U.S. Geological Survey. [Reports - Open file series]

BEDROCK GEOLOGIC MAP

OF

MONTEREY QUADRANGLE, MASSACHUSETTS

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U.S. GEOLOGICAL SURVEY

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Introduction

The Monterey quadrangle ~~lies~~ is near the western edge of the Berkshire Higlands (Fig. 1), just east of the major west-facing salient of Beartown Mountain in the Great Barrington quadrangle (Ratcliffe, in press). The Precambrian rocks of Beartown Mountain are connected to the east with the main mass of the Berkshires by the narrow east-west belt of gneiss north of Lake Garfield. The relationship of the Monterey quadrangle to major geologic features is shown in Figure 1.

Low-angle overlapping thrust faults of Precambrian and Paleozoic rocks dominate the western front of the Berkshire massif. From the north end of the South Sandisfield quadrangle, these fault slices overlap northward (Fig. 1). The higher hills in the Monterey quadrangle are underlain by Precambrian and Paleozoic rocks of the Beartown Mountain and East Lee slices, which are breached by erosion to expose highly deformed Stockbridge marble in the lowland near Monterey and in the Tyringham valley.

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The area has been multiply deformed and has been subjected to a Precambrian as well as possibly two Paleozoic metamorphisms. The sequence of tectonic events and structural features associated with each are described in Table 1. The low-angle overthrusting of the Beartown Mountain and East Lee slices and the ancillary Lake Buel, Dry Hill, and Hunger Mountain slices may have been emplaced during the end stages of the earliest Paleozoic metamorphism, but this faulting predated the high-grade staurolite-kyanite-sillimanite regional metamorphism responsible for the isograds. Thus the low-angle faults in Figure 1 and in Table 1 are classed as synmetamorphic with respect to the older Paleozoic metamorphism.

Previous investigation in the Monterey area was by Emerson, who discussed the calcium silicate mineralization in Hop Brook (1899, p. 52-55). Adjacent quadrangle reports are State Line, Stockbridge, Great Barrington (Ratcliffe, in press), Bashbish Falls (Zen and Hartshorn, 1966), and Egremont (Zen and Ratcliffe, 1971). Ratcliffe and Harwood (1975) discuss the regional significance of the blastomylonite fault fabric associated with overthrusts.

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	…eveloped in …ontercy …uadrangle	Characteristics of folds or faults	Important crystaloblastic and rock textures	Igneous activity and/or faulting	Metamorphic character	Orogenic Period
		No folds recognized	Hematite cemented breccia in high-angle fault at Dry Hill	High-angle reverse and normal faults trending NNE and NW	Post metamorphic	?
5		N. 25°-40° E. trending upright to ~~northwest~~ NE overturned folds of foliation or of slip cleavage with axial planar slip or crenulation cleavage	Sillimanite in axial surface of fold set 4; Ørenulat~~ion~~al near Abbey and Town Hills		Late or post metamorphic	Acadian
4		N. 30°-40° W.-trending upright to southeasterly overturned folds of foliation with axial planar slip or crenulation cleavage	Sillimanite aligned in axial surface foliation in southeast; elsewhere biotite, muscovite, garnet include earlier fabrics	Undeformed calc-silicate (diopside - plagioclase) deposits formed in older faults, healing faults	Barrovian regional metamorphism intensity increased to southeast overprints older metamorphism	Acadian
3		N and NNW-trending recumbent to strongly overturned and reclined folds of foliation (Paleozoic rocks) and of gneissic layering (Precambrian rocks) folds concentrated near low angle overthrusts	New mineral growth of biotite, muscovite, hornblende aligned in blastomylonite, mylonite gneiss and mylonite schist associated as axial planar foliation to isoclinal and recumbent minor folds in and near faults	Alaskite preferentially intruded or locally derived by partial melting in fault zones; alaskites are less sheared parallel to faults than country rocks but share weak subhorizontal cataclastic structure with surrounding rocks	Metamorphic grade sufficiently high to produce new lepidoblastic muscovite, biotite, and hornblende aligned in foliation in blastomylonite	Taconic
2		Strongly overturned folds of autochthonous rocks; axial traces highly variable owing to refolding, axial planar foliation with lepidoblastic muscovite, biotite	First-generation muscovite, biotite, and, in lower grade rocks to west, chlorite. Prominent schistosity in Paleozoic rocks formed		Regional metamorphism, grade increased to east	Taconic
			Angular unconformity and metamorphic discontinuity			

Stratigraphy

Precambrian rocks.--The Precambrian stratigraphy is largely the same as in the Great Barrington and Stockbridge quadrangles (Ratcliffe, in press) and will not be described again here. However, an extensive and well-exposed section of pЄbg in the Hayes Pond-West Otis area has been subdivided at a finer scale than in the quadrangles noted above. Newly recognized distinctive lithologies interlayered with pЄbg are: a greenish-yellow garnet-epidote-rich quartzose gneiss (pЄbe), a rusty aluminous schist (pЄbcr) associated with the calc-silicate rock, and an extensive hornblende gneiss and amphibolite unit (pЄbh).

The hornblende gneiss and amphibolite (pЄbh) (see explanation for lithologic discriptions) laterally replaces the gray biotitic paragneiss unit and the calc-silicate unit by interbedding. This hornblende-rich paragneiss is herein correlated with the type Lee gneiss in the East Lee quadrangle, originally defined as a meta-sedimentary unit by Emerson (1899, p. 33). The later usage as Lee Quartz diorite (Emerson, 1917, p. 153) should be abandoned and priority given to the previous name, based on remapping of the type Lee Gneiss in the East Lee quadrangle (Ratcliffe, unpublished data) where the type Lee is found in the identical stratigraphic position as pЄbh in this quadrangle.

No objection. Suggest you expand to indicate that there are several horizons of pЄbh at least that is what I see from [illegible].

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Tyringham Gneiss and other granitic gneisses.--The type Tyringham Gneiss (Emerson, 1898, p. 18; 1899, p. 34), exposed in the northern part of the quadrangle, is mainly a light-gray to pinkish-gray-weathering granodioritic biotite augen gneiss with ferrohastingsite and a distinctive quartz rodding. The border of the unit (p€ta) is a fine-grained alaskitic rock carrying microphenocrysts of microcline perthite at both its upper and lower contacts.

Excellent exposures north of Dimmock Road show dikes of augen gneiss porphyritic alaskite crosscutting gneissic layering in the Washington Gneiss. An indistinct compositional layering produced by slight variations in biotite concentration is seen locally and is shown by the symbol for parallel foliation and compositional layering. However, this layering is unlike the obvious relict sedimentary layering inthe paragneiss units.

The intrusive contact of the Tyringham against the felsic gneiss unit is unconformably overlain by the Dalton Formation northwest of Hayes Pond. The prominent metamorphic foliation responsible for granulation of the Tyringham and other Precambrian rocks also is angularly overlain by the Dalton Formation, thus demonstrating the Precambrian age of the Tyringham of its country rocks, and of the gneissic foliation. These data suggest the Tyringham may have been intruded syntectonically in the Precambrian dynamothermal event.

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Granitic gneiss (p€gg) in the southern and central parts of the quadrangle resembles the Tyringham closely but is locally coarser grained and spotted with large clots of biotite unlike the type Tyringham. Therefore, they are mapped separately, although they are probably coeval. Intrusive contacts of the granitic gneiss against Washington Gneiss can be seen at Abbey Hill, and against the calc-silicate unit northwest of Royal Pond.

Dalton Formation.--The basal member of the Dalton Formation (€p€dsc) overlies with angular unconformity the Precambrian gneisses from Hayes Pond to the northern edge of the map. The basal unit is highly feldspathic and variable in composition (see explanation), reflecting local derivation and lack of extensive reworking.

Structure

Beartown Mountain slice.--Precambrian and Paleozoic rocks of the Beartown Mountain slice override the entire Paleozoic sequence along its sinuously folded leading edge that runs from the Great Barrington border northeastward to the Hunger Mountain area and then southwestward to the South Sandisfield border. Continuity of the thin map units in the Precambrian gneiss east and west of Curtain Pond rules out any great movement on the northwest-trending faults in the Hop Brook area, and the Beartown Mountain slice is therefore essentially continuous with the Precambrian rocks northeast of the Tyringham valley. There are excellent exposures of the trailing edge of the Beartown Mountain slice on Cobble Hill in Tyringham (Ratcliffe, 1969a).

Thrusts ~~developed~~ beneath the Beartown Mountain slice.--The low-angle thrust slice of Dalton and Cheshire at Dry Hill (Dry Hill slice) overrides a lower thrust slice (Lake Buel slice) composed of Stockbridge and Walloomsac. The leading edge of the Lake Buel slice is exposed in the southwest part of the Monterey quadrangle, where it disappears to the east beneath the Precambrian rocks of the Beartown Mountain slice.

To the northeast, a thrust sheet (Hunger Mountain slice) composed of Dalton-Cheshire, Stockbridge, and Precambrian calc-silicate rock (pЄbcs) overrides Stockbridge A and B of the Lake Buel slice. Rocks of the Hunger Mountain slice evidently continue beneath the Precambrian rocks of the Beartown Mountain slice, based on exposures in two windows, one at Steadman Pond and the other in the open fields 7,000 feet north of Hunger Mountain. Figure 2 shows an enlarged cross-section of the latter area. They reappear at the surface at Cobble Hill and along the eastern side of the Tyringham valley. The Hunger Mountain and Dry Hill slices may be erosional remnants of a once continuous fault slice.

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Deformational structures associated with overthrusting.--A distinctive "fold-thrust" fabric, composed of vertically stacked isoclinal recumbent folds (Fold set 3) with amplitude to wavelength ratios of up to 15:1 and a penetrative blastomylonitic foliation, is found in the Dalton and Precambrian rocks above the Beartown Mountain and Hunger Mountain thrusts. The penetrative foliation crosscuts an earlier inclined foliation, resulting in reclined or nearly reclined folds of foliation that are indicated by a special symbol on the map. Dark-gray to black biotite-rich blastomylonite or mylonite gneiss (terminology follows Higgins, 1971, p. 11-13), 25 to 50 feet thick forms the base of the Beartown Mountain slice at Halls Hill and Cobble Hill. At both localities the intensity of cataclasis and recrystallization decreases away from the fault, as the isoclinal fold-thrust fabric with irregularly spaced, 1/4 to 1/2 inch seams of black blastomylonite becomes dominant.

What is the difference in the field between blastomylonitic foliation & foliation (regional)? How can reader [illegible] without explanation

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The special cross section, Figure 2, section E-E', shows the complex fold thrust fabric above the Hunger Mountain and Beartown Mountain thrusts north of Monterey. A strong foliation parallel to the Beartown thrust is the axial plane of numerous F_3 folds that are particularly well outlined by the calc-silicate units (p€bcs) and the hornblende gneiss (p€bh). Fold axes of the F_3 folds plunge down the dip of the axial surface at 15-20° toward the northeast, thus producing reclined folds. As a result, these folds project upwards into the section as shown. Parallel to and about 75 feet above the thrust a thin alaskite-aplite (ODa) has been intruded along the trace of the axial surface of the lowermost F_3 refold. Precambrian and Paleozoic rocks on both sides of the Beartown thrust have a strongly developed late blastomylonitic foliation.

Above the fault are isoclinal recumbent folds of larger wave length and amplitude than at the fault. However, these folds have the same penetrative blastomylonitic fabric. Folds of this kind are classed as fold set 3 on the map, and are particularly abundant north of West Otis and north of Hunger Mountain, where they appear to have formed as large-scale drag folds resulting from strong, east-over-~~north~~west movement of the main mass of the Berkshire massif. These folds plunge at gentle angles to the northeast down the axial surface and project into the cross section B-B' to the north. The small amount of throw on the thrust faults in the West Otis area indicates the complex deformation in this area was largely ductile.

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The ductile fold style and the blastomylonitic fabric, in which newly formed biotite, hornblende, epidote, and muscovite are aligned, indicate the overthrusting took place under metamorphic conditions of at least the quartz-albite-apidote-almandine subfacies of the greenschist facies (Winkler, 1967). Therefore, the thrust faults are synmetamorphic with respect to one of the metamorphic episodes that affected this area (see Table 1).

<u>Alaskite.</u>--Massive alaskite is found in six localities in the Beartown Mountain slice. Four exposures (north of Hunger Mountain, in Harmon Brook, in Rawson Brook, and on Cobble Hill) are at the sole of the thrust. In all places ~~cases~~ the alaskite shares a common foliation with the cataclastically deformed rock it intruded but is less intensely deformed than its host. Evidently alaskite was intruded or produced in situ during the overthrusting. Similar alaskites rich in magnetite are uniquely associated with thrust faults in the East Lee quadrangle to the north (Ratcliffe, unpublished data). Isotopic dating of these rocks might help determine the time of overthrusting of the basement rocks.

Direction of thrusting.--Analysis of F_3 drag folds in blastomylonite zones after the technique of Hansen (1971) has yielded slip line determinations for seven localities identified on the map (see explanation) that range from N. 60° E. to S. 75° E. on east-dipping fault zones and N. 88° W. from a west-dipping fault (Cobble Hill). The slip line directions determined from drag folds agree at the localities measured with estimates of slip direction from folded lineations and slickenslides on blastomylonite surfaces. After the removal of the effects of F_4 and F_5 folding, the slip lines are consistent with thrusting from the east.

Fold systems.--The axial traces of five fold systems are recognized on the map by special symbols and are further described in Table 1. The oldest folds (of Precambrian age) have a strong penetrative metamorphic foliation and were formed after intrusion of the Tyringham Gneiss but before deposition of the Dalton Formation. U-Th-Pb data from Tyringham and Washington Gneiss zircons (Ratcliffe and Zartman, 1971) indicate this metamorphism may be approximately 1030 m.y. old. This date is consistent with estimates of hornblende granulite grade metamorphism in Precambrian rocks in the Hudson Highlands, New York (Long and Kulp, 1962; Ratcliffe and others, 1972) and with the metamorphism of the "Grenville" metasediments of the Adirondacks of New York State (Silver, 1969). The Precambrian rocks originally trended east~~-west~~ but are now highly folded by four Paleozoic fold systems.

Fold set 2, of Paleozoic age, is responsible for the symmetrical repetition of Paleozoic rocks as young as the Walloomsac Formation. The prominent foliation in the Stockbridge and Walloomsac Formations probably formed during this event.

A crosscutting set (3) of overturned to recumbent folds ("fold thrust fabric") cuts both limbs of the older folds (1 and 2) and formed during overthrusting of the basement rocks from the ~~north~~east. During overthrusting the previously mentioned distinctive mylonite-gneiss-blastomylonite was formed as the axial surface to fold set 3.

Folds of set 4 trend northwestward and are largely upright, open, and fold the low-angle thrusts and older folds. An axial planar crenulation cleavage, slip cleavage, or foliation is developed in schistose rocks, and sillimanite is aligned in this axial surface near the eastern map border.

The fifth set of folds trends N. 25°-30° E., are open to tight, and are assymetrically overturned to the northwest. The intensity of this folding appears to increase to the southeast.

Data from quadrangles to the west (Ratcliffe, 1969a, b; Stockbridge, Great Barrington, and State Line quadrangles, Ratcliffe, in press) are contradictory regarding the relative ages of fold sets 4 and 5, because at different localities the sequence of superposition is not consistently developed, and in fact the folding may be contemporaneous. However, data in this quadrangle indicate the northeast-trending folds are the latest folds developed here.

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Aeromagnetic anomalies

Pronounced magnetic anomalies (Boynton and others, 1965) are found at 1) Halls Hill, 2) one-half mile northwest of Monterey in OЄsb, and 3) near Hunger Mountain. At Halls Hill, pЄgg contains unusually abundant magnetite in an area where the fold thrust fabric and blastomylonite are extremely well developed. Likewise, high-amplitude magnetic anomalies in the East Lee quadrangle (Popenoe and others, 1964) are produced by magnetite-rich granitic mylonite gneiss and associated alaskite concentrated in observable fault zones (Ratcliffe, unpublished data). The granitic Tyringham and other gneiss in the Great Barrington, East Lee, Monterey quadrangles are notably flat aeromagnetically except in fault zones. In these fault zones, ferrohastingsite and biotite show alteration to aggregates of microcline, plagioclase, epidote, and new magnetite forms abundant porphyroblasts. These observations suggest that magnetite enrichment was produced by metamorphic reactions coincident with thrust faulting, ~~and~~ formation of mylonite gneiss, and the alaskite. Therefore, the high-amplitude anomalies that have no relation to surface rocks, such as at Monterey and Hunger Mountain, and east of Phelps Swamp, may be caused by near-surface occurrences of similar zones of magnetite enrichment along buried thrusts. There is no evidence in the East Lee, Monterey, Great Barrington quadrangles that magnetite deposits are stratigraphic, and all available evidence indicates that magnetite enrichment sufficient to produce aeromagnetic anomalies is closely associated with ~~either buried or exposed overthrusts.~~

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Metamorphism

Precambrian rocks exposed in the Great Barrington quadrangle exhibit relict Precambrian assemblages (Ratcliffe, in press). However, such distinctions are not recognized in this quadrangle owing to recrystallization of all rocks to staurolite, kyanite, or sillimanite grade during the Paleozoic. Paleozoic fibrolitic sillimanite is widespread in the southeastern part of the map in the Washington Gneiss, and is present in the Walloomsac at Gould Road and on Dry Hill. The assemblage sillimanite-kyanite-garnet-quartz-biotite-muscovite is present in pЄbers near Geisler Swamp. Sillimanite has not been found north of that point, except at Washington in the northeast corner of Eigure 1, where relict (presumbbly Precambrian) sillimanite is abundant. The Paleozoic regional sillimanite isograd that runs N. 20°-25° E. from Pawling, New York (Fisher, et al., 1961), swings strongly east-northeast in the Monterey quadrangle.

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Nondeformed, vuggy diopside-hornblende-albite rock in the otherwise sheared rocks of the fault zone at Hop Brook (Emerson, 1899, p. 52-55) and beneath the Precambrian at Benton Hill in the Ashley Falls quadrangle (Ratcliffe and Burger, unpublished data) indicate recrystallization after thrusting. In addition, the sillimanite isograd is not offset by the thrusts. These data indicate that the thermal maximum of one metamorphic event postdated the emplacement of the basement rocks, although the overthrusting did take place under metamorphic conditions.

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There is abundant evidence for multiple deformation and metamorphism in this area (Ratcliffe, 1965, 1969a, 1972; Zen and Ratcliffe, 1971; and texts of Great Barrington, Stockbridge and State Line quadrangle reports, Ratcliffe, in press). The details of the various structural and metamorphic events as now recognized are presented in Table 1. Metamorphism occurred during Precambrian time (fold set 1), prior to and during thrusting of the basement rocks (fold sets 2 and 3), (Taconic orogeny?), and after thrusting (fold sets 4 and 5) (Acadian orogeny?). Textural relations of metacrysts in adjacent quadrangles (Ratcliffe, 1969a) and the crystallization of sillimanite in the axial-plane foliation of fold set 4 in the eastern part of this quadrangle indicate that the maximum thermal event occurred during the formation of fold set 4. These data are consistent with the observations of Harwood (1972, p. 19) that the northeast-trending late folds in the South Sandisfield quadrangle crenulate coarse sillimanite. The absolute ages of these events are as yet uncertain, but the early metamrophism and the basement thrusting may be Ordovician, and the later thermal event Acadian. The details of the structural deformations and metamorphic chronology are outlined in Table 1.

The reader is referred to the texts of the Great Barrington and Stockbridge quadrangles for discussions of the tectonic history of this area.

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Applied geology

During construction of the Lake Garfield Dam, drill holes and excavations penetrated a highly weathered, unstable substratum of clay approximately 4 m (12.8 ft.) thick. The excavation exposed the sole of the Beartown thrust in which highly cataclastically deformed gneissic (p€bg) overlies Dalton. The peculiar clay with irregular- to regular-sided green and white pseudomorphic clots was found in pods in the horizontal fault zone. Evidently the clay zone resulted from subsurface weathering of the crushed feldspathic Dalton and small pegmatite bodies that had intruded into the fault zone. Most of the large, continuously flowing springs in the quadrangle are ~~lo-cated~~ near the base of the Beartown Mountain or Dry Hill slices, and probably result from impermeable clayey zones similar to that exposed at the Lake Garfield Dam. If the structural interpretation of the Hunger Mountain slice is correct, the windows at Steadman Pond and the one to the east may be important recharge areas for subsurface water in the southern end of the Tyringham valley.

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Monterey, Mass quad - revised 1/74 - 1/75

DESCRIPTION OF MAP UNITS

(Major minerals are listed in order of increasing abundance)

BEDROCK OF THE AUTOCHTHON AND PARAUTOCHTHON

(Parautochthon includes all rocks of the Berkshire massif and their attached metasedimentary cover--parts of the Dalton, Cheshire, and Stockbridge Formations; allochthonous rocks belonging to the Everett Slice of the Taconic allochthon not present in this quadrangle are exposed to the west in the Stockbridge, State Line, and Egremont quadrangles)

ALASKITE (LATE ORDOVICIAN? TO DEVONIAN?)

ODa

Massive white, extremely fine grained, chlorite-biotite-muscovite-microcline-quartz oligoclase (An_{15}) alaskite in irregular pods near or in low angle synmetamorphic thrust faults of basement gneiss. Rock resembles blocky fractured quartzite in most exposures, and planar structures are difficult to detect. However, a weakly developed foliation parallel to intensely developed blastomylonitic foliation in country rocks is present.

Because the alaskite is less sheared along faults than its country rocks, the alaskite probably was intruded during the late stages of the overthrusting and may have been generated by partial melting of Precambrian granitic rocks such as the Tyringham Gneiss in the faults. Mineralogically this alaskite differs from the white alaskitic border of the Tyringham Gneiss in lacking ferrohastingsite and perthitic ~~microcline, in contain~~ing ~~abundant sodic plagioclase and lacks~~

OЄsa grades into the underlying Cheshire Quartzite in Hop Brook west of Tyringham, ~~and~~ west of Monterey, and 6,000 ft. southeast of Dry Hill where a tremolite-rich calc-silicate rock approximately 5 m thick marks the transitional zone. The unit is not well exposed in this quadrangle, and its thickness appears to be quite variable regionally. In adjacent quadrangles it measures approximately 213 m (700 ft.), but exposures in Hop Brook northwest of Tyringham indicate a thickness of only 23 m (75 ft.)

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CHESHIRE QUARTZITE (LOWER CAMBRIAN)

Mainly massive white- to pinkish-tan-weathering, vitreous metaquartzite, commonly well-jointed and poorly bedded, containing accessory detrital microcline, zircon, tourmaline, and rutile. Bedding shown by laminated quartzite interbeds with silvery muscovitic partings, metaquartzite spotted with magnetite, or by thin intercalated yellow-tan porous-weathering feldspathic metaquartzites. Cheshire Quartzite is composed predominantly of metaquartzite beds with less than 5 percent feldspathic impurities, although feldspathic metaquartzites are interbedded. Rocks composed predominantly of beds of more feldspathic metaquartzite are assigned to the Dalton

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Formation, which is partly a lateral equivalent of the Cheshire Quartzite. The thickness ranges from 7.6 m (25 ft.) to approximately 91 m (300 ft.)

DALTON FORMATION (LOWER CAMBRIAN AND PRECAMBRIAN(?))

ЄpЄd

Mainly yellow-tan-weathering, black-biotite-spotted, muscovitic, feldspathic metaquartzite containing scattered metacrysts of black tourmaline, commonly finely laminated on a mm scale but massive appearing in large outcrops. Feldspar, largely microcline, exceeds 5 percent, and commonly ranges from 15 to 25 percent; red-brown pleochroic biotite ranges from 2 to 25 percent; and muscovite from 2 to 27 percent. This lithology represents the bulk of the Dalton. However, with loss of quartzose interbeds and increase of micaceous and feldspathic impurities, several other rock types have been mapped separately

Yellow-gray to buff-weathering, tourmaline-rich flaggy metaquartzite with beds 1 to 4 cm (0.4 to 1.6 in.) thick or as massive outcrops as much as 5 m (16 ft.) thick of yellowish-gray-weathering feldspathic metaquartzite containing black spots of magnetite and small weathered-out pits of kaolinite that results in a porous, easily crumbled rock where deeply weathered.

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ЄpЄdqc White-weathering, quartz pebble and cobble quartz cemented metaconglomerate at base of ЄpЄdq, best exposed at Hale Swamp, north of the Tyringham Valley. Unit grades laterally into fine-grained metaquartz sandstones of Єp Cdq. The unit is 0 to 10 m (0 to 33 ft.) thick.

[redacted] The basal unit is heterogeneous and consists of the following rock types interbedded on a scale of meters. Dark-gray, rusty-weathering, lustrous tourmaline-quartz-microcline-biotite-muscovite schist with plates of muscovite 0.3 to 0.5 m (0.1 to 0.2 in.) in diameter; finely laminated and cross-laminated, black- and white-spotted, biotite-microcline-plagioclase-quartz and microcline-plagioclase-biotite-quartz metagraywacke or arkosic metasandstone; dark-gray, microcline-biotite-plagioclase-muscovite-quartz schist spotted with equant porphyroblasts of oligoclase 1 to 2 mm (0.04 to 0.08 in.) in diameter and a distinctive dark-gray to silvery-gray biotite muscovite schistose metaconglomerate with stretched pebbles of white quartzite as much as 5 cm (2 in.) long, encrusted with growths of black tourmaline. In all varieties black tourmaline is abundant, commonly aligned in the oldest foliation. A 1 m (3.3 ft.) thick muscovite-microcline-quartz and tourmaline-quartz-muscovite schist with plates of muscovite 0.7 to 1 cm (0.27 to 0.39 in.) in diameter is found locally at the top of the Tyringham Gneiss beneath the Dalton south of Camp Brook. This schist contains structures common to the underlying Tyringham and passes through a transition zone 0.25 m (0.7 ft.) thick into normal Tyringham Gneiss. This schistose zone probably represents a metamorphosed saprolite developed beneath the ~~L~~ate Precambrian(?) to Lower Cambrian unconformity

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GNEISSES OF THE BERKSHIRE MASSIF

INTRUSIVE ROCKS (ORTHOGNEISS)

pЄtg

TYRINGHAM GNEISS (PRECAMBRIAN)- -Pinkish-gray to light-gray, ferrohastingsite-biotite-quartz-plagioclase-microcline perthite metaintrusive granitic gneiss commonly coarsely blastoporphyritic and strongly sheared. Individual microperthitic microcline phenocrysts as much as 6 cm (2.36 in.) long are granulated along borders parallel to the dominant foliation and are cross cut by fractures. Many contain irregular cross-cutting plagioclase replacement veinlets, or rims of granular oligoclase. Plagioclase in the groundmass is broadly zoned from cores of calcic oligoclase or andesine to sodic oligoclase rims with myrmekite at contacts with microcline phenocrysts. Ferrohastingsite, up to 8 percent of rock, is a common mineral in muscovite-poor rocks. Massive appearing outcrops commonly have a poorly defined irregular compositional layering resulting from minor changes in biotite concentrations. This layering is extremely difficult to detect, and is different from the distinct compositional banding found in other Precambrian gneisses. Elliptical elongated segregations of quartz and feldspar sheathed in biotite form a prominent lineation that lies in the penetrative foliation. This lineation is the most obvious structural feature in many exposures. Muscovite, biotite, fine-grained granular nonperthitic microcline, and trails of yellow allanite with rims of epidote or concentrated in zones of intense shearing along the Precambrian foliation

pCtga

Light-gray, fine-grained magnetite, microcline microperthite-quartz- calcic oligoclase alaskite (pCtga) with minor amounts of ferrohastingsite or muscovite and prominent microphenocrysts of microcline-perthite, forms the border of the Tyringham gneiss at most localities. The alaskite grades imperceptably into typical Tyringham by addition of biotite, increase in phenocrysts of perthitic microcline, and coarsening of plagioclase and quartz segregations.

The unit forms dikelets crosscutting bordering gneiss units north of Dimmock Road, and the dikes are cross-foliated parallel to the intense Precambrian foliation in the country rocks. Quartz and feldspar rods lie in this foliation and distinguish this unit from the younger alaskites (ODa) associated with the synmetamorphic thrust faults. This fine-grained unit is interpreted as a narrow chill zone formed at the edge of a sill-like intrusion.

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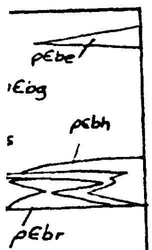
pЄgg BIOTITE-QUARTZ-MICROCLINE-PLAGIOCLASE GRANODIORITE GNEISS--Light-gray to pinkish-gray, coarse-grained ferrohastingsite biotite-quartz-microcline-plagioclase granodiorite gneiss, with indistinct compositional layering and locally well-developed quartz rodding. The unit resembles closely the Tyringham Gneiss but contains coarse biotite splotched granitic gneiss and granulite not found in the type Tyringham. Crosscutting contacts can be seen in outcrop against Washington Gneiss and the biotite-quartz-plagioclase paragneiss and calc-silicate units at Abbey Hill and north of Royal Pond respectively. At these localities dikes 1-3 m thick of pЄgg crosscut quartzite beds in pЄwq and diopside-hornblende calc-silicate layers in pЄbcs. The dikes are, however, strongly foliated across their intrusive contacts parallel to the gneissic layering in the country rocks

PARAGNEISS AND METAVOLCANIC ROCKS (PRECAMBRIAN)



cs

BIOTITE-QUARTZ-PLAGIOCLASE PARAGNEISS--Mainly dark-gray to light-gray, well-layered, fine-grained, quartzose, plagioclase-rich, biotitic paragneiss (p€bg) containing interbeds of yellow-gray to tan-weathering granitic gneiss and biotite schist. Thin 2 to 10 cm mafic layers are fine-grained flinty-textured, biotite-rich, plagioclase- and quartz-bearing amphibolite or yellow-green epidote-biotite schist, and lesser well-layered green hornblende amphibolite. The unit contains a distinctive light- to medium-greenish-gray, garnet-epidote-quartz±magnetite calc-silicate gneiss (p€be) that weathers to a deeply pitted surface with aggregates of quartz raised in relief above a matrix composed of granular yellow-green epidote and cinnamon-brown garnet 1 to 2 mm (0.4 to 0.8 in.) in diameter. The epidote content varies from 5 to 30 percent of the rock. The unit is not present in all exposed sections of p€bg and varies from 0 to 15 m (0 to 50 ft.)

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An irregularly developed calc-silicate horizon (pЄbcs) in or at the base of pЄbs contains yellow- to beige-weathering calcite-chondrodite-diopside-zinnwaldite marble, chondrodite-dolomite marble, massive dark green diopside-hornblende-sphene-plagioclase rock, diopside-hornblende-microcline granulite, well-bedded diopside-garnet rock interlayered on a cm scale with diopside-calcite marble, and diopside-scapolite rock. Associated with the calc-silicate rocks are thin microcline-plagioclase-sphene-bearing aplites and pegmatites. Exposures adjacent to granitic gneiss north of Royal Pond contain fosterite-clinohumite-calcite marble, and calcite-titaniferous clinohumite-diopside rock extensively altered to vesuvianite and chlorite. The fault sliver of pЄbcs in Hop Brook is massive greenish-gray diopside rock that contains vuggy fillings of coarse, dark-green diopside and albite in crystals up to 2 cm (0.8 in.) long and in adjacent to the faults. Evidently crystallization of the coarse diopside and albite postdated the faulting there. Associated with the calc-silicate unit near Hayes Pond is a coarse-grained orangish-brown-weathering sillimanite-kyanite biotite muscovite schist and magnetite-garnet-muscovite schist (pЄbcrs). This schist is up to

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10 m (33 ft.) thick but commonly is much thinner and is interbedded with the calc-silicate unit (pꞒbcs) on a meter scale. Black and white biotite-hornblende-microcline-plagioclase gneiss (pꞒbh) well-layered on a mm to cm scale and plagioclase-rich granulite spotted with 0.5 cm (0.2 in) spots of dark-green hornblende and biotite, both with stringers of coarse hornblende-diopside pegmatite near exposures of calc-silicate (pꞒbcs). Biotite-quartz-plagioclase paragneiss (pꞒbg) replaces the hornblende gneiss laterally and vertically by interbedding. pꞒbh occupies the same position with respect to pꞒcs and pꞒbg as does the Lee Gneiss (Emerson, 1898) in the East Lee quadrangle (Ratcliffe, unpub. data) and probably is correlative

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RUSTY SCHISTOSE GNEISS AND GRANULITE --Rusty-weathering, mucsovite-biotite quartz-ribbed gneiss or granulite, quartzo-feldspathic granulite, and biotite-muscovite schist with 1 cm porphyroblasts of microcline. Unit is characteristically biotitic, well layered, and fine grained and is crosscut by poorly-defined migmatitic layers containing perthitic microcline. Rusty-weathering, yellow-stained graphitic schist and associated pale-greenish-gray tremolite-actinolite calc-silicate rocks (p€rcs) are sparse but distinctive minor lithologies. Exposures south of Cobble Hill and north of Swan Brook contain rusty blue quartz gneiss and white quartz plagioclase granulite spotted with irregular splotches of biotite up to 2 cm (0.8 in.) in diameter, similar to Washington Gneiss (p€wg). The unit evidently thickens at the expense of p€bg with which it interfingers, but appears to disconformably overlie p€fg locally, as north of Swan Brook. Black, dense, fine-grained sphene-garnet-hornblende-plagioclase amphibolite (p€amp) interlayered in p€brs at its contact with p€bg may be metabasalt dikes or flows, or metamorphosed calcareous shales

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BIOTITE-MAGNETITE FELSIC GNEISS--Medium-gray to pinkish-gray-weathering, massive, well-foliated, biotite-quartz-microcline-plagioclase granitic gneiss studded with minute octahedra of magnetite. Rock is fine-grained, even textured, and poorly layered in most exposures. Locally more coarsely crystalline granitic gneiss having alternating 0.5 cm (0.2 in) thick pink, microcline-rich, and black, biotite-rich layers is distributed throughout pЄfg. The generally darker gray color, finer-grained texture, and more evenly distributed quartz and biotite distinguish this unit from pЄtg and pЄlg. Unit contains 3 to 5 mm (1.2 to 1.9 in.) perthitic microcline porphyroblasts crystallized across zones of granulation, unlike the porphyroblasts of microcline microperthite in the Tyringham gneiss that are strongly granulated along the Precambrian foliation. The contact with pЄbg or with calc-silicate rocks in adjacent quadrangles is sharp. The contact with pЄag appears to be gradational as a result of interbedding with amphibolite. The general massive, nonlayered aspect of this unit together with its rather uniformly felsic composition suggests a protolith of felsic volcanic material

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HORNBLENDE-GARNET AMPHIBOLITE AND AMPHIBOLITIC GNEISS--Dark-greenish-gray, hornblende-rich gneiss and amphibolite interlayered with biotite-plagioclase-quartz gneiss with individual beds of rusty-weathering, nonlayered coarse-grained hornblende-garnet-plagioclase-magnetite amphibolite as much as 5 m (16 ft) thick, or black and white hornblende and plagioclase granulites having an average grain size of about 2 mm (0.08 in). Amphibolites lack or contain only traces of quartz and biotite distinguishing them from the biotite-rich quartz-bearing amphibolites interlayered in p€bg. Some amphibolites contain relict monoclinic pyroxene almost wholly altered to dark-green to bluish-green-pleochroic hornblende. Locally garnets have alteration rims of hornblende and red-brown biotite. The rocks differ markedly along strike, varying texturally from well-layered amphibolites to massive hornblende-garnet rock to black and white granulite. Each variety is intercalated with well-layered hornblende-biotite plagioclase gneisses suggesting a protolith of basaltic volcanic rocks and volcanic derived sedimentary rocks

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pЄlg

LEUCOCRATIC BIOTITE GNEISS AND GRANULITE--Light-gray to yellowish-gray-weathering leucocratic biotite granitic gneiss and quartz-microcline-plagioclase biotite-poor granulite interlayered in varying proportions. The rock has indistinct layers parallel to foliation and with ~~irregular~~ streaks of granulated microcline and quartz, and ~~scattered~~ clots of biotite scattered irregularly throughout the matrix. Contacts with pЄag and pЄwg appear to be sharp. The origin of this unit is uncertain and may be either intrusive or a metamorphosed felsic volcanic rock

WASHINGTON GNEISS AND ASSOCIATED RUSTY BIOTITE GNEISS AND AMPHIBOLITE UNIT

pЄwg Mainly dark-colored, rusty-weathering, biotite-rich muscovite, lavender- or white-quartz-bearing gneiss, metaconglomerate, and quartz granulite with 2 to 5 mm (1.2 to 1.9 in.) flakes of graphite. Anastomosing ribs of rutile containing lavender quartz 0.5 to 1 cm (0.2 to 0.39 in.) thick stand out in positive relief against the finer-grained matrix composed of granular andesine, irregular clots of both green and brown biotite, hornblende, garnet, and scattered pockets of scapolite and rarely kyanite. Intensely blue quartz is only found on the low side of the sillimanite isograd. Interbedded white, mica-poor, plagioclase-rich quartz containing granulite of dacitic composition with scattered dark-reddish-brown garnet and irregular scattered clots of biotite and sillimanite is interlayered on a meter scale with blue-quartz pebble metaconglomerate and gneiss (pЄwg), which it laterally replaces. Exposures at Sky Hill and at the head of Crystal Brook contain garnets extensively retrograded to biotite; whereas in areas farther up metamorphic grade to the southeast biotite reaction rims on garnets are absent. Kyanite is found in pЄwg(?) at the southwest corner of the map and west of Dorman Mountain at the northern border of the quadrangle

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p€wcs

Thin 1 to 2 m (3.28 to 6.5 ft.) thick yellow-brown, rusty, punky-weathering pyrite-diopside calcite calc-silicate, yellowish or gray diopside rock (p€wcs) is interbedded on a meter scale with p€wg

p€wb

Well-laminated, gneissic light-gray to rusty-gray-weathering biotite, plagioclase-microcline quartz metasandstone or metagraywacke with interbeds of muscovite-biotite schist and dakk-rusty brown biotite-quartz schist. The unit is distinguished from p€wg by its lack of quartz ribbing and less schistose texture

p€hg

Fine- to coarse-grained, massive, hornblende-garnet amphibolite and well-layered hornblende-plagioclase-biotite gneiss and hornblende schist interlayered on a saale of tens of meters. Unit interfingers with all lithologies of the Washington Gneiss and may represent different metamorphosed mafic volcanic flows, intercalated throughout the Washington Gneiss

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SPECIAL ROCK TYPE

O?bm BLASTOMYLONITE AND MYLONITE GNEISS--Dark-gray, fine-grained 0.2 to 0.5 mm (.008 to .02 in.) biotite-muscovite-microcline-plagioclase-quartz-mylonite gneiss and blastomylonite with porphyroclasts of granitic and other gneisses up to 3 cm (1.3 in.) thick but more commonly 1 to 3 mm (.04 to .1 in.) thick. Excellent exposures up to 3 m (10 ft.) thick can be seen along the sole of the Beartown Mountain slice from Halls Hill south to the quadrangle border, at Cobble Hill, and north of Lake Garfield. Unit is too thin to be shown individually but is identified by symbol (O?bm) and pointers.

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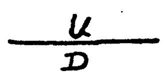
CONTACT--Long dashed where approximately located; short dashed where inferred beneath thick glacial cover; dotted in water

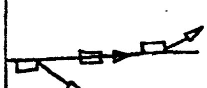
FAULTS--Long dashed where approximately located; short dashed where inferred beneath thick glacial cover; dotted in water

Synmetamorphic--Sawteeth on upper plate. Formed synchronous with foldset 3 below, folded by foldsets 4 and 5 and locally overturned



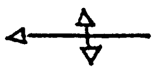
Steep fault--Postmetamorphic--U, upthrown side, D, downthrown side

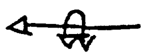
MAJOR FOLDS--Showing approximate trace of axial surface and direction of plunge. Arrows show direction of dip of limbs, barbs show dip direction of axial surface. Folds are classed by age of formation based on superposition of folds from 1, the oldest, to 5, the most recent

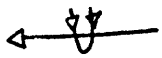


Foldset 1--Probable Precambrian fold. Bar shows dip direction; arrow shows bearing and plunge of axis. Folds are not classed by direction of closure because of highly variable attitude. Dominant foliation or gneissosity is axial planar to foldset 1

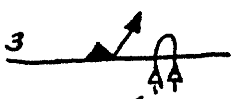
Foldset 2--Folds of bedding in Paleozoic rocks

 Anticline

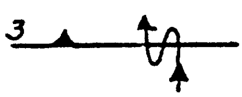
 Overturned anticline

 Overturned syncline

Foldset 3--Folds of foliation in Paleozoic and Precambrian rocks, related to overthrusting of basement gneisses. Dip direction of axial surface foliation shown by attached barb, plunge direction identified where known.

 Overturned synform

 Overturned antiform

 Inverted anticline, oldest rocks in core of fold and in inverted sequence

Foldsets 4 and 5--Open to tight folds of foliations affecting rocks above and beneath synmetamorphic thrust faults, generation shown by superscript. Foldset 4 tends northwest, has axial planar foliation in east, and crenulation or slip cleavage in west. Foldset 5 trends northeast and has axial planar crenulation or slip cleavage

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Antiform

Synform

Folded fold axis--Showing approximate orientation and direction of plunge as seen in outcrop. Plunge value indicated where observed to be relatively uniform, otherwise not indicated

PLANAR FEATURES--Where two symbols for planar features are combined, the younger feature is indicated by a solid triangle or rectangle; their intersection marks point of observation

Strike and dip of bedding--Ball indicates top of beds known from sedimentary features

Inclined

Vertical

Horizontal

Right-side-up

Upside down

Strike and dip of foliation

Inclined

Vertical

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Strike and dip of parallel foliation and bedding

Inclined

Vertical

Strike and dip of parallel composition layering and foliation (gneissosity) in Precambrian rocks

Inclined

Vertical

Strike and dip of gneissic foliation in Tyringham and other granitic gneiss without distinct compositional layering

Inclined

Vertical

Strike and dip of slip cleavage or of ~~second~~ younger foliation in Precambrian and Paleozoic rocks

Inclined

Vertical

Strike and dip of axial surface of isoclinal fold in bedding (Paleozoic rocks) or parallel compositional layering and foliation (Precambrian rocks). In both Paleozoic and Precambrian rocks the folds have a well-developed axial surface foliation

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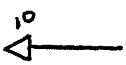
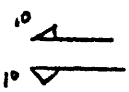
Strike and dip of axial surface of isoclinal to tightly appressed folds in foliation (foldset 3) and of blastomylonitic foliation. In both Paleozoic and Precambrian rocks the folded surface is an older axial-surface foliation; folds are concentrated near synmetamorphic thrust faults and have axial planar foliation in which biotite, hornblende, muscovite are aligned parallel to zones of crushing and shearing spaced 1 mm (0.039 in.) to centimeters apart. Shear zones are composed of gray fine-grained seams of blastomylonite. The intensely developed axial planar blastomylonitic foliation is expressed in thin section by minute 0.5 mm thick zones of cataclasis marked by granulation of feldspar, quartz, biotite, and hornblende and by recrystallization of a second generation of finer grained biotite and muscovite. Stringers of crushed rock rich in newly crystallized clinozoisite and magnetite are aligned along the shear zones. This new foliation is both cataclastic, as shown by the milling of preexisting minerals, and metamorphic, as shown by the crystallization of new lepidoblastic and (retrograde) mineral assemblages in the sheared zones. This feature is widespread and is uniquely associated with deformation along the soles of the basement overthrusts throughout the Berkshires (see Ratcliffe and Harwood, 1975)

Strike and dip of axial surface of post-thrust open to light folds in foliation. Foldset identified by superscript

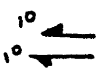
LINEAR FEATURES

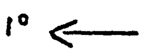


Bearing and plunge of axis of minor fold in bedding (Paleozoic rocks) or of first generation fold in Precambrian rocks. Half arrow indicates side that move up for a drag sense



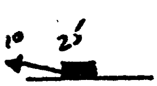
Bearing and plunge of minor fold in foliation or of gneiss layering in Precambrian rocks; half arrow indicates side that move up for drag sense





Bearing and plunge of long axis of deformed alkali feldspar phenocrysts and/or quartz rodding lying in Precambrian foliation in Tyringham and other granitic gneisses

Bearing and plunge of lineation produced by intersection of compositional layering and foliation in Precambrian rocks, or bedding and foliation in Paleozoic rocks



Bearing and plunge of lineation produced by intersection of older foliation with axial planar foliation associated with synmetamorphic thrust faults. Locally hornblende is aligned in plunge direction

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Linear symbol shows direction and plunge of slip line in plane of blastomylonite (slip plane) near thrust faults, as determined from analysis of drag sense and separation angle of F_3 minor folds. Slip line approximates movement on thrusts. Slip lines determined at 7 localities listed north to south: Cobble Hill; 1,000 feet northeast of Curtin Pond in pЄbg; on west shore of Lake Garfield in pЄbg; two localities 500 feet east of Sandisfield Rd. on Halls Hill; 2,300 feet south of Halls Hill in pЄwb; and 200 feet east of Monterey Rd., 3,500 feet south of Harmon Brook in pЄwg. The determined slip lines are consistent with a general westerly thrust direction. Slip line orientations agree with the orientation of lineations on thrust surfaces and with slip directions determined from analyses of folded lineations at the localities cited.

Location of core boring or excavation used for bedrock information

ISOGRAD--Approximate location of Paleozoic isograd; index mineral shown on high side of isograd. Sillimanite isograd post-dates synmetamorphic thrusts

Sillimanite + Muscovite

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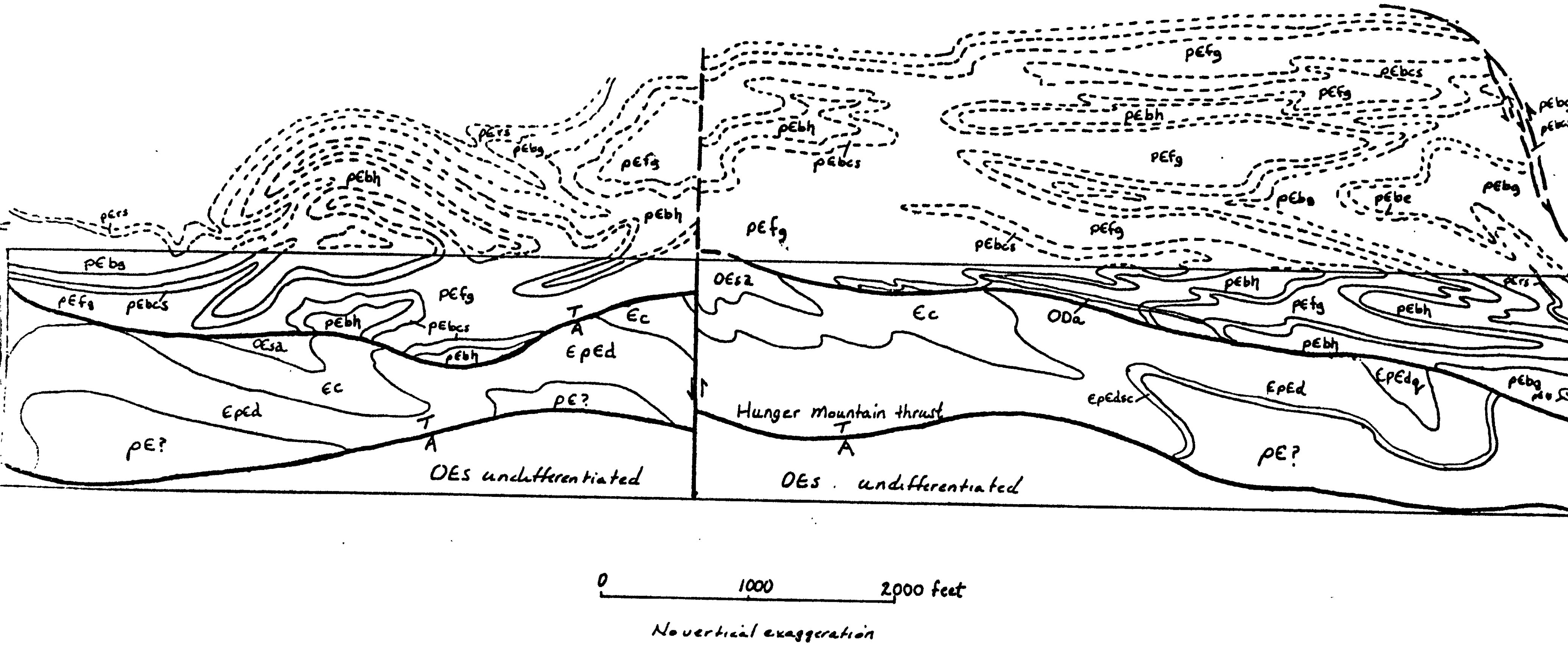

Fig 2. Diagramatic cross section illustating recumbent folds concentrated along sole of Beartown mountain thrust North of Monterey and projective techingue for reclined folds (see map for location)

N.R. 2/11/74

Linear symbol shows direction and plunge of slip line in plane of blastomylonite (slip plane) near thrust faults, as determined from analysis of drag sense and separation angle of F_3 minor folds. Slip line approximates movement on thrusts. Slip lines determined at 7 localities listed north to south: Cobble Hill; 1,000 feet northeast of Curtin Pond in p€bg; on west shore of Lake Garfield in p€bg; two localities 500 feet east of Sandisfield Rd. on Halls Hill; 2,300 feet south of Halls Hill in p€wb; and 200 feet east of Monterey Rd., 3,500 feet south of Harmon Brook in p€wg. The determined slip lines are consistent with a general westerly thrust direction. Slip line orientations agree with the orientation of lineations on thrust surfaces and with slip directions determined from analyses of folded lineations at the localities cited.

Location of core boring or excavation used for bedrock information

ISOGRAD--Approximate location of Paleozoic isograd; index mineral shown on high side of isograd. Sillimanite isograd post-dates synmetamorphic thrusts

Sillimanite
+
Muscovite

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