC GNEISS (p€ht)

This is a fine- to medium-grained quartz-plagioclase gneiss with subordinate microcline and accessory epidote and sphene. Locally, it is a banded gray and white gneiss, the alternating layers carrying different amounts of biotite. The layers range from a centimeter to over a meter in thickness. It is generally finer grained than the biotite-granite gneiss, and plagioclase, rather than microcline, is the dominant feldspar. The microcline ranges from a trace to about 5 percent and typically is interstitial to the larger plagioclase grains. In addition to biotite, some of the darker layers contain blue-green hornblende. The cataclastic texture is much less obvious than that of the biotite-granite gneiss because the trondhjemitic gneiss is commonly fine grained. However, crushed streaks and micaceous folia are ubiquitous. Quartz typically exceeds 25 percent.

The uniform composition of the trondhjemitic gneiss and its locally layered or banded character suggests that the protolith was volcanic material: flows, sills, or volcanigenic sediments.

BIOTITE-QUARTZ-PLAGIOCLASE PARAGNEISS (p€hp)

This paragneiss occurs as thin lenses in the biotite-granite gneiss and is of very limited extent. It is a very thinly layered assemblage of extremely fine- to medium-grained feldspathic quartzites and quartz-plagioclase gneisses, with very minor layers of mafic or amphibolitic gneiss, 1-5 cm thick. Minor amounts of microcline are present; biotite and muscovite range from a trace to more than 15 percent. Many layers are mica-poor, very fine grained and "cherty appearing." In a few places, magnetite grains, 1-3 mm across, are abundant.

This lithology is distinguished from that of the biotite-granite gneiss and the trondhjemitic gneiss by its very fine grain, its millimeter-scale layering, and its heterogeneity.

HOUSATONIC HIGHLANDS UNDIFFERENTIATED ON RED MOUNTAIN (p€hu)

The gneiss of the Housatonic massif that overlies the inverted Dalton Formation on the southwestern half of Red Mountain appears to have a lithology different from any of the units described above. The rocks are generally gray, fine- to fine-medium-grained granitic gneisses with considerable range in the proportions of plagioclase and microcline. Plagioclase-rich granite occurs adjacent to microcline-rich granite. All are protomylonites and show considerable crushed material between the angular porphyroclasts of microcline and plagioclase. Biotite, the predominant mica, is peppered through the rock; continuous biotite folia are rare.

Possibly, the strongly cataclastic nature of these rocks so obscures their original textures that they are unrecognizable as equivalents of other mapped units. Alternatively, these rocks on Red Mountain may be a slice of Precambrian crust from a root zone much different from that of the rocks on Sharon and Mine mountains.

AMPHIBOLITES AND MAFIC GNEISSES (p€ha)

There are several areas where dark rocks composed primarily of hornblende and biotite prevail. These rocks range from normal amphibolites to biotite-hornblende gneisses with subordinate quartz, plagioclase, and microcline. Characteristically, microcline is less than 5 percent and quartz rarely exceeds 20 percent. Typical accessories are epidote and sphene.

The larger mapped bodies of amphibolite may be metavolcanic rocks or possibly intrusive rocks; the thin layers (1-5 cm) present in other rock types represent basic volcanic debris.

THE DALTON (CHESHIRE?) FORMATION

General statement

The Dalton-(Cheshire?) Formation unconformably overlies the Housatonic massif in an extensive W- and NW-dipping sheet on the northwestern side of Sharon and Mine mountains in the southeastern quarter of the quadrangle. This is part of a discontinuous and faulted carapace that mantles Barrack Mountain in the contiguous South Canaan quadrangle to the east (Gates, 1975). The Dalton Formation also occurs in a thin, discontinuous layer on Red Mountain, where the Housatonic massif overlies both the Dalton and Walloomsac formations. This occurrence is similar to that at the northwestern end of Cobble Hill in the South Canaan quadrangle, where the Housatonic massif also overlies the inverted Dalton Formation. In both cases, the Dalton Formation probably lies on the lower limb of anticlinal nappe structures.

The Dalton Formation (Precambrian(?)-Cambrian) is considered to grade laterally and vertically into the Cambrian Cheshire Quartzite. Characteristically, the Dalton Formation is an interlayered assemblage of muscovitic and feldspathic metaquartzites and quartzites, whereas the Cheshire Quartzite is a rather poorly bedded, pure, vitreous metaquartzite. Ratcliffe (1974a,b) has recognized three members of the Cheshire Quartzite locally, the lower two being feldspathic metaquartzites and the upper member a massive, white, vitreous metaquartzite. He also maps four micaceous and feldspathic metaquartzites and schists in the lower part of the Dalton Formation. It is by the decrease in the abundance of the micaceous, feldspathic metaquartzites and the increase in the pure vitreous metaquartzite beds that the two formations intergrade.

In the Sharon quadrangle the rocks mapped as the Dalton-Cheshire Formation were originally called Poughquag quartzite (Percival, 1842), unquestionably equivalent to the combined Dalton Formation and Cheshire Quartzite. The name Dalton is preferred here, even though the rocks have lithologic similarities to both typical Dalton rocks and to the Cheshire Quartzite. The anomaly is that the lower part of the formation is largely a vitreous quartzite to a slightly feldspathic metaquartzite and the upper exposed part is a more micaceous, feldspathic metaquartzite, the reverse of the normal sequence.

Lithology

The Dalton-Cheshire Formation in the Sharon quadrangle is an interlayered assemblage of metaquartzites with a wide range in texture and in the amount of muscovite, biotite, and feldspar. Typically, the accessories are tourmaline and magnetite, with trace amounts of zircon, monazite, and epidote. The most abundant rock type is a pure, vitreous metaquartzite with only a trace of muscovite and microcline. It is rather massive and poorly bedded; the bedding revealed by discontinuous muscovite folia and by thin layers of feldspathic metaquartzite 2-25 cm thick. A second major lithology is a very thinly laminated, very fine-grained, tan- to brownish-weathering, muscovitic, feldspathic metaquartzite, characterized by millimeter-scale laminations and black tourmaline metacrysts, 1-5 mm, in the muscovite folia. In addition, in the bottom 10-15 m from the contact with the Housatonic massif, there are conglomeratic layers, 2 cm-1.5 m thick, of feldspathic metaquartzite with flattened "pebbles" of polycrystalline quartz, granite and microcline.

The Dalton-Cheshire Formation closest to the contact with the Housatonic massif, although variable, tends to be predominantly vitreous metaquartzite with interlayers, 2-25 cm thick, of feldspathic metaquartzites and subordinate conglomerate layers. The conglomerate layers are particularly common in the Sharon Mountain area (the northern half of the carapace). The rocks grade upward into a rather pure vitreous to granular metaquartzite (lithologically resembling the type Cheshire Quartzite) that forms the tops of the knobs on Sharon Mountain and much of its western slope, Mt. Easter, and the crest of Mine Mountain. The predominantly vitreous metaquartzite section is 65-100 m thick here.

Within the vitreous metaquartzite is a lens, approximately 10 m thick and probably 600 m long, of a very feldspathic and micaceous, tan to dark-gray metaquartzite and schist (Cds). This NE-trending lens is 700 m north of the junction of Clay Beds and Sharon Mountain roads. Several much smaller lenses of a tan, flaggy, muscovitic, feldspathic metaquartzite occur elsewhere within the vitreous metaquartzite.

The contact between the Dalton-Cheshire Formation and the Housatonic massif is exposed at the base of the small ridge trending N 30° E from the top of Mine Mountain. The rock at the contact is a light- to dark-gray "cherty" metaquartzite that is a blastomylonite. The fluxion structure is shown by color streaking, micaceous seams, and by alternating millimeter-scale layers of crushed and recrystallized quartz.

The vitreous white metaquartzite passes rather abruptly upward into flaggy, tan-weathering, very fine-grained muscovitic, feldspathic metaquartzites (Cds) containing as much as 50 percent muscovite, biotite, and feldspar. The feldspar is predominantly microcline. The contact is marked by the valley trending N 20° E between the eastern and western knobs of Mine Mountain. The tan-weathering, flaggy, feldspathic metaquartzite contains subordinate beds of the white, vitreous metaquartzite, 10 cm-3 m thick. The upper part of the Dalton-Cheshire Formation dominated by the flaggy, tan-weathering metaquartzite is approximately 60 m thick.

In summary, the Dalton-Cheshire Formation here is heterogeneous as it is elsewhere, but the normal sequence of progressively purer quartzites upward is reversed; the more feldspathic and micaceous metaquartzites increase upward.

THE STOCKBRIDGE FORMATION

General statement

The Stockbridge Formation underlies most of the central valley extending from Salisbury near the northern border to Sharon at the southern border of the quadrangle. It also underlies the small valleys of Wildcat Hollow, Wetawanchu, White Hollow brooks, and Indian Lake Creek. It is flanked by Walloomsac and Everett schist on the ridges of Mt. Riga, Thorpe and Indian mountains on the west and Wetawanchu, Falls, Forge, and Red mountains on the east. The formation occurs in a series of NW-trending folds overturned to the west and plunging gently NW.

The Stockbridge Formation was divided by Zen (1966) into seven units designated A to G. Units A, B, and C are predominantly dolomitic carbonates and units E and G are calcitic carbonates. Units D and F are heterogeneous calcitic and dolomitic marbles and quartzites between other units and interdigitated with them. Units A, F, and G do not crop out in the Sharon quadrangle and units B, C, and E underlie the largest areas of it. Metamorphic grade increases from the northwest to the southeast where the carbonate rocks became recrystallized to marble and have a different appearance from those to the north, described by Zen. The Stockbridge units in the Sharon quadrangle, however, are directly traceable into the Bashbish Falls quadrangle.

Lithology

In response to increasing grade of metamorphism, the Stockbridge Formation was converted to marble and the argillaceous impurities in the carbonate rocks to micas and other silicate minerals, where the composition is appropriate. Tremolite and diopside are the diagnostic metamorphic minerals.

UNIT A (O€sa)

Although unit A does not crop out in the Sharon quadrangle, there are active quarries in it about 2 km east of the north-eastern corner of the quadrangle. The rock there is a gray- to white-weathering, medium- to coarse-grained dolomite marble with local "sunbursts" of tremolite crystals, 1-5 cm across. Small flakes of pale-brown phlogopite, 1-2 mm across, are ubiquitous, and accessory pyrite, pyrrhotite, quartz, epidote, and tourmaline are present. Ratcliffe (1969) reports vitreous quartzite beds, 1 cm-3 m thick, near the base, where the Stockbridge Formation grades into the underlying Cheshire Quartzite.

UNIT B (O€sb)

The clearest exposures of unit B are in two small anticlinal structures in Wildcat Hollow and in Sugar Hollow (Wetawanchu Brook). There are no outcrops of unit B in White Hollow and only limited ones west of the schist ridges of Wetawanchu, Falls, Forge, and Red mountains. The unit is primarily a gray- to tan-weathering, fine-grained dolomite marble with millimeter-thick partings of phlogopite mica, quartz, plagioclase, diopside, and secondary calcite. Locally there are layers, 0.5-1 m thick, of tan-weathering feldspar-quartz-diopside-dolomite marble, or dolostone. Where this impure dolomite marble alternates with the purer marble, a distinctively craggy weathered surface results. Layers of tan quartzite, 1-2 cm thick, are sparsely present. Elsewhere (Gates, 1975; Ratcliffe, 1974), unit B contains a very distinctive sub-unit of quartz, tremolite, and calcite. Quartz forms the matrix of the rock, with calcite and tremolite occurring as amoeboid-shaped pockets. The weathered surface is exceptionally craggy and irregular.

UNIT C (O€sc)

Characteristically, unit C is a massive to thickly or thinly bedded, white to mouse-gray, fine-grained calcitic to dolomitic marble. White to rusty quartz knots, streaks, and seams, 2-10 cm, are common. Locally, dolomite rhombs, 2-5 cm, stud the weathered surface. Bedding is shown by alternating layers of thinly laminated gray and white marble, with traces of phlogopite, and by alternating layers of thinly laminated gray marble and massive white marble. The rock weathers to gray, rounded surfaces. It is crumbly or friable where the calcite is leached out.

The best exposures of this unit are in the area east of Lakeville, both north and south of Farnum Road, along the western side of Lake Wononskoopomuc, and between Hotchkiss School and Wononpakook Lake. There are several small, long-abandoned quarries in this area.

UNIT D (O€sd)

Zen (1969) describes this unit as 0-250 ft (0-75m) thick and interdigitating with units C and D. It is a heterogeneous assemblage of dolomitic and calcitic marbles, transitional between units C and E, that includes quartzite, quartzitic marbles, and micaceous quartz marbles. Typically, the dolomite marbles are fine grained and the calcite marbles are coarse grained, as are units C and E, respectively. These lithologies are interlayered with gray, tan, or orange quartzites, quartzitic marbles, and micaceous quartz marbles. In addition to calcite and dolomite, quartz, plagioclase, muscovite, and pyrite are the principal minerals. The quartzites and micaceous quartz marbles occur as interlayers, 0.5-> 1 m thick, in the purer white to gray marbles. In general, the thickness of the quartzite layers increases away from the contacts with units C and E. The diagnostic rock in unit D is a tan- or orange-weathering quartzite. Locally, it is the only lithology between the marbles typical of units C and E.

Unit D is best exposed in the area between Camp Sloane and Wononpakook Lake and about 600 m east of Camp Easton.

UNIT E (O€se)

This unit is most readily recognized by its coarse grain size and its calcitic composition, in contrast to the predominantly dolomitic rocks of units A, B, and C. Its characteristic lithology is a mottled white and gray or salmon-colored coarse-grained calcite marble. There are a few rusty-weathering micaceous quartzitic layers or lenses and, locally, beds of fine-grained dolomite marble, 3-6 m thick, that are similar in lithology to unit C. The dolomitic marble beds are easily seen in the area extending southward for 2 km from Camp Sloane. They are more abundant at the gradational contact of unit E with units D or C.

THE WALLOOMSAC FORMATION

General statement

The Middle Ordovician Walloomsac Formation unconformably overlies the folded and beveled beds of the autochthonous Stockbridge Formation (Zen, 1966; Zen and Hartshorn, 1966; Ratcliffe, 1969). Zen (1967) interprets the formation as a westward-spreading "mantling black shale," resulting from a bathymetric reversal attending the Taconic tectonic event. As presently defined by Zen (1966) and Zen and Hartshorn (1966), the Walloomsac Formation encompasses the upper calcareous marble and schist assigned to the Stockbridge by Dale (1923) and the Berkshire Schist of Emerson (1917) and Dale (1923) and the Salisbury Schist of Agar (1932).

The Walloomsac Formation is generally divided into a lower impure calcitic marble unit and an upper black quartzitic to aluminous shale, slate, or schist. The lower unit (Owm) is composed of 1) calcite marble, 2) carbonaceous calcareous schist, and 3) interlayered calcite marble and quartzose schist. The upper unit is composed of a black carbonaceous, quartzitic schist (Ows) and a silvery to gray, muscovite-biotite-quartz schist with megacrysts of garnet and staurolite (Owsg). These rock types are interlayered and also intergrade.

The relationship of the Walloomsac and the Everett formations is equivocal, as they appear to be interlayered and to intergrade, at least locally (Zen and Hartshorn, 1966; Agar, 1932).

Lithology

LOWER UNIT (Owm)

The lower unit of the Walloomsac Formation ranges widely in thickness locally but, most significantly, it thickens eastward (Ratcliffe, 1969). The lower unit is absent on the western side of Indian Mountain and thickens to perhaps more than 250 m, 14 km to the east, where it underlies the Canaan Mountain Formation in the eastern part of the South

Canaan quadrangle. The isoclinal folding on the western flank of Canaan Mountain makes the determination of thickness speculative. Rock types characterizing the lower Walloomsac Formation are: 1) calcite marble weathering to gray or orange brown, 2) rusty to dark-gray or black schistose or quartzitic marble, and 3) gray, fine-grained diopside-calcite-quartz granulite. These rock types are thin bedded to thick bedded and interlayered. The quartz-and silicate-rich rocks generally increase in abundance upward and thicken from west to east. The quartzose and silicate-rich rocks are abundant near Canaan Mountain but are sparse to absent in the northeastern corner of the quadrangle and around Red Mountain in the Sharon quadrangle. Locally, the calcite marble that weathers gray to orange brown forms steep slopes and cliffs up to 60 m high at Gallows Hill and near Forge Mountain. The predominantly calcite marble here contains subordinate amounts of quartz, tremolite, phlogopite, and microcline. The silicate-rich beds in the calcite marble are composed predominantly of these minerals.

UPPER UNIT (Ows and Owsg)

The upper unit of the Walloomsac Formation is composed of two lithologies that appear to intergrade, occur as lenses, and to be interlayered. The major rock types are: 1) a medium-gray to nearly jet-black, fine- to medium-grained schist, composed of variable amounts of biotite, muscovite, quartz, plagioclase, and carbonaceous material (Ows) and 2) a light-gray to silvery, quartz-streaked, muscovitic schist with megacrysts of staurolite and garnet (Owsg). The megacrysts of garnet and staurolite, ranging from 1 mm to 10 mm, and the development of a silvery sheen on the foliation surfaces distinguishes *Owsg* from *Ows*.

The mapped distribution of the black quartzitic schist (Ows) and the garnet-staurolite schist (Owsg) does not produce a decipherable stratigraphic pattern. However, there appear to be several layers and lenses of *Owsg* in the black quartzitic schist of *Ows*. Folding events may have so convoluted the primary structures as to make the present configuration undecipherable. Locally, the staurolite-garnet gneiss directly overlies the Walloomsac marble (Owm) or the Stockbridge Formation and elsewhere is separated from the Stockbridge by 1-3 m of the black to medium-gray quartzitic schist. On the western side of Indian Mountain, a dark-gray to black phyllitic schist directly overlies the Stockbridge Formation for 2,000 m along strike. There are thin chloritoid-garnet schist layers only 20 m above the contact with the Stockbridge.

It is most probable that there is an interlayering of these two rock types (Ows and Owsg), and gradational types as well. It is also possible that there is a structural duplication or imbrication on a scale of 3-15 m. The interlayering and gradational lithologies can be seen on the western sides of Forge and Falls mountains and in the steep slopes northeast of Wildcat Hollow Road.

The dark-gray to black schist (Ows) is composed principally of muscovite, biotite, plagioclase, and quartz, with carbonaceous material providing the dark color. Although the proportions of the essential minerals range widely, biotite typically predominates over muscovite, and quartz is more abundant than plagioclase. Garnet is commonly present in minor amounts; staurolite is sparse. However, there appears to be a gradation between the black, quartzitic schist and the staurolite-garnet schist, with staurolite, garnet and muscovite increasing at the expense of biotite and quartz. Tourmaline and zircon are typical accessories.

The light-gray, silvery, muscovite-plagioclase-quartz schist (Owsg), with megacrysts of garnet and staurolite, is characterized by abundant fine seams, lenses, and layers of quartz, alternating with the staurolite-garnet-muscovite-rich layers. The garnet and staurolite megacrysts range from 1 mm to 5 mm on the average, and are readily seen on weathered surfaces. Excellent exposures of this rock type are on the northern slope of the knob north of Lime Rock, on the steep slopes 0.5 km south of Gallows Hill, and along the power line between the road east of Salmon Creek and the top of Falls Mountain. This lithology is very similar to the staurolite-garnet-bearing rocks of the Everett Formation and poses a major problem regarding the relation of the Everett and Walloomsac formations.

Kyanite is present locally in the Walloomsac Formation on Wetawanchu, Falls, and Red mountains and on the top of Mt. Prospect. Garnet and staurolite accompany the kyanite. Ratcliffe (1969) reports kyanite and staurolite in the Walloomsac Formation in western Great Barrington and Ashley Falls quadrangles, Massachusetts, although Zen (1969, p. 3-7) did not find kyanite north of this area in the Bashbish Falls quadrangle. Very minor amounts of fibrolitic sillimanite were found in rocks collected from Falls and Forge mountains and from the northern half of Red Mountain.

Within the Walloomsac Formation are large blocks of carbonate rocks 3-35 m across. Only some are recognizable lithologies of the Stockbridge Formation. Several were seen in the upper part of the Walloomsac Formation near its contact with the Everett Formation, particularly along the eastern side of Indian Mountain and southeast of Bird Peak. However, several other exotic blocks of carbonate are widely scattered in the Walloomsac Formation in the area north of Wononskopomuc Lake. These would be near the Everett Formation contact only if the present erosion surface is near the contact. Similar blocks have been reported by Zen (1927a,b) and Potter (1972) and are considered part of the wildflysch immediately underlying thrust slices.

THE EVERETT FORMATION

General statement

The Everett Formation is principally a greenish to greenish-gray phyllitic schist that structurally overlies the Walloomsac Formation. Currently it is considered by workers in the area immediately to the north (Zen and Ratcliffe, 1966, 1971; Zen and Hartshorn, 1966; Zen, 1969; Ratcliffe, 1969, 1974a,b,c; Ratcliffe, Bird and Bahrami, 1975) to be allochthonous—the result of soft-rock sliding or hard-rock thrusting in the Middle to Late Ordovician. The nature of the contact between the Everett and the underlying Walloomsac is equivocal in this area and a normal sedimentary transition must be considered. Gradational contacts, lack of a zone of shearing or tectonic breccias, and particularly the similarity of the staurolite-garnet schist (Owsg) of the Walloomsac and the staurolite-garnet or chloritoid-garnet phyllitic schists of the Everett Formation are not readily explained by an allochthonous theory.

The Everett Formation occurs largely along the high ridges from Thorpe Mountain and Mt. Riga in the northwestern corner of the quadrangle to Indian Mountain along the western border, and on a low knob in the extreme southwestern corner of the quadrangle. The contact between the Walloomsac and Everett formations is well exposed in the steep slopes on the western side of Indian Mountain and on Thorpe Mountain.

Lithology

The predominant rock type in the Everett Formation in the Sharon quadrangle is a green-gray phyllitic schist, composed, in order of decreasing abundance, of muscovite, chlorite, quartz, and albite-oligoclase. Commonly this phyllitic schist contains megacrysts of almandine-rich garnet, albite-oligoclase, chloritoid, and staurolite, which collectively range in amount from a few porphyroblasts per hand sample to 20-40 percent of the rock. Garnet and plagioclase are the most common megacrysts, with chloritoid and staurolite less common. The megacrysts range from less than 1 mm to as much as 1 cm, but most are 1-3 mm. Where the megacrysts of garnet and staurolite are abundant, the rock strongly resembles the staurolite-garnet-muscovite-schist (Owsg) lithology of the Walloomsac Formation. Zen (1969) found that the garnet and staurolite in the Walloomsac Formation and in the Everett Formation at Lion's Head in the Bashbish Falls quadrangle are chemically indistinguishable. Outcrops of these similar rock types can be seen at Lion's Head or on the Mt. Riga Road in the Sharon quadrangle 200 m south of the northern border and on the 1200-ft knob north of the Appalachian Trail, 150 m east of Bunker Hill Road. The major difference, in general, between these two garnet-staurolite schists is that the megacrysts in the Walloomsac are larger, as might be expected from the increase of metamorphic grade to the southeast. The presence of plagioclase megacrysts in the Everett Formation is readily revealed in outcrop by a pitted, weathered surface, as the plagioclase weathers more easily than the muscovite-chlorite matrix. Accessory constituents include magnetite, ilmenite, tourmaline, and zircon. Ubiquitous carbonaceous material occurs in small flakes and in dusty trains marking primary bedding.

Variations of the predominant lithology of the Everett Formation reflect compositional changes mainly in the amount of quartz and biotite. Some phyllitic schists are light gray to dark gray and are interlayered with the greenish phyllitic schist on a scale of a few millimeters to a meter or more. It appears that many of the darker gray rock types are more abundant in the area between typical Everett and Walloomsac lithologies. In many places the contact seems gradational over a few meters.

Relatively rare quartzite, mica quartzite, and feldspathic mica quartzite are present in thin beds in the phyllitic schist. The relative thinness of these beds and their lack of continuity have thwarted attempts to establish an internal structure. In general, the Everett Formation in this area is rather homogeneous, with shale as the major protolith.

The lithological differences between the Everett and Walloomsac formations are of paramount concern when mapping in the contact area and interpreting the origin of the Everett Formation. The bulbous area extending for 5,000 m south of Mt. Riga includes many rock types that appear to be transitional to the dark-gray to black quartzitic schist of the Walloomsac Formation (Ows). These dark-gray phyllitic schists, mapped as Everett, have characteristics of both the Everett and the Walloomsac. Although there appear to be lithologic types with characteristics transitional between the formations, there are differences between the "typical" lithologies. This is contrary to the views of Zen and Ratcliffe (1966), who maintain that the difference is largely one of color: greenish gray for the Everett Formation and dark gray to black for the Walloomsac Formation. The main feature that distinguishes the typical Everett lithology from the typical Walloomsac is the abundance of muscovite (sericite) and chlorite in the Everett, in contrast to the predominant biotite in the Walloomsac. Rocks of the Everett Formation characteristically have lustrous, rust-stained, crenulated, micaceous folia, whereas the folia of the Walloomsac Formation are duller and gray black. Another field characteristic differentiating the two formations is that the Walloomsac is hard, brittle, and flaggy, and the Everett Formation is more homogeneous, and softer under the hammer. This characteristic probably reflects the differing ratios of quartz to mica in the two rock types.

STRUCTURE

General statement

The structure of the rocks in the Sharon quadrangle is dominated by the essentially coaxial fold systems of the Taconic and Acadian tectonic events involving the Stockbridge, Walloomsac, and Everett formations and the thust (probably in the late Taconic) of the Housatonic massif westward over the autochthonous sediments in high-angle reverse faults and nappes. The Taconic folds trend NNW, with axial planes dipping E, whereas the much weaker later folding developed W-dipping axial planes. The Housatonic massif has a high-angle-fault contact along much of its western boundary. A low-angle thrust fault occurs below the sliver-like nappe on the southern end of Red Mountain.

The Stockbridge Formation

The major structure of the Stockbridge Formation is a series of N-plunging anticlines and synclines trending NNW and overturned to the west. The geometry of the folds is revealed by stratigraphic Units B to E, with Unit C underlying the broad central valley of the quadrangle.

Equal-area projections of bedding planes define a fold axis N 32° W at 5° in the northern half of the quadrangle, changing to S 22° E at 10° in the south (figs. 2a,b). The bedding-plane maximum changes from strike N 45° W, dip 23° E in the north to N-S, 24° E in the south.

The truncation of the Stockbridge Formation by the Walloomsac Formation clearly indicates a period of diastrophism after the Stockbridge was deposited and before the deposition of the Walloomsac Formation, but whether the Stockbridge Formation was severely folded before deposition of the Walloomsac Formation is not clear. The contacts between the Walloomsac and the Stockbridge formations (see cross section AA′) might suggest that the Stockbridge Formation was folded prior to deposition of the Walloomsac or that the Walloomsac Formation is parautochthonous. The different rock types of the Walloomsac Formation at the Stockbridge Formation contact support the latter view, but evidence for a tectonic contact is missing. Several limonite-ore bodies, such as that at Ore Hill, occur along the Stockbridge-Walloomsac contact, indicating a pre-Walloomsac erosional and weathering interval.

The Walloomsac and Everett formations

The structure of the Walloomsac Formation is most easily considered in three sections; 1) the northeastern series of ridges from Wetawanchu to Falls and Forge mountains, 2) the northern part of Red Mountain from Lime Rock to the nappe of the Housatonic massif, and 3) the western ranges from Mt. Riga and Thorpe Mountain to Indian Mountain.

WETAWANCHU TO FORGE MOUNTAIN

The distribution of the three recognizable rock types of the Walloomsac Formation (Owm, Ows, and Owsg) does not provide enough stratigraphic information to reveal the internal geometry of the folds but may suggest a tectonic contact, in part, with the underlying Stockbridge Formation. Structural data on foliation planes, mica crenulations, and minor-fold axes provide a very consistent structural pattern that is similar to the structure of the Stockbridge Formation. Equal-area plots of mica crenulations and minor-fold axes show a strong concentration, indicating a fold axis N 32° W at ± 5° (fig. 2c). A plot of the foliation planes confirms the fold axis and shows a strong maximum with strike N 20° W, dip 25° E (fig. 2d). A plot of the axial planes of mesoscopic open folds also shows a fold axis N 32° W-S 32° E.

LIME ROCK TO SOUTHERN END OF RED MOUNTAIN

Equal-area plots of foliation, axial planes of open folds, mica crenulations, and axes of minor folds show an essentially random distribution that may reflect the relatively limited amount of data. The only conclusion drawn is that this ridge is structurally separate from the series of ridges from Wetawanchu to Forge Mountain and probably is segmented by a series of NW-trending faults. The ridges may be related to or affected by the nappe of the Housatonic massif.

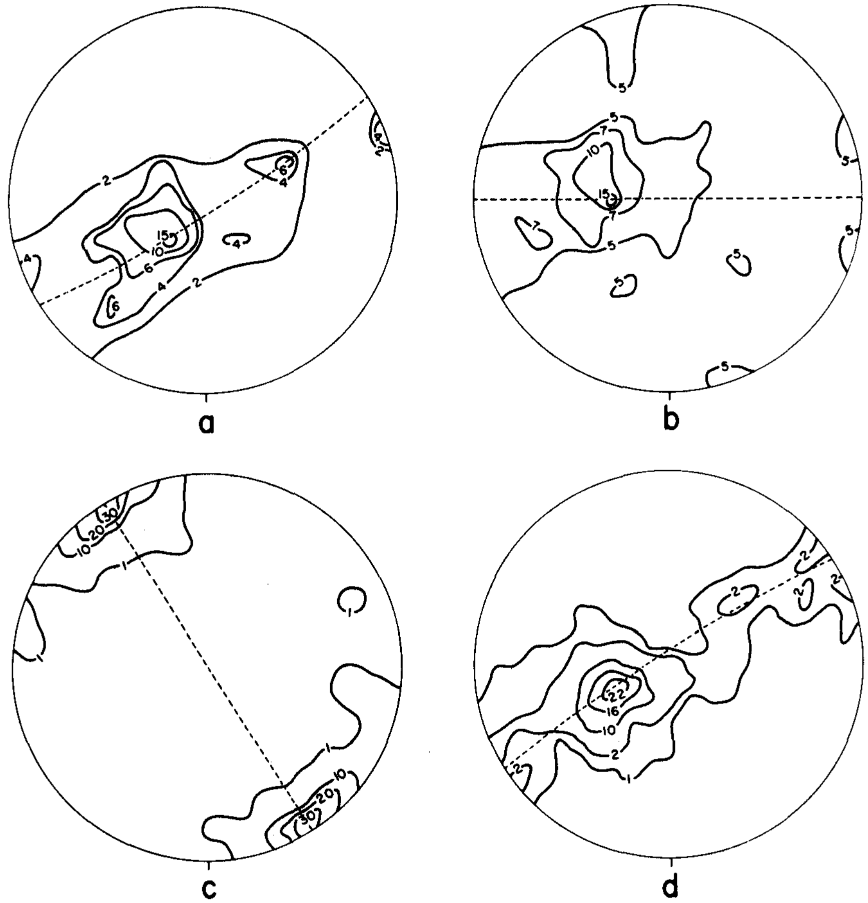

Fig. 2. Equal-area stereonet plots

a. Poles to bedding planes of the Stockbridge Formation in the valley north of Hotchkiss School. Contour lines are 2, 4, 6, 10, and 15 percent; 55 points.

b. Poles to bedding planes of the Stockbridge Formation in the valley south of Hotchkiss School. Contour lines are 5, 7, 10, and 15 percent; 50 points.

c. Axes of mica crenulations and minor fold axes in the Walloomsac Formation in the area from Wetawanchu to Forge Mountain. Contour lines are 1, 10, 10, and 30 percent; 135 lineations.

d. Poles to foliation planes in the Walloomsac Formation in the area from Wetawanchu to Forge Mountain. Contour lines are 1, 2, 10, 16, and 22 percent; 155 points.

THE WESTERN RANGES FROM MT. RIGA AND THORPE MOUNTAIN TO INDIAN MOUNTAIN

The structural features of the Walloomsac and Everett formations in this area are identical and are combined here. The contact between these formations does not appear to be a tectonic one or, if it was, Acadian metamorphism has obliterated the evidence. The predominant foliation-plane attitude is N 18° W, 50° E, well shown on an equal-area plot of their poles. The girdle of this plot of foliation poles shows a subhorizontal fold axis trending NNW (fig. 3a). An equal-area plot of the linear elements shows a fold axis N 20° W-S 20° E in the Mt. Riga-Thorpe Mountain area and S 20° E at 10°-25° in the Indian Mountain area.

The Housatonic Highlands massif and Dalton-Cheshire Formation

The Housatonic Highlands massif is a Precambrian mass approximately 33 km long and 8 km wide, trending NNE and lying between the Berkshire and Hudson Highlands massifs (Balk, 1926). The massif has a discontinuous carapace of the Dalton Formation (Poughquag Formation of Balk), on its western side and on both ends. Balk (1936) indicated that the Housatonic massif is bounded on the west by moderate- to high-angle thrust faults carrying the Dalton Formation up with it into the overlying Cambro-Ordovician carbonates and shales.

In the Sharon quadrangle a moderate- to high-angle thrust fault forms the major western boundary on the Housatonic massif; in addition, there is a low-angle thrust slice that lies on inverted Dalton Formation. The evidence for a high-angle *vs* a low-angle thrust fault along the western boundary of the Housatonic massif is equivocal, but the relatively undisturbed aspect of the Dalton-Cheshire Formation favors a high-angle thrust. The subhorizontal attitude of the contact between the Housatonic massif and other rock units favors a low-angle thrust. The southern half of Red Mountain and the rocks along the southern border form an arcuate slice of the Housatonic massif that now overlies the inverted, gently westward-dipping Dalton or Walloomsac formations. The Dalton Formation was apparently carried westward in a nappe structure similar to that described by Ratcliffe (1974) for Bear Mountain between Great Barrington and Stockbridge in Massachusetts. The extent of the overthrusting is not known; however, the lithology of the inverted Dalton Formation on Red Mountain is similar to that on Barrack Mountain in the South Canaan quadrangle to the east (Gates, 1975) and rather dissimilar to that on the adjacent Mine and Sharon mountains and Mount Easter. The Dalton Formation underlying the Housatonic massif on Red Mountain is a thinly interlayered assemblage of quartzite and muscovite-feldspathic quartzite, whereas the Dalton-Cheshire Formation on Sharon and Mine mountains is predominantly a vitreous quartzite.

The stratigraphy of the Housatonic massif is too limited to provide information on the internal structure. However, equal-area plots of the

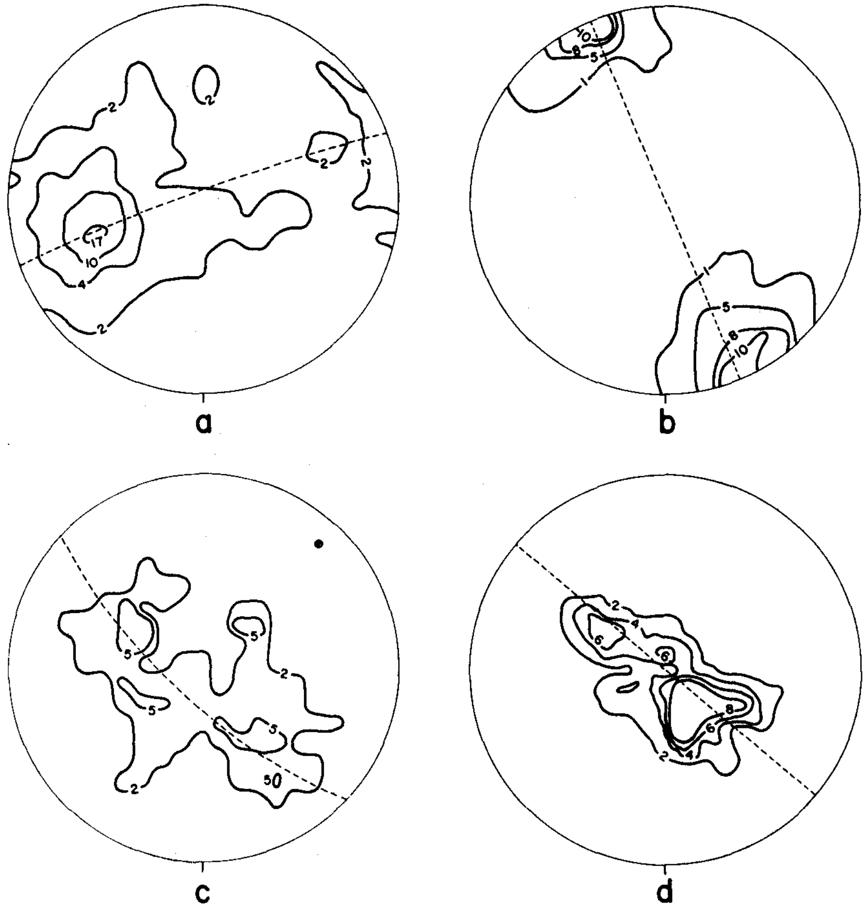

Fig. 3. Equal-area stereonet plots

a. Poles to foliation planes in the Walloomsac and Everett formations in the area from Mt. Riga and Thorpe Mountain to Indian Mountain. Contour lines are 2, 4, 10, and 17 percent; 411 points.

b. Axes of mica crenulations and minor folds in the Walloomsac and Everett formations in the area of Mt. Riga and Thorpe Mountain. Contour lines are 1, 5, 8, and 10 percent; 158 lineations.

c. Poles to foliation planes in the Housatonic massif. Contour lines are 2 and 5 percent, 215 points.

d. Poles to bedding planes in the Dalton Formation. Contour lines are 2, 4, 6, and 8 percent; 84 points.

poles to foliation planes indicate a fold axis trending N 43° E at 14° (fig. 3c). A similar plot of foliation in the area between Tarradiddle and Titus Mountain in the South Canaan quadrangle indicates a horizontal fold axis trending N 55° E, possibly reflecting a weak NNW-trending crossfold.

Except in a zone near the contact with the Housatonic massif, the Dalton-Cheshire Formation does not appear to be severely folded. Many of the beds remote from the edge of the massif are subhorizontal and elsewhere they dip less than 45°. An equal-area plot of 84 poles to bedding planes shows a horizontal fold axis trending N 40° E (fig. 3d) almost identical to the fold axis shown for the foliations of the underlying Housatonic massif. The fold axis for the Dalton Formation on Barrack Mountain in the South Canaan quadrangle is N 60° E at 25°, also tending to confirm the weak NNW cross folding. The interpretation is that the NE-trending fold axis is related to an early fold system and that the weak NNW-trending fold axis is a weak response to the dominant Taconic folding.

Near its contact with the Housatonic massif, the Dalton-Cheshire Formation has a zone, 3-10 m thick, of blastomylonitic quartzites with pronounced fluxion structure, succeeded by zones, less than 0.5 mm thick, of crushed quartz and shreddy muscovite seams alternating with thicker zones of polygonal metaquartzites. The underlying Housatonic massif similiarly is a mylonitic gneiss within 10 m of the contact, where the foliation becomes parallel to the bedding of the Dalton-Cheshire Formation. These relations and structural features are best seen on Mine Mountain.

METAMORPHISM

Based on the occurrence of chloritoid, staurolite, and kyanite, the Sharon quadrangle can be divided into three areas. The metamorphic grade increases from west to east, with the isograds trending NNE at a moderate angle to the structural trend. The chloritoid isograd extends roughly from just east of Mt. Riga to the southern end of Indian Lake. The isograd is not sharp; chloritoid and staurolite co-exist in a narrow belt. The central belt, which includes both the northeastern and southeastern corners of the quadrangle, is at staurolite-grade metamorphism. The typical assemblage in the Everett and Walloomsac formation is: garnet-staurolite-muscovite-quartz-oligoclase ± chlorite-biotite-magnetite. The eastern boundary of the staurolite zone is marked by the appearance of kyanite in the Walloomsac Formation in the arcuate range of hills extending from Falls Mountain to the Housatonic massif thrust fault at the southern end of Red Mountain. Two samples containing a trace of fibrolitic sillimanite also were found.

Some textural features of the metamorphic minerals indicate at least two periods of metamorphism: 1) The muscovite and biotite lie in the plane of the major foliation, 2) some of the micas are aligned parallel to a later slip cleavage that is axial planar to crenulations of the earlier foliation plane, and 3) muscovite occurs in a decussate pattern commonly transverse to the older foliation planes. Biotite, particularly in the Walloomsac Formation, occurs commonly as metacrysts, 1-5 m across, transverse to the major foliation.

Porphyroblasts of garnet, staurolite, and plagioclase preserve relict trains of carbonaceous material, probably reflecting original bedding and the lepidoblastic texture of the earlier foliations. It is not uncommon to find convoluted and tightly folded trains of carbonaceous material and micas enclosed in the garnet and staurolite porphyroblasts.

The conclusion is that the last metamorphic event postdated the last deformation. Further, it is apparent that muscovite and biotite were developed paralled to axial planes of the early isoclinal folds and that subsequently this axial-plane foliation was crenulated and a later non-penetrative incipient axial-plane foliation developed. These conclusions are in agreement with the tectonic and metamorphic sequence presented by Ratcliffe and Harwood (1975) and by Norton (1975). Rb/Sr and K/Ar ratios obtained from biotite and muscovite, respectively, from the Walloomsac Formation indicate Acadian metamorphism (Zen and Hartshorn, 1966). Zartman and others (1970) obtained a K/Ar age of 390 ± 19 m.y. on muscovite from the Walloomsac Formation in the Sharon quadrangle.

ECONOMIC RESOURCES

Limestone, iron ore, gravel, and clay have been obtained commercially in the past, but now there are no active operations. Due to the residential nature of the area, it is unlikely that any commercial extraction of mineral resources is possible in the future. Historically, iron ore was mined from saprolitic deposits in the Stockbridge Formation below the Walloomsac unconformity. The major limestone quarries in the Stockbridge Formation prior to 1918 were identified by Dale (1923) and no new ones have been developed in the sixty years since. Clay was obtained from maturely weathered Dalton Formation in the area south of Clay Beds Road in the southeastern corner of the quadrangle.

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