



**INTRODUCTION**

Considerable data were gathered in the Ashfield quadrangle in the course of mapping the adjacent Heath (Hatch and Hartshorn, 1968), Rowe (Chidester and others, 1967), Plainfield (Osberg and others, 1971), Worthington (Hatch, 1969), and Goshen (Hatch and Warren, 1971) quadrangles, and in doing reconnaissance for a bedrock geologic map of Massachusetts (unpublished data). This map presents the results and interpretation of them, and relates those data to earlier mapping in the Colrain (Segerstrom, 1956a), Shelburne Falls (Segerstrom, 1956b), and Williamsburg (Willard, 1956) quadrangles.

The original detailed studies of the area including the Ashfield quadrangle were done by Emerson (1884, 1886, 1917), Balk (1944) mapped the Shelburne Falls dome. Leo M. Hall recently remapped the dome and kindly made his unpublished map available to me. Some refinements in the Collinsville-Goshen contact are attributable to his map, although I have not everywhere followed it in detail. I have also not shown the outermost (uppermost) 50-150 m of the formation as containing significantly more amphibolite than the lower part of the formation.

The metamorphic rocks of the Ashfield quadrangle are part of a sequence of metasedimentary and metavolcanic units that have been traced along the east side of the Green Mountain and Berkshire massifs from the Quebec border to Long Island Sound. Although both fossil and radiometric dates are extremely rare in this sequence, there is general acceptance of a Proterozoic Z to Ordovician (pre-Silurian) age for the western part of the sequence and a Silurian to Early Devonian age for the eastern part (fig. 1). The pre-Silurian rocks reappear in a series of domes within the Silurian and Devonian terranes. One such dome, the Shelburne Falls dome, crops out in the northeast corner of the quadrangle; another, the Goshen dome, is in the Goshen quadrangle, to the south. The whole Paleozoic sequence is cut off on the east by the Mesozoic basin (fig. 1).

**STRATIGRAPHY**

The system of stratigraphic nomenclature, symbols for units, and age assignments on this map differ slightly from usages on earlier maps by myself and colleagues (see especially Hatch and Hartshorn, 1968). In particular: 1. The unit of aluminum pelite with punky-weathered marble beds labeled Waits River Formation in the Heath quadrangle (Hatch and Hartshorn, 1968) to the north is here interpreted as a member of the Goshen; 2. The Goshen and Waits River Formations are now considered Lower Devonian rather than Silurian and Devonian; 3. The core rocks of the Shelburne Falls dome in the northeast corner of the quadrangle are now believed best correlated with the Collinsville Formation, which cores similar domes in western Connecticut (Stanley, 1964), rather than the possibly time-correlative Hawley Formation as shown by Hatch and Hartshorn (1968).

An exposure of biotitic quartzite too small to be shown on this map, at the contact between the amphibolites of the dome sequence and the Goshen schists 160 m S. 35° E. of the summit of Goodnow Hill, is of

possible significance. This biotitic quartzite may simply be a more quartzose basal interval of the Goshen, or it may also be a small interval of Shaw Mountain Formation of Vermont, or Russell Mountain Formation, or another correlative Silurian unit.

**STRUCTURE**

**Early Folds and Schistosity**

The widespread isoclinal folds, which have been reported (Hatch, 1968, 1975) in the Goshen Formation, are well documented in the southwest corner of the Ashfield quadrangle by four tight synclines of the Goshen (units Dg and Dg1). Closely spaced reversals of facing direction of very well preserved graded beds in the Goshen (unit Dg) elsewhere in the quadrangle indicate the widespread presence of isoclinal folds within that unit. Mapping the traces of these intercalated folds would require much more detailed field work than was done for this study, but the available structural data clearly document the presence throughout the area of the Goshen (units Dg and Dg1).

In the adjoining quadrangles to the north, west, and south of the Ashfield quadrangle, the dominant schistosity in the Goshen is generally axial planar to the isoclinal folds and thus is parallel to bedding except in immediate areas of hinges. These isoclinal folds and their associated schistosity have been assigned to deformational stage II by Hatch (1975). The common occurrence in the Ashfield quadrangle of schistosity at an angle to bedding deformation, particularly in the area northwest and west of Ashfield Pond, may well reflect a greater complexity of stage II deformation, particularly in the area northwest and west of Ashfield Pond. The somewhat anomalous abundance in this area of observed stage II minor isoclinal folds may also indicate complex stage II deformation, but the exact nature of these complexities is not understood.

At a few localities of stage II isoclinal folds in the Heath quadrangle and at one locality in the Deerfield River in the north part of the Ashfield quadrangle (shown here by axial surface of stage II minor fold dipping 75° W. 1.25 km west of the junction of Avery Road and the Mohawk Trail), Osberg (1975) observed that graded beds indicated that older, rather than younger, beds cored synforms and that younger, rather than older, beds cored antiforms. He suggested that these upside-down isoclinal resulted from a period of recumbent folding, which produced inverted beds in the areas of their overturned limbs, followed by vertical isoclinal folding of these upside-down facing beds during stage II.

Other examples of probable upside-down isoclinal folds were seen in this study under the power line west of Ashfield village near the point where Bear Swamp Road impinges on the power line. Proper interpretation of the sense of the beds or the closing sense of the folds, is obviously critical to understanding the structural history of the area. Evidence from the Goshen quadrangle to the south seems to support a model wherein the stage II isoclinal folds were originally at least semi-recumbent and were later, probably during stage III, warped or "rotted over" the domes and compressed into their

present upright configuration west of the domes. At the same time, the isoclinal folds were refolded so that on one limb of these later (stage III) folds the isoclinal folds became inverted. Osberg's (1975) model thus calls upon a pre-stage II Anabian episode of recumbent folding of the only evidence for which is the inverted stage II isoclinal. The model proposed here, although it does not preclude the possibility of Osberg's folds, does explain the inverted isoclinal folds by refolding the stage II folds about regionally widespread and well recognized stage III folds.

**The Décollement**

The boundary between the Collinsville and Goshen Formations in the northeast corner of the quadrangle is shown as a décollement. This designation is intended to indicate that the intense, high-amplitude stage II isoclinal folds that characterize the Goshen do not appear to be present in (or underlying) Collinsville. Thus, during stage II, the Goshen "rug" crumpled differently. Because the boundary between the two formations is also not involved in the large isoclinal folds, considerable slippage must have taken place along this surface, and thus the décollement.

**Late Folds and Cleavage**

Speed, or slip cleavage that clearly deforms the stage II schistosity is widespread and well developed in the quadrangle. Minor folds that fold isoclinal folds are also present. The dominant orientation of this cleavage and the associated fold axial surfaces is northeast with a moderate northwest dip, an orientation that has been observed throughout this, and the area adjacent to the west, tip of quadrangles in Massachusetts, and has been designated as stage III (Hatch, 1975). Locally, in the southwest part of the quadrangle, however, this cleavage strikes east-west or northeast while maintaining its northerly dip. This change in orientation is believed to result from refolding of stage III cleavage about stage IV axial surfaces and post-stage II fold axial surfaces on Seventy Six Hill, on the south edge of the map, and Mary Lyon Hill, in the east-central part of the map, may be stage IV structures. But without more detailed mapping it is not possible to distinguish them with certainty from stage III structures deformed into their present orientation by major stage IV open warps.

The refolds in the isoclinal synclines of the Goshen (unit Dg) in the southwest part of the quadrangle are interpreted as being stage III (Hatch, 1975) and as being associated with the abundant northeast-striking stage III slip cleavage in that area. Although the folds themselves were not slip cleavage in that area, they are inferred from apparent westward offsets of the quartzite contacts.

**References Cited**

Balk, Robert, 1946. Geologic map at Shelburne Falls, Massachusetts: Geological Society of America Bulletin, v. 57, no. 2, p. 125-159.

**CORRELATION OF MAP UNITS**



**DESCRIPTION OF MAP UNITS**

Notes in the following descriptions of metamorphic rocks, minerals are listed in order of decreasing abundance.

- Dg** **GOSHEN FORMATION (LOWER DEVONIAN)**—Light- to dark-gray, fine- to medium-grained carbonaceous schist and phyllite characteristically in graded beds 5-15 cm thick that grade upward from light-gray, fine-grained quartz-mica granulite or schist through medium-gray, medium-grained quartz-muscovite-biotite schist to dark-gray, medium-grained muscovite-quartz-biotite-garnet-staurolite-plagioclase-graphite schist or phyllite. Quartz-mica granulite beds generally less distinct in north part of quadrangle. About 8 m of buff, fine-grained biotitic quartzite present at base of formation 160 m S. 35° E. of summit of Goodnow Hill in northeast corner of quadrangle.
- Dg1** **Predominantly light-gray to light-gray brown, fine-grained micaceous quartzite and quartz-muscovite-biotite-garnet granular schist.** Locally graded bedded. Lesser amounts of calc-silicate granulite composed predominantly of quartz, plagioclase, mica, chlorite, garnet, tremolite, calcite, and zoisite, with minor sphene and characteristic of micaceous quartzites. Rare beds as much as 2 m thick of light-gray, dark-brown-punky-weathered quartzose marble consisting of 80-90 percent fawn calcite or dolomite plus quartz, biotite, garnet, hornblende, and accessory minerals.
- Dw** **Well-bedded, graded-bedded granulite and schist characteristic of Goshen (unit Dg) with abundant beds of gray, dark-brown-punky-weathered quartzose marble characteristic of the Waits River Formation.** Distinguished from Goshen (unit Dg) by presence of punky-weathered marble beds, from Goshen (unit Dg) by predominance of aluminum schist and paucity of thick quartzose granulite beds, and from Waits River Formation by less contorted, well-bedded character of schists.
- Dw** **WAITS RIVER FORMATION (LOWER DEVONIAN)**—Predominantly dark-gray, medium- to fine-grained, poorly bedded to very thick quartz-muscovite-biotite-graphite schist with local garnet and staurolite. Schist characteristically complexly contorted in marked contrast to schist in Goshen Formation (unit Dg and Dg1). Gray-brown, medium-grained, sandy-textured, contorted quartz-biotite-muscovite schist. Unit characterized by beds 50 cm-10 m thick of gray, medium-grained, dark-brown-punky-weathered quartzose marble irregularly distributed throughout unit. Marble locally contains 1 cm porphyroblastic knots of garnet and/or amphibole beds as much as 25 cm thick; reaction zones around quartzose marble beds of dark-green medium- to coarse-grained actinolite-zoisite-plagioclase-quartz-garnet-sphene-chlorite granulite. Minor beds as much as 1 m thick of light-brown, fine-grained micaceous quartzite. Minor beds of white vein quartz a few centimeters thick and tens of centimeters long common in schists generally parallel to schistosity. Unit distinguished from Goshen (units Dg and Dg1) by abundance of brown-weathering quartzose marble beds.
- Oh** **HAWLEY FORMATION (MIDDLE ORDOVICIAN)**—Dark-green to black, medium-grained hornblende-plagioclase-epidote-chlorite amphibolite. Minor local garnet and muscovite. Hornblende may form conspicuous sprays or fascicles of blades 1-8 cm long. Exposed only in northwest corner of quadrangle.
- Ohb** **Dark-gray, fine-grained, rusty-weathering quartz-muscovite-biotite-graphite-epidote schist and micaceous quartzite with minor interbedded medium-grained hornblende-plagioclase-epidote-chlorite amphibolite.** Distinguished from overlying Goshen Formation by the rusty-weathering and splintery noncrumpled character of the schists, the finer grained, less sandy-textured, cleaner quartzites, and the presence of interbedded amphibolite. Exposed only in northwest corner of quadrangle.
- Oco** **COLLINSVILLE FORMATION (MIDDLE ORDOVICIAN OR OLDER)**—Very light-gray to light-tan, medium-grained plagioclase-quartz-biotite gneiss with local minor muscovite and garnet. Massive to strongly schistose. Minor interbedded medium-grained hornblende-plagioclase amphibolite becomes major constituent of uppermost 15-150 m of unit

**PLANAR FEATURES—Where two symbols for planar or linear features are combined, their intersection marks the point of observation. Where two symbols for planar features are combined with one or more symbols for linear features, the point of observation is the intersection of the symbols for planar features.**

- Strike and dip of bedding—Ball indicates top of bed known from sedimentary structures. Position of 90 on vertical bed indicates top
- Inclined
- Vertical
- Overturned
- Strike and dip of schistosity—Where unaccompanied by bedding symbol, bedding not apparent in outcrop
- Inclined
- Vertical
- Overturned
- Strike and dip of parallel bedding and schistosity—Ball indicates top of bed known from sedimentary structures. Position of 90 on vertical bed symbol indicates top
- Inclined
- Vertical
- Overturned
- Strike and dip of cleavage—Slip cleavage in schistose rocks and fracture cleavage in granulose rocks. In schistose rocks, cleavage may vary from a weak crenulate cleavage to a well developed slip cleavage
- Inclined
- Vertical
- Strike and dip of axial surface of minor fold that folds bedding; schistosity is parallel to the axial surface. All stage II minor folds shown by this symbol
- Inclined
- Vertical
- Strike and dip of axial surface of minor fold that deforms schistosity (bedding is either parallel to schistosity or not apparent in outcrop); cleavage not recognized in outcrop. Includes stage III and possibly younger folds
- Inclined
- Vertical
- Strike and dip of axial surface of minor fold that folds schistosity (bedding is parallel to axial surface. Includes stage III and possibly younger folds
- Inclined
- Vertical

**LINEAR FEATURES—May be combined with any of the above planar features**

- Bearing and plunge of axis of small fold or crenulate fold
- Inclined
- Horizontal
- Pattern of folded bedding or schistosity on horizontal surface—combined with symbol for axial surface of minor fold
- Left-handed
- Right-handed
- Neutral
- Anticline
- Overturned anticline
- Syncline
- Overturned syncline

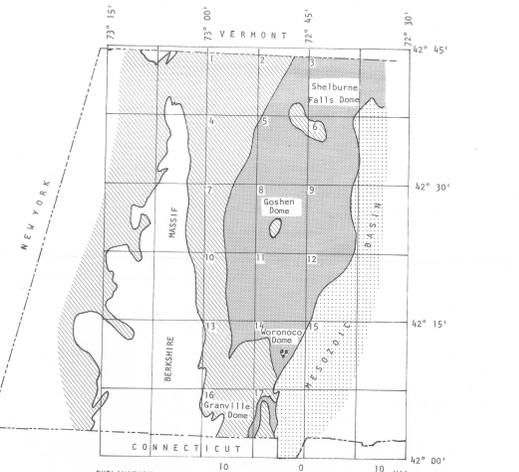


Figure 1.—Outline map of western Massachusetts showing principal geologic terranes and 7.5-minute quadrangles. Numbered quadrangles are named as follows with references (in parentheses) to geologic quadrangle maps that are available and referred to in text: 1. Rowe (Chidester and others, 1967); 2. Heath (Hatch and Hartshorn, 1968); 3. Colrain (Segerstrom, 1956a); 4. Plainfield (Osberg and others, 1971); 5. Ashfield (this map); 6. Shelburne Falls (Segerstrom, 1956b); 7. Worthington (Hatch, 1969); 8. Goshen (Hatch and Warren, in press); 9. Williamsburg (Willard, 1956); 10. Chester; 11. Westampton; 12. Easthampton; 13. Blandford; 14. Woronoco; 15. Mount Tom; 16. West Granville; and 17. Southwick.

**RECONNAISSANCE BEDROCK GEOLOGIC MAP OF THE ASHFIELD QUADRANGLE, FRANKLIN COUNTY, MASSACHUSETTS**

By  
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1981