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Stratigraphy, Structure, and Metamorphism of the Taconic Allochthon and Surrounding Autochthon in Bashbish Falls and Egremont Quardangles and Adjacent Areas

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Stratigraphy, structure, and metamorphism of the Taconic allochthon and surrounding autochthon in Bashbish Falls and Egremont quadrangles and adjacent areas[1]

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INTRODUCTION

The Taconic Range is underlain by pelitic schists varying in metamorphic grade from chlorite zone to staurolite-almandine zone. The stratigraphic position and structural history of these rocks have been part of the classical Taconic controversy. We now know that there are really two problems: 1) that of the "low Taconics," comprising the north end of the Taconic Range and all of the slate belt of Vermont and New York; and 2) that of the "high Taconics," comprising most of the Taconic Range from Dorset Mountain, Vermont, to at least Indian Mountain, Connecticut. In the low Taconics, the age of the rocks is known but the geometry is uncertain. Fossils indicate that the rocks are correlative with those of the surrounding Middlebury synclinorium and its southward continuation. In contrast, in the high Taconic region, the problem is one of known geometry but uncertain age. There has been general agreement, since the days of Dana (1884), that the schists are in synclinoria and rest above early Paleozoic carbonate units, but because these schists have never yielded fossils, assignments of their stratigraphic ages have always depended on long-range correlations, the credibility of which has depended on the bias of individual geologists.

Detailed bedrock geologic mapping in the southern part of the Taconic Range has been carried out since 1961 by the writer and by N. M. Ratcliffe. We have gathered data now to show that:

1. There is a mappable stratigraphy within the Stockbridge Formation in the country surrounding the Taconic Range. This stratigraphy is consistent with that of western Vermont (Doll et al., 1961) on one hand, and with those of the Pine Plains area (Knopf, 1962) and of the New York City area recently deciphered by Hall (1968) on the other. Fossils found within the highest subunit of the old Stockbridge Limestone, now reassigned to the overlying Walloomsac Formation, are of Middle Ordovician age; therefore the bulk of the Stockbridge Formation is now assigned with confidence to the Cambrian and Early Ordovician, in agreement with the age of comparable units in Vermont and New York, previously correlated on lithic basis alone.

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2. An angular unconformity exists between the Stockbridge Formation and the overlying fossiliferous Middle Ordovician (probably Trenton) Walloomsac Formation.

3. The carbonate units have been deformed at least twice with noncoincident axes of folding.

4. The controversial pelitic schists of the Taconic Range (Everett Formation) occur as one or more sheets overlying the Stockbridge and Walloomsac Formations. At many places, the contact is marked by slivers of carbonates (in beds or blocks) of the Stockbridge Formation; by breccia of carbonate, Walloomsac, and Everett lithology, and by intimate interlamination of the black-grey schists of the Walloomsac and the green schist of the Everett. From this we conclude that the Everett Formation does indeed constitute an allochthonous mass, part of the complex of the Taconic allochthon. This local evidence is independent of regional correlations.

5. Available evidence suggests strongly that the rocks of the Taconic Range, especially the Everett Formation, have undergone two episodes of regional metamorphism, of which the later one presumably set the K/Ar and Rb/Sr isotopic clocks to an "Acadian" age (360 million years, more or less).

These new data and reinterpretations help to solve some of the problems of the high Taconic region but bring forth new problems which will be outlined later. Trips 3A and 3B show the outlines of the stratigraphy, within both the autochthon and the allochthon, demonstrate the main features of structure, particularly the interrelations of the autochthon and allochthon, and finally show some of the problems in metamorphism and related chronologic questions. Trip 3A will be concerned mainly with the stratigraphy and structure of the autochthon, whereas trip 3B will be concerned largely with the structure and metamorphism of the allochthon.

WARNINGS AND ACKNOWLEDGMENTS

To preserve the outcrops for future workers and visitors, hammers may not be used except where announced. Most of the features of interest can be seen, and seen better, on the naturally exposed and weathered surfaces. Several important bits of evidence have already been damaged by earlier visitors who hammered on the rocks before I had an opportunity to tell them of the significance of the features being bashed. I thank all participants of the trips, as well as future users of this guidebook, in advance for their cooperation. I also thank the landowners for permission to visit the outcrops. The Egremont quadrangle was mapped jointly with Nicholas M. Ratcliffe, and I am indebted to him for allowing me to present the geological map of the entire quadrangle before its publication. Ratcliffe, John S. Dickey, Jr., and Nicholas Lampiris worked with me at various times in the field, and I thank them for their able assistance. D. S. Harwood, N. M. Ratcliffe, J. C. Reed, and R.S.Stanley commented on the manuscript and on the outcrops; they suggested many improvements. Responsibility for the data and interpretations, however, are mine alone. I thank my lucky stars for escape from serious injury despite extensive field use of defective automobiles.

STRATIGRAPHY

The lithostratigraphic succession and lithic characteristics and thicknesses of units in the field-trip area are given in table 1 (p. 12). A generalized geologic map of the Egremont and Bashbish Falls quadrangles and parts of adjacent quadrangles is given in figure 2 (see fig. 1 for location).

Fossils have been found in a thin-bedded blue-grey limestone near Pittsfield, Mass., at a stratigraphic position corresponding to the basal unit of the Walloomsac Formation (see Zen and Hartshorn, 1966, text). These fossils include cup corals that are no older than Black River and more probably Trenton in age. Fragmentary brachiopods and hash of pelmatozoan stems in a basal thin-bedded, phyllitic black limestone of the Walloomsac Formation (stop A-7) are of similar age. Thus, the rock units here assigned to the Dalton, Cheshire, and Stockbridge formations are most likely Paleozoic but pre-Trenton. The lithostratigraphic equations given in table 1 thus seem probable, though these equations do not demand the suggested correlations in detail.

Subunits d and f of the Stockbridge Formation have proved particularly troublesome to map. Unit d separates a massive, grey dolostone from a massive pure-white to grey-mottled calcite marble. Unit d is locally only a few feet (1 meter or more) thick but elsewhere, particularly in the north-central part of the Egremont quadrangle (fig. 2), a large assemblage of heterogeneous units is mapped as part of unit d because of the stratigraphic position of the units. As mapped, unit d must be lenticular and interdigitate laterally with units c and/or e; interdigitation on scale of a few tens of feet is locally visible. Similar variability and uncertainty exists for the contact of units f and g, which closely correspond lithically to units d and e. We will see this variation at stops A2 and A3.

The base of the Walloomsac Formation, which unconformably overlies the Stockbridge Formation, is at places a black phyllite (stop B6), at places a thin-bedded silty-micaceous black-blue limestone (stop A7), and at places a massive ferruginous silty limestone, typically weathering brown, and as much as 200 feet (70 meters) thick. This last lithic type is best exposed on the east shore of Lake Washining. Along this basal zone, both in the trip area and beyond, iron ores were mined in the 19th century. This iron-rich material may represent weathering residua accumulated on the unconformity surface and redeposited with the younger sequence. Where both residua and carbonate deposits are absent, typical black phyllite of the Walloomsac directly overlies the Stockbridge Formation.

A large area of black phyllite occurs in the northwestern part of the Bashbish Falls quadrangle and adjacent part of the Egremont quadrangle (stop B2). This area is completely enclosed within the Everett Formation (fig. 2). On the published geologic map of the Bashbish Falls quadrangle (Zen and Hartshorn, 1966), this unit was mapped as the Egremont Phyllite. The rocks are very similar to those of the Walloomsac Formation and occupy a corresponding geometric position. In fact, east of Mount Fray (Egremont quadrangle), the Walloomsac and the Egremont are separated only by a high ridge and occur at about the same elevation on the two flanks. On figure 2, therefore, the area is shown as underlain by the Walloomsac Formation, even though carbonate slivers, so typical of the Walloomsac-Everett contact over much of the trip area, are absent here. The structural implication of the Egremont-Walloomsac equation is discussed in the section on structures.

Within the allochthon, massive quartz (rarely feldspar) pebble conglomerate, having a green silty phyllite matrix, and interlaminated with quartzite and phyllite on 1/8 inch (3 mm) scale, occurs locally in the Everett Formation in the western part of the trip area (fig. 4). At Cedar Mountain near Bashbish Falls, it is at least several hundred feet (100 meters or more) thick. This unit is here lithically equated with the Lower Cambrian(?) Rensselaer Greywacke of the low Taconic sequence (Zen, 1967). The conglomerate sequence is much thinner than the Rensselaer of the Rensselaer Plateau area, but this is in accord with the previous suggestion (see Zen, 1967, p. 49) that the high Taconic sequence is the eastern facies equivalent of the Rensselaer. The Rensselaer is a turbidite deposit (Bird, 1963) which had a generally westerly source, so the restriction of the massive conglomerate to the western periphery of the high Taconic sequence makes sense. If the correlation of the conglomerate in the Everett with the Rensselaer and, by implication, the Pinnacle Greywacke of the Camels Hump Group of Vermont (see Zen, 1967; Doll et al., 1961) is correct, then the bulk of the Everett would be correlated with the Underhill Formation of northern Vermont (Doll et al., 1961) and with the Hoosac and possibly part of the Pinney Hollow Formation of southeastern Vermont (Doll et al., 1961). This is in agreement with the previously suggested correlation (Zen, 1967) made before these conglomerate bodies were recognized in the trip area.

Rocks of the autochthonous Dalton, Chesire, and Stockbridge Formations were laid down in a shelf environment where the water was shallow and where many reefs were probably being built. To the east, the shelf terminated abruptly against the deep basin, part of the eugeosyncline (see Rodgers, 1968; Zen, 1967, fig. 14). In Early and Middle Ordovician time, downfaulting of blocks of the shelf, related to upfaulting in the eugeosyncline, led to an overall deepening of water on parts of the shelf and to local derivation of clastic sediments from the eugeosynclinal area, accounting for the unconformity at the base of the Walloomsac Formation and for the change in sedimentary regime at Walloomsac time (Zen, 1967). Locally, however, the shelf was raised above sea level and became eroded and weathered, as indicated by the iron-rich basal Walloomsac Formation.

Within the deep basin itself, deposition of the Everett Formation started earlier than the beginning of Dalton sedimentation and had a western cratonal source before the evolution of the shelf cut off sediment supply from that direction. If the regional stratigraphic correlations suggested by the writer in 1967 (plate 2; fig. 5) are correct, this cutoff was approximately synchronous with the deposition of the uppermost exposed Everett Formation, though lack of stratigraphic markers in the Everett makes any more detailed assignment meaningless. Nonetheless, sedimentation within the deep trough presumably continued without a major break, though the direction of sediment transport may have shifted with the rearranged hydrologic pattern after the establishment of the shelf, and, very likely, the ultimate source of sediments probably also shifted from a western craton to eastern eugeosynclinal islands. Rocks of the upper Bull Formation or younger sediments (Zen, 1967, fig. 5), which are lithically distinctive, are not present in the Everett Formation of the trip area (with the possible exception of one small area in northwest Egremont quadrangle, in a structurally separate unit; see section on structure).

STRUCTURE

Structures within the autochthon

Within the autochthon, two overturned to recumbent folds extend en echelon from the northern part of the Egremont quadrangle to the southern part of the Bashbish Falls quadrangle. The lower, more southern of these folds has been designated the Foley fold (Zen and Hartshorn, 1966). The axial trend of the folds is much distorted by later folding, but the average trends are nearly north. The recumbent nature of the folds is brought out by later refolding along more northwesterly axes, which crenulated the contacts between units, for example unit c of the Stockbridge and higher members of that formation, and led to the presence of younger units within cores of anticlines which plunge south-southeast in response to the geometry of the early folding (stop A4).

West of the Taconic Range, the Stockbridge Formation has been folded, but the present mapping is insufficient to provide a detailed picture. The carbonates have clearly been faulted by a series of high-angle faults, but these faults may be the latest event (see below).

Whether the Walloomsac Formation, which unconformably overlies the Stockbridge, partakes in the early recumbent folding as indicated in fig. 2, is not clear. Near Alford, Mass., isolated patches of Walloomsac rest on overturned units of the Stockbridge; the relation could be construed as evidence of pre-Walloomsac folding of the Stockbridge, but the Walloomsac might have been thrusted in after the folding.

Structure within the allochthon

Although the overall map pattern (fig. 2) shows the allochthonous rocks in the trip area in a single structural sheet, the sheet very likely is a composite of several thrust slices. Lack of units within the Everett Formation that can be traced for more than a few thousand feet, however, leaves the internal structure of the allochthon uncertain. Where traceable beds do occur locally, the rocks are seen to be intricately folded on a small scale.

We do know, nonetheless, that rocks of the allochthon have been deformed at least twice. Evidence for this is the presence of folded foliations (stop B1, B2, B4, B5). The trends of the two foliations (the latter commonly a slip cleavage) broadly agree with the early and late fold trends in the Stockbridge Formation. A possible interpretation of these data will be given later.

Structures along the base of the allochthon

The contact between the autochthon and allochthon is marked by a zone of intense tectonic movement and locally inclusion of exotic rock masses (stop A6). Most readily recognized among these masses are slivers of carbonates, which can be identified as units of the Stockbridge (Zen and Ratcliffe, 1966). Within the slivers, the carbonates can be recognized locally as beds, but elsewhere they are blocks in a breccia associated with rarer blocks of phyllite, identified as the Walloomsac and the Everett formations. The limestones appear to have flowed whereas the dolostones shattered and were later healed with quartz and calcite (fig. 3). Associated with these breccias and slivers are tectonic interlaminations of black and green phyllite. Both the early and late cleavages are recognized in the movement zone. Because the tectonic contact zone is mapped on both the east and west sides of belts of outcrop of the Everett, as well as at the plunging ends of such belts, the slivers are not the product of local upthrusting, and the relations constitute independent structural evidence for the allochthon.

On the west side of the Taconic Range, a repetition of allochthonous rocks below some Walloomsac shows that the Walloomsac itself is locally at least parallochthonous. One patch of rocks mapped as the Everett, about 1 mile (1.6 km) south of stop A6, may be the remnant of an older slice of the Taconic allochthon (Zen, 1967). Small areas of isolated Everett lithology within the authochthon, not shown in fig. 2, are interpreted as debris of the allochthon left behind as it moved westward. If so, then the present erosion surface must closely approximate the surface over which the allochthon moved, thereby making it possible for the moving allochthon to pick up pieces of the Stockbridge, to be preserved as slivers.

Just north of Route 23 (fig. 1), the Taconic Range is actually mainly underlain by the Walloomsac Formation, the Everett being preserved only in a slender syncline on the east flank (stop B1). Thus even though the Taconic Range on the whole is a synclinorium, locally, as in the trip area, a late anticline is developed along the central part of the synclinorium. This is significant because it makes more reasonable the suggestion that the Egremont Phyllite and the Walloomsac Formation are the same unit, and furnishes means for estimating the preserved thickness of the allochthon. This thickness cannot be more than a few thousand feet and is the basis for the tentative estimate (table 1) of the thickness of the Everett itself.

The Everett and Walloomsac have been faulted together by at least one high-angle fault having a pattern similar to that involving the authochthonous Stockbridge Formation and Walloomsac Formation west of the Taconic Range. These high-angle faults may well record the last significant diastrophic event in the area.

METAMORPHISM

As indicated in table 1, rocks of the trip area have been metamorphosed over a wide range of grades. In the northern half of the area (see fig. 1), the Everett and Walloomsac are typically fine-grained chlorite-muscovite-quartz-albite phyllites. Chloritoid is found in phyllites near Alford; almandine is found in the Long Pond area, in the Jug Eng-Mount Bushnell ridge area, and thence southwest across the Bashbish Falls quadrangle. Staurolite is found approximately southeast of a line trending southwest from Mt. Race. Kyanite, though reported by Agar (1932, p. 38), has not been verified by the present work. Paragonite is found sporadically in the Everett Formation. The pairs chloritoid-biotite and chloritoid-staurolite are common, and cummingtonite-almandine-biotite rocks are locally traceable within the higher grade Walloomsac near Lions Head. Both albite and paragonite (rarely both) are found with chloritoid. Epidote is ubiquitous within the small-pebble conglomerate, here equated with the Rensselaer; it is definitely not a detrital mineral in these rocks.

Within the carbonate units, phlogopite is the most common iron-magnesium silicate (stop A4). Hornblende is found only in calcareous beds of the Walloomsac in the southeastern part of the trip area, where the metamorphic grade is the highest. Unit a of the Stockbridge characteristically contains white radiating clusters of tremolite near the eastern margin of the trip area, in beds originally rich in quartz, but its appearance is apparently not related to faulting as interpreted by Hobbs (1893b, p. 794). This mineral is also found at the contact between the Walloomsac and unit c of the Stockbridge (stop B6).

Petrographic and electron microprobe studies show that the plagioclase in the Everett Formation, over a broad belt that trends northeast across the northern Bashbish Falls and southern Egremont quadrangles, is zoned in a peculiar way: the core grades outward from a high-Ca albite into an oligoclase, but then a sharp contact separates this zone from an outermost zone of nearly Ca-free albite. The gradational zoning outward into a calcic feldspar is what one would expect in prograde regional metamorphism, but the sharp reversal in zoning must be associated with a pervasive regional retrograde metamorphism. In some feldspar grains, the high-Ca zone is completely altered to a micaceous mixture, the mica foliation being parallel to the foliation in the matrix of the rock.

Regional metamorphic grade generally increases towards the southeast in this part of New England (see Thompson and Norton, 1968). The higher grade rocks have yielded Acadian K/Ar and Rb/Sr isotopic ages (see Long, 1962; Zen and Hartshorn, 1966; Clark and Kulp, 1968), whereas the low-grade rocks in the northern part of the Taconic allochthon have yielded older ages (Harper, 1968). It is therefore suggested that the higher grade metamorphism in the southern part of the trip area is Acadian, whereas the low-grade metamorphism in the northern part is an earlier event. The Acadian metamorphic grade rises steeply to the south. The belt of peculiar feldspar (stop B2) represents the first effect of the Acadian event, detectable today only because the plagioclase is relatively coarse grained. Any early effect originally present in the Acadian high-grade zone has been wiped out; the higher grade rocks show no reversals in the zoning of the feldspars, and one of these samples (stop B5) has been dated as 355 m.y. on a biotite (Rb/Sr) and 390 m.y. on a coexisting muscovite (K/Ar). The conformity of mica folia in the retrograded feldspars to the foliation in the matrix, mentioned earlier, lends support to the idea that the fabric even in the retrograded zone has been so reorganized by the later metamorphic event that the isotopic clock was completely reset.

The implications of a pre-Acadian regional metamorphism are far reaching; we are currently making a systematic study of isotopic ages in the Taconic rocks with this possibility in mind. The following section presents a consistent chronology of events on the assumption of two metamorphic events.

SOME PROBLEMS IN CHRONOLOGY

The preceding summary shows that the following large-scale geologic events occurred in the area: (1) deposition of the miogeosynclinal rocks; (]) simultaneous deposition, presumably to the east, of eugeosynclinal sediments of the Everett Formation; (3) two folding events in the carbonates, the earlier involving recumbent folds; (4) at least two deformations in the Everett Formation; (5) development of a regional unconformity between the Stockbridge and Walloomsac Formations; (6) emplacement of slices of the Taconic allochthon; (7) two regional metamorphic episodes, the earlier one of low grade and the later one of rapidly rising grade to the southeast; (8) development of high-angle faults.

Sedimentation, with miogeosynclinal deposits on the platform to the west and eugeosynclinal deposits in the basin to the east, proceeded without large-scale interruptions from the earliest Paleozoic until about the end of Early Ordovician time (Zen, 1967). In Middle Ordovician time, in response to tectonism to the east that eventually led to the emplacement of the early slices of the Taconic allochthon (Sunset Lake and Giddings Brook slices; Zen, 1967), the sedimentary regime of the platform changed from carbonate deposition to black shale deposition. Concomitant tectonic activities in the miogeosyncline led to the development of an angular unconformity at the base of the black shale. Although this phase of tectonism may have included the early, recumbent folding in the carbonates, the tectonic style of the recumbent folding suggests a deeper seated environment. Instead, the writer now suggests that the recumbent folding accompanied the later emplacement of the allochthonous rocks of the high Taconic sequence (part of the "Dorset Mountain Slice"; Zen, 1967) because penetrative shearing, breccias, recumbent folds, and tectonic intercalation of rock units along the contact show that the deformation was not due to soft rock sliding and must have occurred in indurated rocks, perhaps under significant load. The patches of Everett, interpreted as remnants of thrust sheets, within the areas of Stockbridge Formation show that the surface over which the allochthon moved was approximately the present erosion surface, so that the development of the recumbent folds by interaction with the allochthon seems reasonable. This sequence of events is consistent with the relative ages of unconformity and recumbent folding shown at stop B6.

The age of the earlier metamorphism relative to the emplacement of the allochthon cannot be fixed until we can show either (1) that the autochthonous rocks have similarly undergone two metamorphic events of comparable grades, (2) that the earlier metamorphic fabric in the Everett was affected by a fabric related to the emplacement of the slices, or (3) that a metamorphic discordance exists between the allochthon and autochthon at least over part of the area of the high Taconic region. So far, all we can be sure of is that both the earlier metamorphic event and the arrival of the Everett as part of the Taconic allochthon predated the peak of the Acadian thermal event and postdated the emplacement of the Giddings Brook slice of the Taconic allochthon, a late Trenton event. Furthermore, progressive albeit slight change of metamorphic grade in the Taconic allochthon, without regard to boundaries of individual slices, makes it plausible that the metamorphism occurred after all the slices had been emplaced. Isotopic geochronologic studies, now initiated in the area by Marvin Lanphere and the writer, should shed light on this important question and allow a better synthesis of data from the trip area with regional relations for the northern Appalachian belt.

Because of the similarity in the structural orientation, the early deformation of the Everett Formation and of the Stockbridge may well have been simultaneous. The considerations of the preceding paragraph would then suggest that the early deformation of the Everett was associated with the emplacement of the slice.

The late deformation in the Stockbridge, the Walloomsac, and the Everett certainly occurred when these rocks were already in their present relative position, except for possible minor adjustments. The orientations of the structural features in these units seem to broadly agree; these features presumably define the Acadian structural grain of the region. The Acadian metamorphic trend, however, for unknown reasons does not parallel the structural trend, but cuts the later trend at a relatively high angle (see also Clark and Kulp, 1968). The metamorphic trend nearly parallels the present trend of the structural front of the Hudson and Housatonic massifs; one is tempted to speculate on a causal relation between them. But the structural history of these massifs is itself an enigma wrapped in mystery, and so we must leave this discordance between late structural and late metamorphic trends as a phantom mystery of northern Appalachian knowledge.

A few final words should be added about the high-angle faults in the area. Near Alford in the northeast part of the Egremont quadrangle, Zen and Ratcliffe (in press) have shown that the map pattern requires a hidden pre-Walloomsac fault in the Stockbridge Formation, which they supposed to be a high-angle fault. Such high-angle faults are well known in the Middlebury synclinorium (see Zen, 1968, for summary); similarly Thompson (1967, p. 87) has shown the need for a concealed pre-Walloomsac fault in western Vermont. Faulting of this age thus seems definite.

The high-angle-faulted Everett-Walloomsac contact in the southwestern part of the Egremont quadrangle indicates similar deformation after the arrival of the allochthon, a conclusion that agrees with mapping in the northern part of the Rensselaer Plateau (Potter, 1963). The straight trace of these later high-angle faults, clearly shown by topographic lineaments in the Hillsdale quadrangle (fig. 2), suggests that these faults may be the last major structural event in the area, postdating the Acadian folding. Acadian dislocations may account for the thrusting of Cheshire over the Everett in the northeastern part of the Egremont quadrangle, for the faulting west of Vossburg Hill, and for similar small-scale faulting in the autochthon.

Table 1.--Stratigraphic Data

Bedrock of the allochthon

Everett Formation: (Ꞓev on fig. 5) Probably in excess of 2,000 feet (700 meters). Mainly quartzose and less commonly micaceous phyllite in shades of green and grey green; locally purple. Included in the unit are massive small-pebble conglomerate layers that grade into and is interbedded with impure quartzite layers; the pebbles consist predominantly of quartz with subsidiary feldspar and granite; matrix consists of granulated quartz, plagioclase, chlorite, muscovite, with rarer, disseminated epidote, stilpnomelane, and magnetite. In the northern part of the trip area, the Everett Formation is a chlorite-albite phyllite, occasionally containing chloritoid, but the metamorphic grade rises rapidly so that it is an almandine-chloritoid-chlorite schist near Mount Bushnell and an almandine-chlorite-staurolite schist east of Mount Everett. The unit is here equated lithically with the Greylock Schist of Mount Greylock, with the Mount Anthony Formation of MacFadyen (1956) of the Equinox and Bennington quadrangles, Vermont (Hewitt, 1961; MacFadyen, 1956), with the Hoosac and part of the Pinney Hollow Formations of southern Vermont, and with the Underhill Formation, including the Fairfield Pond Member of Doll et al.(1961) of northern Vermont.

Carbonate slivers and tectonic breccia: (OꞒss and OꞒt on fig. 5) Dominantly carbonate, as beds, blocks, or chips, ranging from fraction of inch (1 cm) to several feet (2-3 meters) across. Lithically the pieces and layers in the tectonic breccia can be assigned to the Stockbridge Formation, the Everett Formation, or the Walloomsac Formation.

Bedrock of the autochthon

Walloomsac Formation, including the Egremont Phyllite (Ow and Oeg on fig. 5): Probably about 1,500 feet (500 meters) thick. Jet-black to silvery-grey, fine-grained, silty carbonaceous, calcareous or pyritiferous phyllite or slate. Locally at or near the base of the unit are white or blue-grey limestone beds as much as several feet (1 meter) thick. In the southeast corner of the Bashbish Falls quadrangle and adjacent areas, the basal unit is locally a massive cliff-forming grey schistose marble, as much as 200 feet (70 meters) thick, mottled by dark irregular 1/2-inch (1 cm) phyllite blebs. The formation is a muscovite-chlorite-stilpnomelane phyllite over most of the area, but in the Bashbish Falls quadrangle its metamorphic grade rises southeastward, so the rock becomes an almandine-staurolite-biotite-oligoclase schist near Lions Head. Local layers of almandine-cummingtonite-biotite-magnetite-quartz rock. The Walloomsac is Middle Ordovician, in part because of fossils of that age in the basal beds; it is correlated with the Ira Formation (Zen, 1964a; see also Doll et al., 1961) and with the Hawley Formation and possibly part of the Moretown Formation of west-central Massachusetts (Hatch, 1967).

Stockbridge Formation: Total thickness estimated at about 3,500 feet (more than 1,000 meters). Unit g (OЄsg on fig. 5): Massive, white to grey, mottled calcitic marble or limestone; interbeds of uniform, compact, homogeneous, pale yellow-grey dolostone a meter thick or less, and local interbeds of thin-bedded silty marble and phyllite. Thickness about 400 feet (130 meters). Correlated with the Chipman Formation and part of the Bascom Formation of Vermont (Doll et al., 1961), and the Copake Limestone and part of the Rochdale Limestone of the Pine Plains area (Knopf, 1962).

Unit f (OЄsf on fig. 5): Discontinuous, heterogeneous unit that includes tan-weathering calcareous sandstone, commonly cross-stratified; grey, fine-grained silty limestone; massive calcareous sandstone; massive grey dolostone; grey friable dolostone; silty, dark-grey calcareous slate. Thickness abruptly varies along strike and ranges from 0 to 300 feet (100 meters). Correlated with the Cutting Dolomite of Vermont, but the thicker, more heterogeneous parts may include rocks mapped in Vermont as the Bascom Formation, which is also a heterogeneous unit including comparable rock types (see Doll et al., 1961).

Unit e (OЄse on fig. 5): Very similar to unit g above, but locally the basal beds are a massive dolostone. About 400 feet (130 meters) thick. Unit e is here correlated with the Shelburne Formation as recently revised by Thompson (1967), or the Columbia Marble Member of the Shelburne Formation as used by, for example Doll et al. (1961) and Zen (1964b). It is also correlated with at least part of the Halcyon Lake Formation of the Pine Plains area (Knopf, 1962).

Unit d (OЄsd on fig. 5): Very similar in lateral variability and in lithic assemblage to unit f, but includes a grey limestone-matrix, dolostone and limestone pebble conglomerate. Thickness estimated at between 0 and 250 feet (80 meters). Unit d is correlated with the higher members of the Clarendon Springs Dolomite as used by Thompson (1967), or the lower members (Sutherland Falls Marble and intermediate dolomite) of the Shelburne Formation as used by Doll et al., (1961); also with parts of the Halcyon Lake Formation of the Pine Plains area (Knopf, 1962).

Unit c (OЄsc on fig. 5): Massive to thin-laminated, pale grey-weathering, white to iron-grey dolostone; in wooded areas outcrops are commonly low, rounded blocks or solution-widened pavement exposures. Individual beds as much as 5 meters thick. Stratification on millimeter scale, defined by concentrations of floating rounded quartz sand grains, locally shows cross-stratification or sedimentary slump features. Impure dark-grey chert beds as much as 1 foot (30 cm) thick occur in the western areas; these beds metamorphose into quartz nodules and quartzitelooking layers. Thickness about 700 feet (230 meters). Correlated with the Clarendon Springs and Danby Formations of western Vermont (Doll et al., 1961), and with the Briarcliff Dolomite of the Pine Plains area (Knopf, 1962).

Unit b (OЄsb on fig. 5): Predominantly dolostone, but includes numerous black or silver-grey silty to phyllitic seams and subsidiary rusty-weathering quartzite or arkose beds. In most of the Egremont quadrangle and adjacent parts of the Hillsdale quadrangle, it can be further divided into three units: the highest unit, b3, is a brown- to tan-weathering grey, salmon, pink, yellow and white compact dolostone, having interbeds of grey silty to green micaceous phyllite, calcareous siltstone, rotten-weathering dolomitic sandstone, and calcareous and feldspathic sandstone. The intermediate unit, b2, is a grey-weathering, dark-grey massive dolostone having but minor phyllite partings. The lowest unit, b1, is much like the highest unit but contains fewer silty and sandy beds. Unit b is estimated about 600 feet (200 meters) thick. It is equated with the Winooski Dolomite and at least part of the Monkton Formation of Vermont (Doll et al., 1961), and with the Pine Plains Formation and possibly the upper part of the Stissing Dolomite of the Pine Plains area (Knopf, 1962).

Unit a (OЄsa on fig. 5): A pale-grey, white, and grey-and-white-mottled, massive, grey- or white weathering dolostone. Near its base the unit contains vitreous quartzite beds half-inch to 10 feet (1 cm to 3 meters) thick. Rosettes of tremolite characterize the lower part of this unit; their occurrence apparently is controlled by the presence of quartzite beds in areas of higher metamorphic grade. The unit is about 700 feet (230 meters) thick. The unit is equated with the Dunham Dolomite of Vermont (Doll et al., 1961), and with the bulk of the Stissing Dolomite of the Pine Plains area (Knopf, 1962).

Cheshire Quartzite (Єc on fig. 5): More than 300 feet (100 meters) thick. The unit is a pale-buff, white, grey, vitreous, massive quartzite, weathering glistening white. Bedding is rarely visible. Top of the Cheshire grades into unit a of the Stockbridge by acquisition of dolomitic cement, which helps to reveal thin bedding-lamination, and by interbedding of massive quartzite and dolostone. The unit is lithically equated with the Cheshire of Vermont and northwestern Massachusetts (Doll et al., 1961) and with the Poughquag Quartzite of the Pine Plains area (Knopf, 1962).

Dalton Formation (Єd on fig. 5): Exposure of the unit is extremely limited in the trip area; thickness, estimated from adjacent areas, is about 200 feet (70 meters). The rock ranges from a massive to thin-bedded quartz-feldspar-biotite-muscovite-tourmaline granulite to biotite schist and to impure quartzite, all of which weather dull grey to orange-brown. The unit grades upward into the Cheshire by increase of quartzite beds. The unit is equated with units mapped as the Dalton in Vermont (Doll et al., 1961).

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ROADLOG TRIP 3A

Mileage

0	Start of trip at A & P store's parking lot, Great Barrington, Mass. Head south on Route 23.
0.3	Bear right with Routes 23 and 41 at traffic light.
1.3	Cross Green River; view of Housatonic valley to the left.
1.5	Turn left at sign "Wyantenuck Country Club."
2.1	Wyantenuck Country Club to the right.
2.7	Stop A1.

Dalton Formation; Cheshire Quartzite; basal unit a of the Stockbridge Formation. The rocks along the road are biotite-feldspar-quartz granulites assigned to the Dalton Formation, the lowest unit exposed in the trip area. Go west up hill. The Dalton is succeeded by a vitreous, massive, buff quartzite, the Cheshire; the contact appears abrupt. About 300 feet (100 m) of the Cheshire is exposed. Unit a of the overlying Stockbridge Formation is first encountered on the steep slope; along the contact is a single outcrop of a feldspathic biotite phyllite. Go up the steep slope, which is the dip slope of the overturned unit a, here a massive white dolostone. Half a mile north along strike, behind the club house of the Wyantenuck Golf Club, however, unit a is a mottled grey dolostone; these outcrops are now concealed "for aesthetic reasons."

The top of Vossburg Hill is underlain by unit a. Also present is a vitreous quartzite, about 15 feet (5 m) thick and traceable for more than 1,000 feet, nearly identical with the Cheshire but interbedded with unit a. Locally the quartzite shows inch-thick bedding visible on deeply weathered surfaces, apparently caused by minute amounts of carbonate. Thus the Cheshire-unit a contact is gradational in two ways: The two rock types interbed, and the quartzite in the contact zone is more calcareous than normal.

Tremolite crystals as much as 2 inches (5 cm) long are found in this stratigraphic position in the trip area, including the south end of Vossburg Hill.

Return directly to the car, proceed to mileage 3.0 to turn around and proceed north.

Mileage

4.5 Same corner as mileage 1.5; turn left on Route 23.

4.9 Intersection with Route 71; continue on Routes 23 and 41.

6.2 Mount Everett Country Club; view of Mt. Everett.

6.6 Bear right with main road at village of S. Egremont.

7.3 Junction of Routes 23 and 41; bear left with Route 41 south. Rocky ridge ahead is the Jug End-Mt. Bushnell ridge, underlain by the allochthonous Everett Formation. Sharp break in slope seen on right end of the ridge is the contact with the underlying autochthonous carbonate rocks.
Caution: Dangerous intersection

7.8 Road cut along Route 41. Stop A2.

Units c through g of the Stockbridge Formation. The roadcut on both sides of the road is grey, massive-bedded dolostone, the top beds of unit c of the Stockbridge Formation. East of the road at waist level is a thin-bedded silty limestone at the base of the heterogeneous unit d; the contact of c and d is concealed. Go east up the embankment. In the first clearing, rusty-weathering dolostone interbedded with brown-weathering calcareous sandstone is the main part of unit d. The next clearing across shows grey-mottled massive calcite marble, unit e. Across a gap, the next outcrop east at the low ledge is a second unit of brown-weathering calcareous sandstone, showing possible cross-stratification indicating an upright section. This is unit f. Continue uphill; the highest clearing is underlain by massive white and grey marble, locally interbedded with pale-buff dolostone (much boudinaged) that weathers into a "thread-scored beeswax" texture; the marble and dolostone are unit g, here in the core of a complex refolded syncline.

Although data from this traverse, from d to g, could be interpreted as a structural repetition of just two lithic units, regional mapping shows this is not so, and the lithic repetition is stratigraphic. At places, for instance west of Berkshire School in the Bashbish Falls quadrangle, outcrops of d and f in a single section show crossbedding that bears out this conclusion.

AT THE REQUEST OF THE LANDOWNER, THERE WILL BE NO SMOKING ON OR NEAR THE STOP. THERE IS A LOVELY 1753 HOUSE ON THE LAND AND ANY BRUSH FIRE COULD LEAD TO DISASTER. THANK YOU.

Proceed south to turn around.

Mileage

8.0 Turn around at side road; proceed north on Route 41.

8.5 Turn left at sign "Jug End Resort" onto secondary paved road.

9.3 Turn left onto tertiary paved road, "Avenue Road."

9.9 Dirt road junction. Bear left.

10.3 Stop A3; park at picnic area provided by the Isaak Walton League. Go west into ravine behind picnic table; beware of poison ivy.

Lithic variations of unit f and some problems in correlation. Outcrop in the ravine next to the road (elevation 840 feet) is marble of unit e. At the 880-foot level in the ravine is another outcrop of unit e. From the 920-foot level on, begin heterogeneous carbonate units, including: Massive grey calcitic dolostone and interbedded white marble; massive white dolostone; thin-bedded grey marble; calcareous sandstone; calcareous siltstone; silty grey limestone. These units are locally folded together. Where the stream branches, follow the northern branch. The section is capped at the 1,000-foot level by a black phyllite of the Walloomsac Formation; however, the Walloomsac-Stockbridge contact here transects contacts of units e, f, and g, and so presumably marks an unconformity or a fault. Continue up streambed and at the 1,020-foot level return to the Stockbridge Formation, here the massive grey and white marble of unit g. Marble continues to the base of steep slope (elevation 1,140 feet) which marks the contact with the Everett Formation (plagioclase-chloritoid-chlorite-almandine schist).

The thick, heterogeneous sequence of carbonate rocks in this traverse, all assigned to unit f of the Stockbridge, is in sharp contrast with the same unit at stop A2. The writer interprets the relations as a lateral facies change between the massive marble of parts of units e and g at stop A2 and the heterogeneous carbonate rocks of this stop. The presence of calcareous sandstone typical of unit f of stop A2 in this traverse supports this idea.

Continue on gravel road (Curtis Road south.)

11.7 Return to Route 41; bear right, proceed south on Route 41.

12.1 Road cut is in unit c of the Stockbridge Formation.

12.2 Spurr Pond on the left.

12.7 Berkshire School on the right.

13.2 Bear left on Berkshire School Road.

13.4 Stop A4 just beyond bridge.

Core of Foley Fold; inverted sequence of units c, d, e of the Stockbridge Formation. The outcrops of massive, compact dolostone on the open ridge north of road are mapped as unit c. Go north into woods, following broad ridge crest. Go west to the top of the next prominent ridge having steep cliffy eastern face. On top of the ridge (el. 770 feet on the topographic map) outcrop of cross-bedded grey dolostone and interbedded quartzite, showing that top is to the west, dips moderately west. The ledge on the east side of the ridge displays lithic characteristics of unit c very well. From here go east across gullies and up the main 840-ft. hill; rare outcrops are folded units c and d that on the whole dip west. Continue uphill; near the top of the hill are low and scattered outcrops of flat-lying unit e. Go southeast from top of hill to abandoned marble quarry on the southeast spur. In the quarry, interbedded calcareous sandstone and marble overlie massive coarse white marble; the calcareous sandstone sequence is best seen along the west rim of the quarry and is assigned to unit d; the main marble is assigned to unit e. Muscovite, phlogopite, and tourmaline are common in the marble. Notice the large recumbent fold and associated minor recumbent folds on the north face of the quarry; the folds have a movement sense consistent either with the normal limb of a fold and west-to-east movement sense, or with the inverted limb of a fold and east-to-west movement sense. Because the regional movement sense is east-to-west, the folds support the interpretation, based on lithic succession, that the sequence here is inverted. The recumbent folds are thus a record of the early deformation, which agrees with the fact that the early deformation in the trip area as a whole shows a recumbent style of folding. Between the outcrop of crossbedded dolostone and quartzite and this quarry, the axial surface of an early fold must exist, but its location cannot be precisely fixed.

The quarry is located in the core of a late anticline; notice that the beds here begin to assume an easterly dip. Farther to the east, the outcrops across the swamp in the woods are unit c again, dipping generally gently east and culminating in a late syncline containing units d and e. In between, however, there exists a zone of steep to vertical bedding dips; this is interpreted as the hinge zone of the early recumbent syncline (topping fold).

Proceed southwest from the quarry. Silty marble and dolostone of unit d showing nearly east trend and gentle south dip are exposed on the south slope of the 840-ft. hill. Continue southwest in wooded area and reenter the zone of west-dipping unit c just before the meadow. Return to car.

13.6 Proceed to driveway about 1,000 feet ahead to turn around. Return to Route 41; same corner as mileage 13.2. Turn right to go north on Route 41.

Mileage

13.7 Berkshire School; lunch on soccor field. Please--no litter! Carry all trash back to car. We are allowed to use the field for lunch through the kindness of the school authority; please do not abuse this privilege.

Proceed north on Route 41.

15.0 Outcrop left of the road is unit e of the Stockbridge Formation.

15.5 Outcrops west of the road are unit e. East of the road, unit f and unit e crop out, the relations are interpreted as a thrust fault.

15.8 Large outcrops in pasture to the east (right) are unit f.

16.9 Junction of Route 23 and 41, same as mileage 7.3. Road cuts are nearly flat-lying calcareous sandstone beds of unit f, here in a series of imbricate thrusts. The same beds crop out in the stream to the southeast, and continue on to become the beds of unit f visited at stop A2.

17.6 Proceed straight north on Creamery Road where Route 23 bears to the right.

18.2 Sharp turn right onto McGee Road.

19.1 Intersection with Route 71; continue straight ahead on road bearing sign "Pumpkin Hollow Road."

19.3 Bridge over Green River.

19.4 Junction with West Plains Road. Continue straight ahead on Locust Hill Road.

19.6 Road cuts are in unit b of the Stockbridge Formation.

20.2 Road corner; big outcrops in garden to the left are in unit b3.

20.5 Road junction; turn left. Big outcrops are in unit bl; outcrops on the hill to the east across the pasture are in unit a.

20.7-21.0 Outcrops on the hill to the left are in units bl, b2, and b3, intricately interfolded.

21.4 Seekonk Road intersection. Turn right.

21.5 Red barn north of road. Stop A5.

Units a and b of the Stockbridge Formation. Park car near barn. Start traverse just behind (north) of the barn. The rocks are interbedded cream, pink, grey, and yellow dolostone, silty dolostone, grey silty phyllite, and arkose that weathers to a green cast; this is typical of the highest submember, b3. The beds dip to the east; they have been folded at least twice. The next rock type is a silty grey massive dolostone without interbedded arkose or phyllite. This is the middle submember, b2. The contact appears gradual. Continue east. This submember is in turn succeeded by a more heterogeneous unit, the lowest submember, bl, very similar to b3. These three submembers can be mapped over large tracts of the trip area and where distinguishable help to define the structural pattern.

Unit b is terminated to the east, along this traverse, by a feldspathic black phyllite with interbedded blue-grey silty limestone. The rock is identical with lower parts of the Walloomsac Formation, and is so mapped, even though the limestone has not yielded fossils, because this rock type is not found in the Stockbridge stratigraphic sequence. The area of black phyllite is limited. To the east, white, massive dolostone, unit a of the Stockbridge, is exposed, here much granulated apparently because the contact against the Walloomsac is a fault.

The contact between units a and b south of this area is gradational by addition of silty layers to the upper beds of unit a. The sequence is in the inverted limb of a major early anticline (bottoming fold). The Walloomsac is here interpreted to be in a graben. It is a relict either of an unconformably overlying sequence or of a thrust slice. Similar remnants of the Walloomsac are found commonly in the trip area. If the first interpretaticn is correct, then the overturned fold in the Stockbridge must be pre-Walloomsac. The writer, however, favors the idea that the Walloomsac, before the development of the graben, was in thrust contact with the Stockbridge. This interpretation has precedents; thrusting of flysch sediments over older carbonate rocks now characterizes much of the subalpine and prealpine zones of the Swiss Alps.

Turn around in barnyard and proceed west on Seekonk Road.

21.9 Road junction; bear right.

22.5 Road junction; bear right.

22.7 Road junction; continue straight ahead.

22.8 Road cuts are calcareous sandstone beds of unit d of the Stockbridge Formation.

Mileage

24.3 Black phyllite crops out in the road; this is the Walloomsac Formation. In the woods to the north are outcrops of carbonate rocks intricately folded with the allochthonous Everett Formation; the carbonate rocks are interpreted as constituting a sliver at the base of the allochthon. Hill south of road is likewise underlain by the Everett Formation.

24.7 Unit e of the Stockbridge Formation.

24.8 Allochthonous Everett Formation. Entering State of New York.

25.4 Intersection with Route 71; turn right.

25.5 Turn left onto Overlook Drive in front of the Green River Hotel and Bar.

25.7 Bridge over Green River.

26.7 Road junction. Continue straight ahead.

27.1 Microwave transmission tower. Stop A6.

Tectonic contact between the Everett Formation and the Walloomsac Formation. Carbonate slivers. Immediately west of the structure housing transmission facilities of the TV tower, green muscovite-chlorite-plagioclase phyllite is exposed; this is part of the main mass of Everett Formation. In the road, black phyllite characteristic of the Walloomsac Formation can be seen. East of the road, low rock outcrops at the north end of large pasture are a jumble of dolostone, limestone, and black and green phyllites; the carbonate rock types can be identified with units of the Stockbridge. Black and green phyllites occur between this outcrop and the next large outcrop of grey marble at the 1,370-foot elevation on the northern ridge of the main hill. The limestone is severely deformed resulting in a laminated S_2 fabric; microscopically the layers are alternatively relatively coarse calcite and extremely comminuted calcite. Note the strike of S_2 conforms to the contact with the main body of the Everett Formation (quartz-chlorite-muscovite-albite-pyrite), exposed immediately to the southeast. Go south along the steep west face of the hill. Warning: It's easy to get a sprained ankle unless you watch your step. Along this scarp, outcrops are nearly continuous for about 1,000 feet (300 m). The following are among features to be observed: The carbonate occurs in a zone varying rapidly from 0 to 10 feet (3 m) thick. Several rock types occur in the carbonate zone, locally obviously as blocks a fraction of an inch to several feet across. Presence of Everett Formation as blocks in the carbonate. Peculiar knobbly weathering surface of the dolostone, due to shattering of the rock later healed by quartz-calcite vein (fig. 3). Large solution cavities in the carbonate, part of which at least are natural and caused apparently by concentration of solution activity along boulder boundary. Repeated interlamination of black-green phyllite, interpreted to be caused by shear movement along Walloomsac-Everett contact. Recumbent fold of layers of limestone (best seen at the south end of the outcrops) whose axial surface passes into the overlying green phyllite to become the early foliation, showing that the foliation is no older than the emplacement of the allochthon and the carbonate sliver. Intense shearing of the phyllite (microscopically, the shear lamination is preserved as dusty inclusions in mica and plagioclase alike; these inclusions are in proper mutual orientation and at least the plagioclase microporphyroblasts grew after the development of the lamination).

The carbonate slivers are found in many places along the Walloomsac-Everett contact; the phyllite near the contact is always intensely sheared (the carbonate does not crop out well; more than once the characteristic intense shearing of phyllite has guided successful searches for the carbonate). The carbonate is assigned to various units of the Stockbridge, and their presence, the shearing of the adjacent phyllite, and the repetition of black and green phyllite along such contacts, have been used as evidence for assigning the Everett to an allochthon, as discussed in the main text.

In the pasture below (to the west of) the scarp, a second, discontinuous zone of carbonate occurs; the northernmost outcrop was seen at the beginning of the stop. From the scarp to the road the area is underlain by green and black phyllite on such a scale that they cannot be separately mapped; the entire zone is one of tectonic breccia. West of the road, the Walloomsac crops out; in turn it is thrust over green and purple slate, here assigned to the Everett Formation, but it may belong to the structurally lower Chatham slice (Zen, 1967). On the hill east of the carbonate zone, the green Everett continues and is part of the main outcrop belt of the Everett here.

Return to the car and proceed in the same direction. Steep down hill.

28.2 Junction with paved road. Bear right.

29.0 Junction with Route 22. Turn right, going north on Route 22.

29.3 Outcrops to the left belong to the Walloomsac Formation.

29.5 North Hillsdale.

29.6 Stop A7.

Unconformity of Walloomsac on the Stockbridge Formation; fossils in the Walloomsac; lithic types in the Walloomsac. Go east across field just north of apple orchard toward wooded hill (elevation 870 feet). At southeast spur of hill, quarry in massive grey dolostone, locally bearing black chert. This is unit c of the Stockbridge. At southeast wall of quarry, the dolostone is succeeded upward by 3-foot (1 meter) layer of dolomite-mottled grey marble, followed by black, silty thin-bedded limestone mapped as basal limestone of the Walloomsac. Go southeast about 400 feet (130 meters) to brook; in brook, black phyllite (Walloomsac) is exposed. On east bank, massive grey dolostone of unit c and calcareous sandstone of unit d rest on the Walloomsac on a thrust contact. Farther up hill unit e is next exposed.

Follow brook north. About 600 feet (200 meters) on, due east of 870-foot hill, black silty limestone like that in the quarry is exposed in the brook. Unit c is exposed locally in the brook as an inlier below the unconformity. Farther north in the brook the black limestone is fossiliferous. Apart from pelmatozoan fragments, a hash of gastropod and brachiopod fragments is preserved. There are no outcrops immediately east of the brook; the next outcrop on the slope is unit d of the Stockbridge again.

The relations at this stop are thus basically simple: Walloomsac, with basal fossiliferous limestone, unconformably on unit c. A thrust fault having an undetermined but probably minor stratigraphic throw locally brings unit c over the Walloomsac. The stop demonstrates the reality of the pre-Walloomsac unconformity, the stratigraphic near-identity of the Stockbridge on the two sides of the Taconic Range (unfortunately time does not permit us to see the other rock types of the Stockbridge west of the Taconic Range, but all units, except the Cheshire, Dalton, and possibly unit a of the Stockbridge have been identified in the proper sequence), and the age of the Walloomsac.

Return to the car. End of trip 3A. Those who wish to go directly to Albany could follow Route 22 north to the Berkshire Spur of the New York State Thruway in Austerlitz (exit B3). Go west across the Hudson River; take exit 24 to headquarters motel. Alternatively, one could pick up Route 203 in Austerlitz, go west to Valatie, and take Route 9 north from there to Albany. Those who wish to return to Great Barrington could either turn around, follow Route 22 south to Route 23 in Hillsdale, and go east on Route 23 to Great Barrington, or continue north on Route 22 for about 3 miles (5 km) to junction with Route 71, follow Route 71 south to Great Barrington.

ROAD LOG, TRIP 3B

Mileage

0 Start of trip at parking area just south of Route 23, 0.1 mile east of the New York-Massachusetts line and 2.9 miles east of junction of Route 22 and 23 in Hillsdale, New York.

Stop B1.

Walloomsac Formation. At least two sets of cleavage are evident in the roadcut; the late cleavage, S_3, folds the early cleavage, S_2 to produce an apparent east-over-west movement sense, most readily seen at the east end of the cut. Average attitude of S_2 is 25° azimuth and 55° dip SE, and the vein quartz is parallel to it. Average attitude of S_3 is 10° azimuth and 70° dip SE. The intersection of S_2 and S_3 produces a gently south-plunging crinkle lineation. There is, however, yet another down-dip crinkle visible on S_3; its origin is unclear. Mineral assemblage of the Walloomsac Formation at this outcrop is quartz-plagioclase-muscovite-chlorite; no carbonate has been found. Although the outcrop is located within the belt of retrogression discussed in the text, the rock does not show the effect because the carbonaceous phyllite of the Walloomsac Formation does not favour the development of even microscopic porphyroblasts.

Proceed east on Route 23.

0.1 Top of the Taconic Range; road cuts are all in the Walloomsac Formation.

0.7 Green phyllite of the Everett Formation at the south end of a narrow late syncline; from here south the syncline expands into the main area of the allochthon. Notice that one outcrop of the green phyllite shows west-dipping early foliation; this is interpreted as the result of refolding during the formation of the late syncline.

0.8 More black phyllite of the Walloomsac Formation and green phyllite of the Everett Formation.

0.9 Carbonate rocks belong to the Stockbridge Formation.

1.0 Turn right onto Jug End Road.

1.5 The ledges in the woods to the right (west) of the road are the Everett and Walloomsac Formations. The Everett is interpreted as debris left behind during the overthrust. The Walloomsac could be a thrust sliver; alternatively, the contact of the Walloomsac against the Stockbridge could be the Middle Ordovician unconformity.

Mileage

1.8 Left of road, behind barn, are calcareous sandstone beds of unit f of the Stockbridge Formation.

2.1 Intersection with Mount Washington Road. Turn right.

2.4-2.5 Outcrops along the road are unit g of the Stockbridge Formation.

2.6 Beginning of cuts in green phyllite of the allochthonous Everett Formation.

2.8 Stop B2.

Everett Formation and Egremont Phyllite in the zone of retrograde metamorphism. The large roadcut includes a variety of rock types that characterize the Everett Formation in areas of medium-low metamorphic grades: Micaceous phyllite, feldspathic phyllite, quartzose phyllite. These rocks are predominantly green, but purplish green varieties can be found, e.g. near the west end of the cut. The rocks show at least two sets of cleavage: S_2, a foliation, is at least locally parallel to bedding, S_1, and can be best seen near the middle one of three concrete storm-sewer covers situated on the north side of the road cut. Here S_1 and S_2 are nearly vertical but S_3 dips east; an apparent west-over-east movement sense results. At one place, the axial parts of S_2 folds can be seen to be refolded by S_3, and the early axes trend diagonally across the late limbs to produce a rhombic interference pattern.

The mineral assemblage here is: Quartz-chlorite-muscovite-plagioclase-magnetite. Magnetite is most readily seen near the west end of the cut, and is in both green and purple (hematitic) phyllites. The plagioclase is zoned, varying from about An_{15} to An_0 according to electron microprobe data, and shows retrogression as discussed in the main text. Notice that the magnetite is also retrograded to chlorite.

From the west end of road cut walk 500 feet (150 m) west to private drive and small bridge across Karner Brook. In the brook is exposed black phyllite typical of the Egremont Phyllite. Some of the phyllite layers are calcareous. Notice the presence of two prominent sets of cleavage again; folding of S_2 by S_3 led to the steeply south-plunging cleavage folds. For reasons discussed in the main text, the Egremont Phyllite is identified with the Wallomsac Formation; compare the outcrop with the outcrop of Walloomsac at stop B1. In fact, the Egremont Phyllite of stop B2 probably is geometrically continuous with the outcrop of Walloomsac at stop B1; these two areas of black phyllite are separated only by a ridge of green phyllite of the Everett Formation, and the green-black contacts occur at about the same elevation on the two sides of the ridge.

Three hundred feet (100 m) downstream, the Everett Formation crops out in the stream bed, thus in map pattern the Egremont Phyllite is completely surrounded by the Everett Formation. Unfortunately, the contact is not exposed here. Because as a whole the Everett occupies high ground and the Egremont occupies lowland, and because in rare exposures of the contact the Everett overlies the Egremont, the Everett is interpreted as geometrically above the Egremont, and the fact that the Everett here crops out 300 feet downstream from the Egremont is explained by local irregularities of the surface of the contact. This contact is considered to mark the base of the allochthon; however, unlike the Everett-Walloomsac contact in much of the Egremont quadrangle (e.g., stop A6), the Everett-Egremont contact is so far not known to be marked by carbonate slivers.

Proceed west on Mount Washington Road.

3.0-3.9 Green and minor purple beds of the Everett Formation; mostly muscovite-albite-chlorite-quartz phyllite containing hematite or magnetite. The Egremont Phyllite occurs almost exclusively in the deep ravine of Karner Brook east (left) of the road.

4.9 Road junction; bear left with paved road.

5.0 Gully crossing. Contact of Everett Formation and Egremont Phyllite has climbed up to this point. The flat area ahead is underlain by the Egremont Phyllite whereas the higher hills surrounding the plain are underlain by the Everett Formation.

5.7 Road corner; turn left with paved road.

7.8 Junction of road to Mount Everett, the highest peak in the southern Taconic Range. On a clear day a fine view can be had from the top.

8.1 Road intersection; continue straight ahead. This is downtown Mount Washington.

9.3 Road intersection, stop B3.

Medium-to-low-grade Everett Formation. Rocks immediately east of road in the woods, opposite gate on Mt. Plantain Road, are chloritoid-muscovite-chlorite-ilmenite-plagioclase schist of the Everett. We are just north of the almandine isograd here. The rock has been separated and analyzed; K/K + Na ratio in the muscovite = 0.8 and d_{002} = 9.95; Ab/Ab+An in plagioclase is about 0.8, but the plagioclase is weakly zoned (no retrograde zoning). The ilmenite is nearly stoichiometric $FeTiO_3$ with minor MnO. In the chlorite, Fe"/Fe"+Mg+Mn+Ca ratio is 0.67

and Mg/Fe"+Mg+Mn+Ca is 0.30; in the chloritoid, Fe"/Fe"+Mg+Mn = 0.84 and Mg/Mg+Fe"+Mn = 0.12

Notice the outcrop of the black Egremon Phyllite in the road.

Proceed south on main gravel road.

9.6 Outcrops below red barn to the west are calcareous phyllite beds of the Egremont Phyllite.

10.0 Back into the Everett Formation; the Egremont Phyllite occupies the lowland on the left (east). Except for one more brief skirmish with the Egremont Phyllite, we will stay in the Everett Formation for the next several miles. We are near the southern terminus of the inlier of Egremont Phyllite.

10.5 Here in the road is the aforementioned brief skirmish with the Egremont Phyllite.

10.8 Mount Ashley to the right; paragonite-bearing chloritoid schist of the Everett Formation.

12.0 Entering Connecticut.

14.8 Stop B4 at parking area. Follow blue blaze to top of Bald Peak.

Medium-grade Everett Formation. View of the Taconic upland, including Bear Mountain to the north, the highest peak in Connecticut, and Mount Frissell to the northwest, whose south slope includes the highest point in Connecticut. Lions Head, the sharp ridge to the ESE, is our next stop. The topographic contrast between the allochthon and the autochthon (lowland) is obvious. Notice in the outcrop the presence of three S surfaces in addition to the bedding: S_2, the early foliation, apparently conforms to the bedding in flat outcrops; however, the vertical outcrop faces along the trail near the top show recumbent folding of bedding having S_2 as the axial surface. S_3, the dominant cleavage, folds S_1 and S_2 to produce a characteristic south-plunging set of folds. S_4 is the latest cleavage; it is nonpenetrative and produces sharp chevron folds of S_3. The rock here is an almandine-chlorite-muscovite-plagioclase schist; the plagioclase and quartz locally are granulated and the plagioclase not obviously zoned. Chloritoid is confined to inclusions in the almandine; staurolite has not been found here. Some magnetite-rich layers are without almandine.

Bald Peak has a tangled nomenclatorial history vis-a-vis its geology. Hobbs (1893a, p. 3) called it Mount Riga, and designated it as the type locality of his Riga Schist, which from his map pattern must be identified largely with the Walloomsac. The hill has since been renamed, and the rock is now mapped as the Everett. However, another peak farther south, in the Sharon quadrangle and visible on the skyline is now called Mount Riga on the U.S.G.S. topographic sheet, and it is indeed underlain by the Walloomsac!

Return to car and continue south.

15.3 Road corner; bear left with main road. Pond just before the corner is South Pond, a private preserve. Stone structure to the right just beyond the corner is a reconstruction of a blast furnace operated by one Joseph Pettee during the early years of the 19th century. The iron ore was hauled up from the valley; many of the pits are still prominent landscape features near Salisbury, Conn. (The ore was developed along the contact of the Stockbridge and Walloomsac Formations, presumably a record of pre-Walloomsac subaerial erosion.) Charcoal for the furnace was locally obtained in the mountains; many platforms where charcoal was produced can still be recognized in the woods today.

15.6 Crossing Wachocastinook Brook which drains South Pond.

16.1 Waterfalls in the brook are visible; almandine-staurolite-plagioclase-chlorite-muscovite-quartz-ilmenite-armoured chloritoid schist of the Everett Formation.

16.4 Lions Head is the sharp ridge to the left. Along the road are cuts in the Everett Formation. The contact with the underlying autochthonous Walloomsac Formation is just ahead, but is not exposed.

17.4 Bridge over the Wachocastinook Brook. Staurolite-almandine-biotite-muscovite-plagioclase-quartz-ilmenite schist of the Walloomsac Formation in the stream.

18.2 Road comes in from the right. 200 feet ahead, Bunker Hill Road comes in from the left. Turn sharply left onto Bunker Hill Road, going north. We are now in unit e of the Stockbridge Formation.

18.5 Road fork; bear left with the main road.

19.2 End of road; stop B5.

Medium-high-grade Everett Formation and Walloomsac Formation. From the house follow the white-blazed Appalachian Trail northwest for a 0.7-mile (1.2 km) walk to Lions Head (total climb about 550 feet, 180 m). View of the autochthonous lowland; the hills along the skyline to the east are in the Berkshire massif. Note the steep scarp of Canaan Mountain to the southeast; this is the type locality of Canaan Mountain Schist of Rodgers and others (1956), a controversial sillimanite-muscovite schist of uncertain age which the writer believes to be mostly high-grade Walloomsac Formation.

On top of the lookout point of Lions Head, coarse-grained staurolite-almandine-chlorite-plagioclase-muscovite schist of the Everett Formation. Fe/Fe+Mg in the chlorite is about 0.6; in the almandine, about 0.86; in the staurolite, about 0.83. A notable feature is enrichment of Zn in the staurolite--about 0.3 wt. percent of ZnO was reported in the analysis of mineral separate. Electron-probe analysis has not shown any zoning of the staurolite; in the almandine, Mn shows mild enrichment in the center, whereas Fe shows a corresponding enrichment in the rim, as might be expected; Ca shows no zonal distribution. Agar (1932) reported kyanite in the general vicinity, but it has not been found in the present study. The grade of metamorphism is consistent with steady increase from chlorite phyllite in the Bashbish Falls area to sillimanite-biotite-almandine-muscovite schist and muscovite-microcline-almandine-biotite schist in the Canaan Mountain region.

Note the presence here of early recumbent folds in S_1 having S_2, the early foliation, as the axial surface. S_2 is folded by S_3 to produce the prominent south-plunging folds.

Return to car via Appalachian Trail. Time permitting, we will go east to low knob in the woods, east of the house and across the narrow part of the pasture. Outcrop just east of top (elevation 1,200 feet) is an almandine-staurolite-biotite-plagioclase-muscovite schist of the Walloomsac Formation; the almandine and staurolite, interestingly, have compositions indistinguishable from those of the Everett Formation at Lions Head. The Fe/Fe+Mg ratio in the biotite is 0.50. The K/K+Na ratio of the muscovite is 0.74, and d_{002} = 9.93. The muscovite and biotite from this outcrop have yielded the isotopic ages given in the main text.

20.1 Return to corner at mileage 18.2. Continue straight ahead.

20.6 Road cuts are rusty weathering staurolite-almandine schist of the Walloomsac Formation.

20.9 Junction with Routes 41 and 44. Village of Salisbury. Turn left onto Route 44, going north and east.

21.0 Go straight ahead on Route 44.

22.2 Road cut of Walloomsac Formation.

22.8 Nearly flat-lying calcareous sandstone and interbedded marble; unit d of the Stockbridge Formation.

23.1 Salisbury School.

23.4 Turn right onto dirt road ("Wildcat Hollow Road"). Outcrops on the main highway ahead are coarse staurolite-almandine-biotite-muscovite-plagioclase-ilmenite-quartz schist of the Walloomsac Formation.

Mileage

23.5 Walloomsac Formation. Relative to the Walloomsac of the next stop, these outcrops have been downfaulted.

23.9 Pasture east (left) of road with tracks leading up to it. Drive into pasture and park. Stop B6.

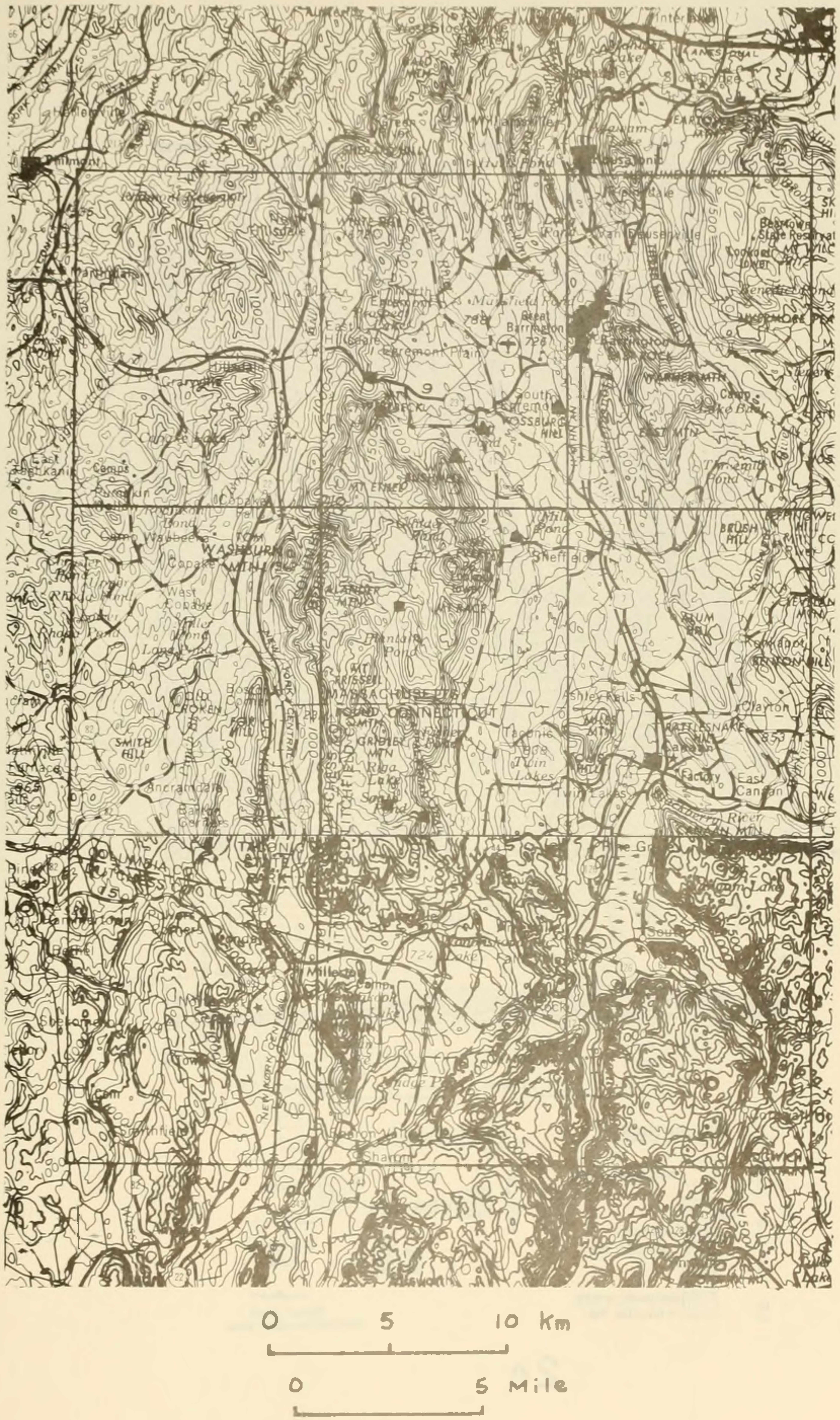
Unconformity of Walloomsac Formation on the Stockbridge Formation. Walk up the pasture east of the road. In the pasture, the low ledge is a buff-cream-weathering cream dolostone interbedded with silty phyllite, characteristic of unit b of the Stockbridge. Continue east into woods. Scattered outcrops are also unit b. Walk up to the base of the steep slope (elevation 950 feet); the outcrop is a massive grey dolostone typical of unit c of the Stockbridge. The contact of the two units shows a complex pattern. Measured axial-plane attitudes of minor folds and exposed contacts of units b and c all show that the axial plane of the larger fold dips east at low angle. Walk up the steep slope to the bluff at 980 feet. Here, grey massive dolostone is directly overlain by black calcite-biotite-plagioclase schist of the Walloomsac Formation. Erosion has exposed the contact in three dimensions; traces of bedding in the dolostone show up the angular unconformity. The origin of the silty material defining the bedding is uncertain: Could it be Walloomsac sediments deposited in weathered-out bedding cracks of unit c?

The unconformity surface has been folded into isoclinal folds whose attitude and style suggest the early, recumbent folds in both the Stockbridge Formation (e.g., stop A4) and in the Everett Formation (e.g., stops A6, B4, B5). The relations thus indicate that the early recumbent folding is later than the deposition of the Walloomsac Formation. (I am grateful to R. S. Stanley for first noticing these folds.)

At the north end of the bluff, fine mats of tremolite are developed as reaction rim along the contact. The top of the hill consists of the Walloomsac. The basal contact can be traced to the south and east, practically continuously for about 1/2 mile (1 km); at the east end of this contact the Walloomsac is directly on unit b of the Stockbridge.

Return to car, end of trip. Go north back to Route 44 for easy access to other major highways.

FIGURE CAPTIONS


MASSACHUSETTS
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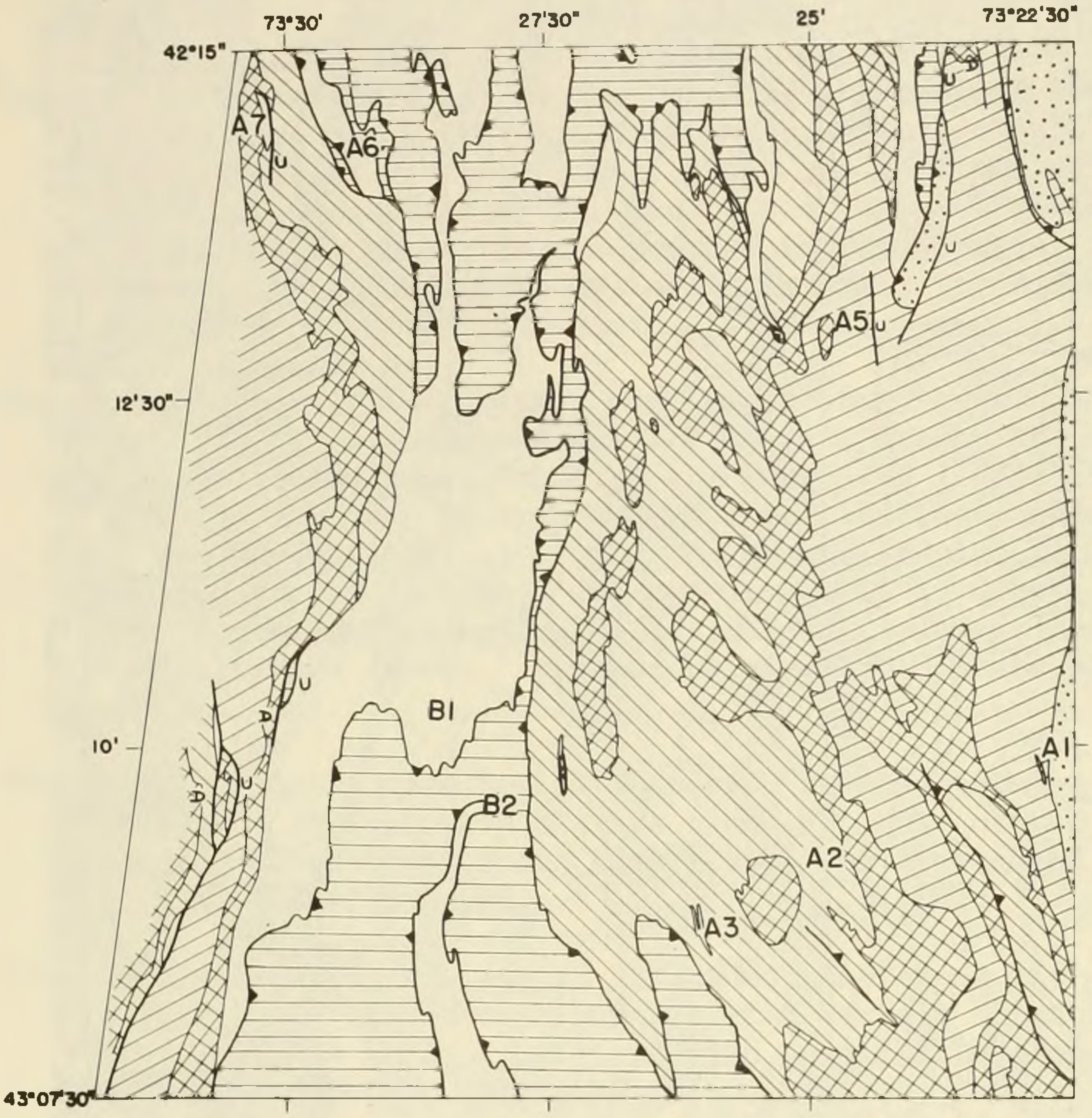
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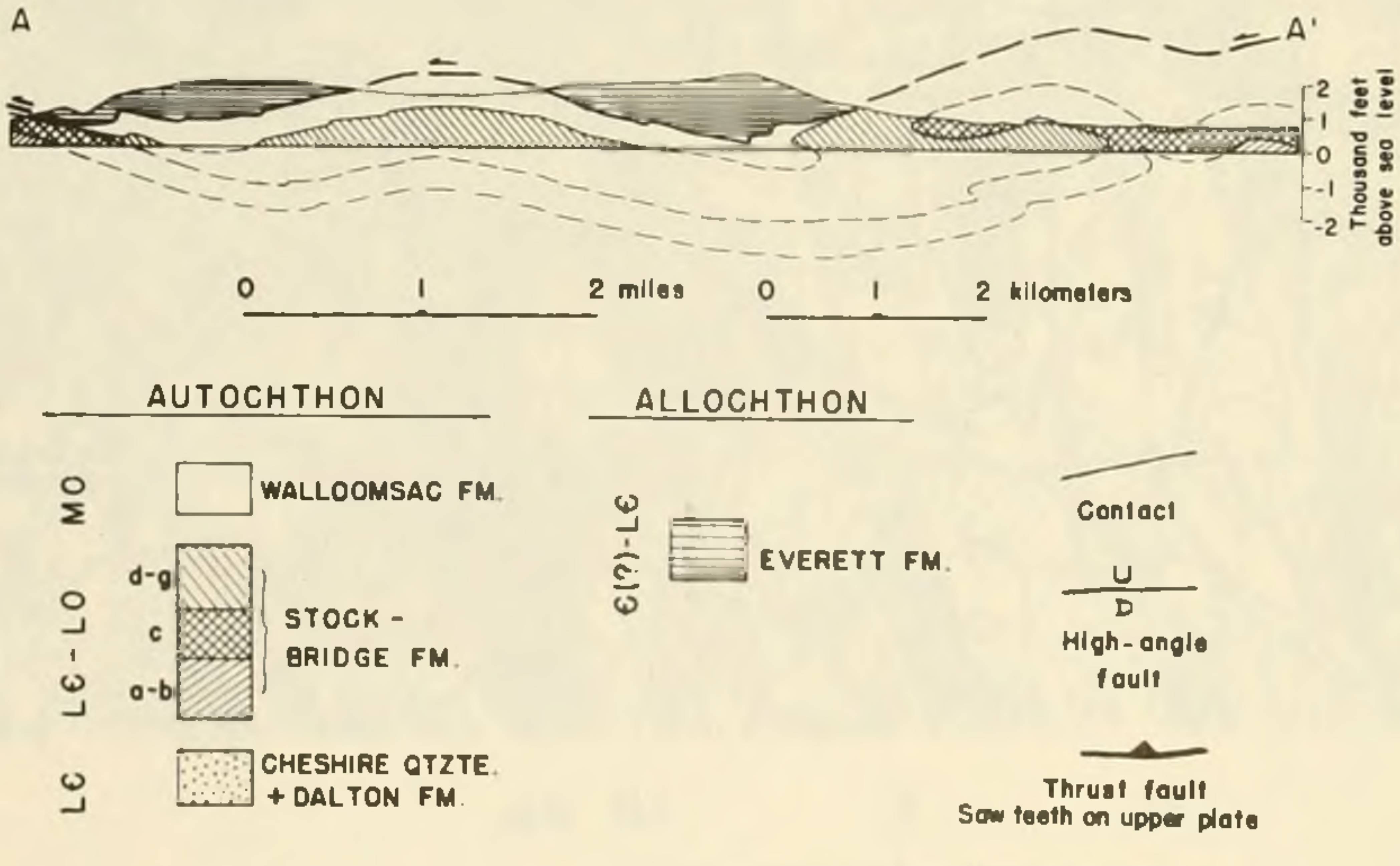
A7
A6
A5
A1
A2
A3
B1
B2

2a


A
A'
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Thousand feet above sea level
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AUTOCHTHON
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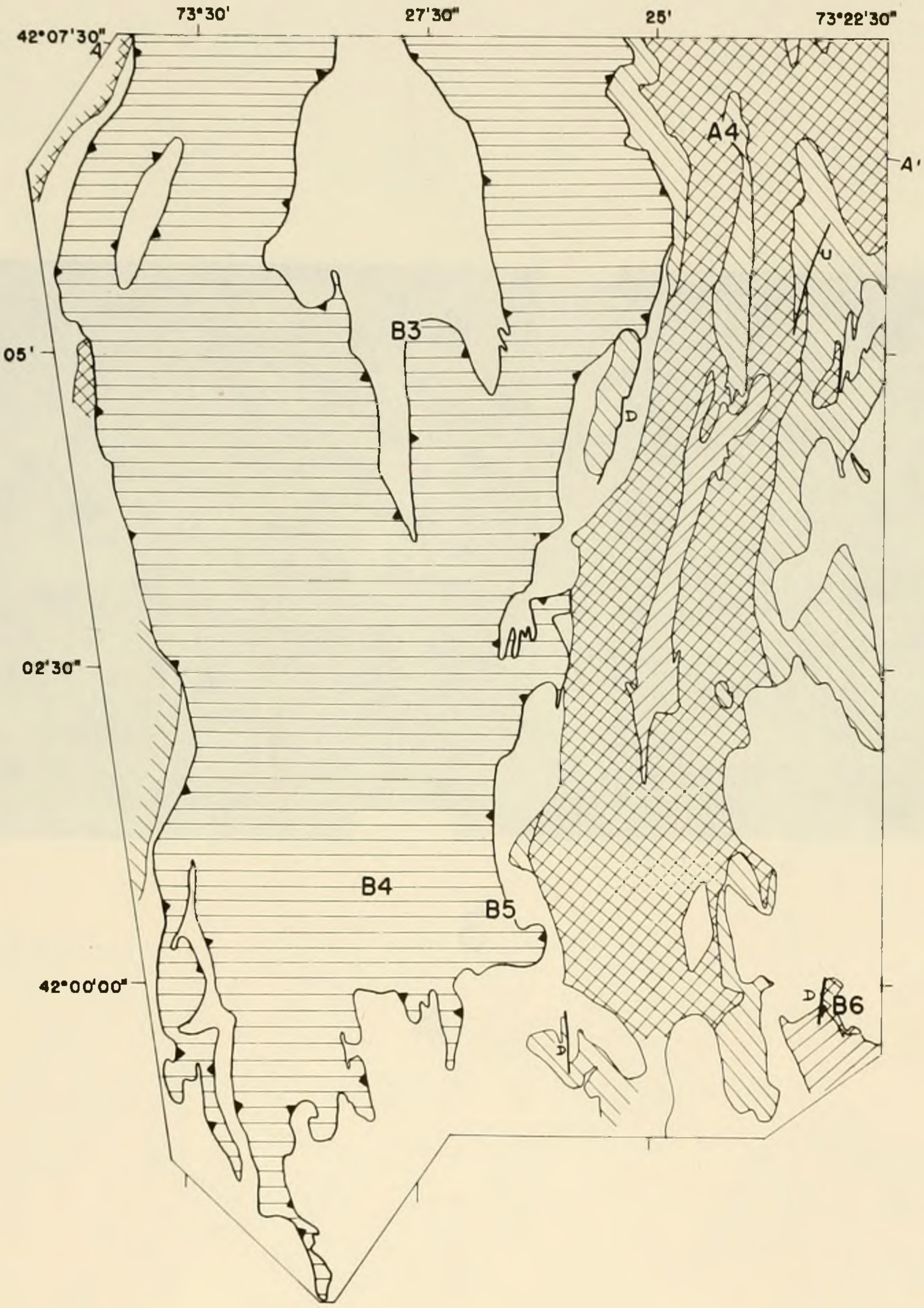
LC-LO
d-g
c
a-b
STOCK-BRIDGE FM.
LC
CHESHIRE QTZTE. + DALTON FM.
C(?)-LC
EVERETT FM.
Contact
U
D
High-angle fault
Thrust fault
Saw teeth on upper plate

2c



73°30'
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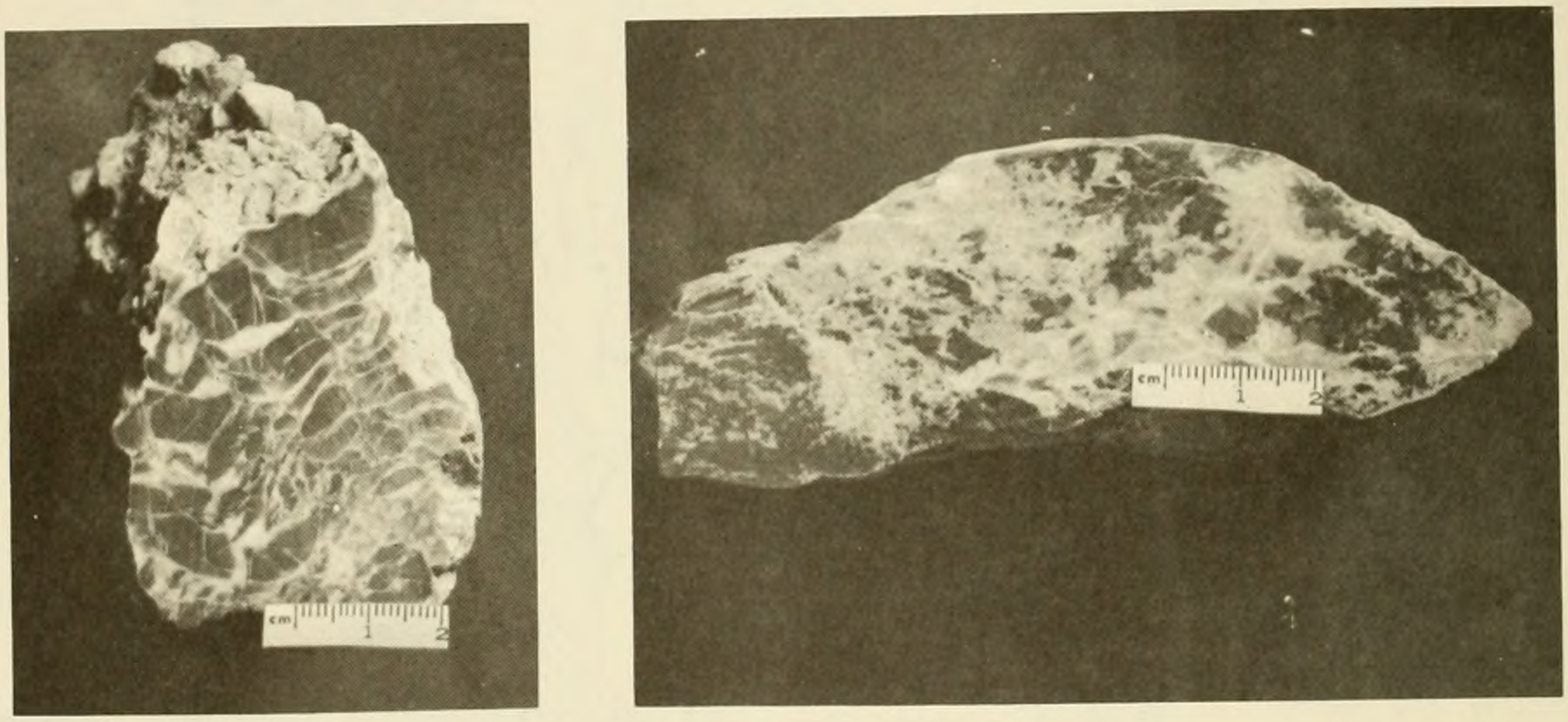
2b



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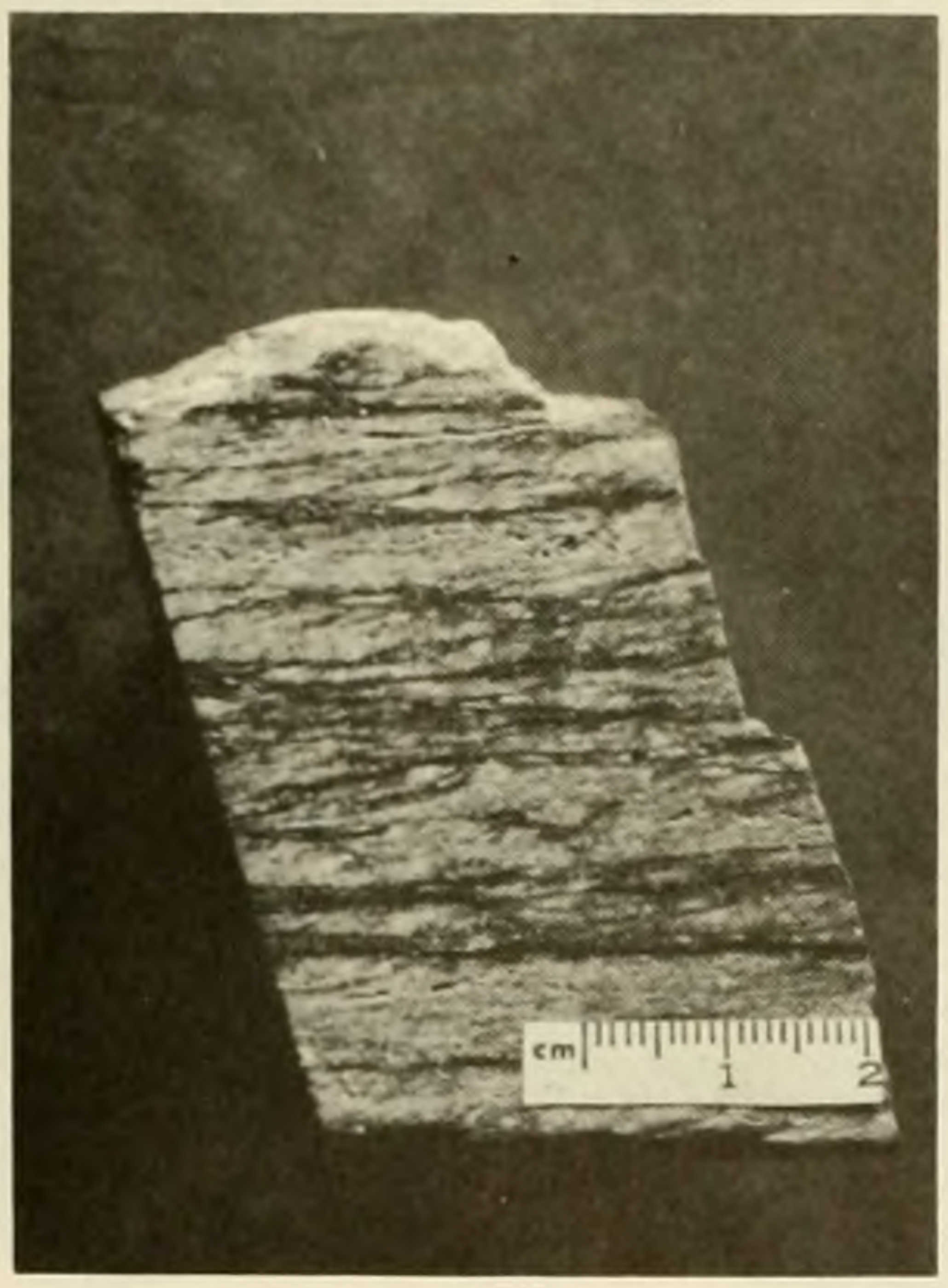

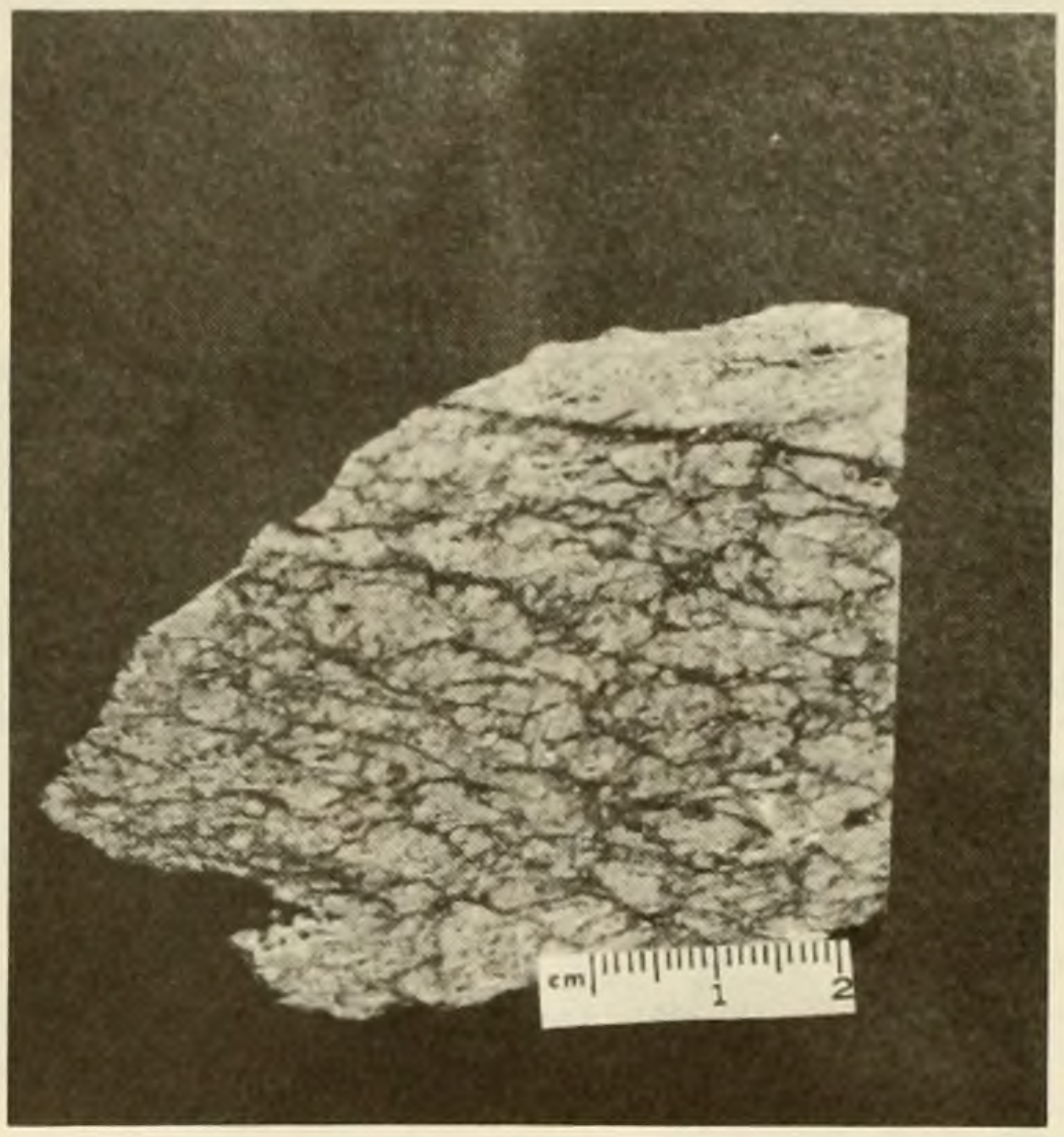

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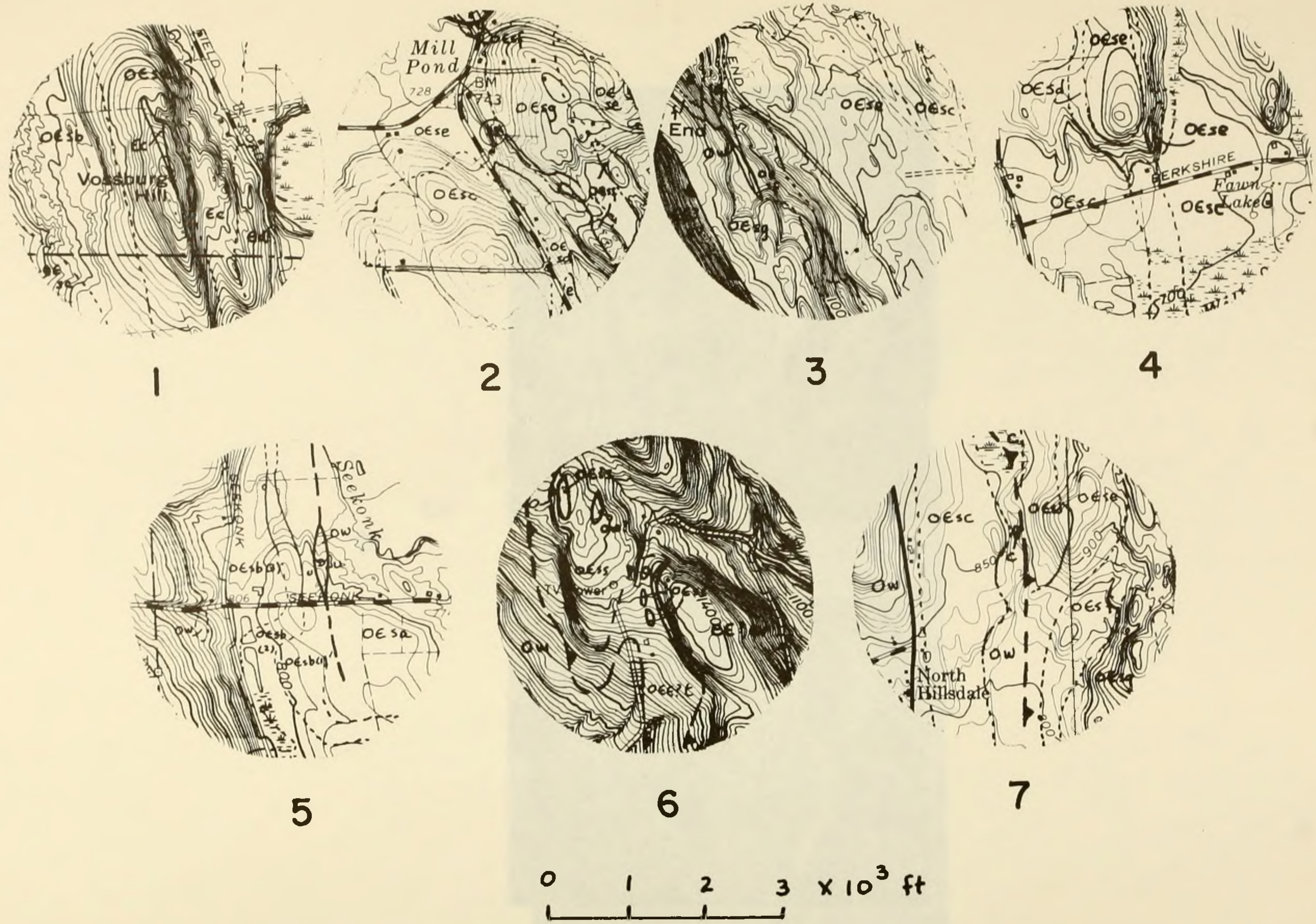
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BERKSHIRE
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SEEKONK
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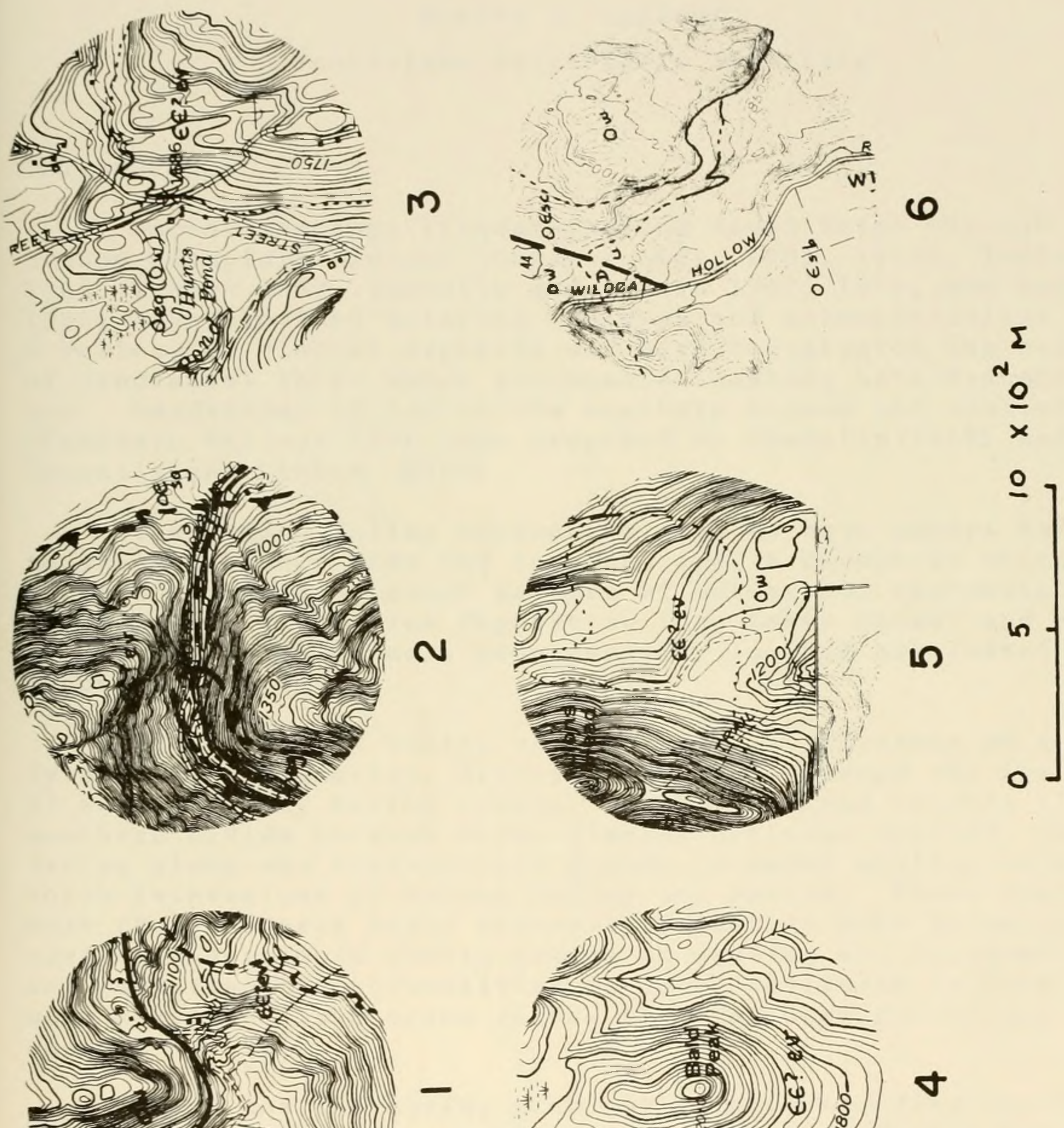
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Hunts Pond
STREET
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1350
1100
900
Bald Peak
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Brook
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TRAIL
WILDCAT
HOLLOW
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5b