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Hampden
JD Peper

Introduction

The Hampden quadrangle covers an area of approximately 143 square kilometers in south-central Massachusetts and adjacent Connecticut. The western half of the quadrangle is part of the Connecticut Valley Lowland, an area of relatively low topographic relief (20-30 m.) and thick surficial cover, underlain by sparsely exposed Triassic sedimentary rocks. The eastern half of the quadrangle is part of the Eastern Upland, an area of greater local relief (200 m.), underlain by metamorphosed Early and Middle Paleozoic sedimentary and volcanic rocks and Early? to Late Paleozoic igneous rocks. The layered crystalline rocks are well-exposed in a band of numerous north-trending hogbacks three kilometers wide that includes Minnechoag Mountain and the Wilbraham Mountains. Surficial cover is thin to absent in band. General features of the bedrock geology were studied and shown on large-scale maps by Emerson (1917) around the turn of the last century. Modern detailed mapping and geologic studies by Universites. Robinson, 1966, Peper, 1966 and Government agencies, Hertz 1954, Aitken, 1953, and Snyder, 1972, Collins, 1954, have enhanced geologic understanding of the quadrangle.and adjoining areas.

74-61 - wrong - not part of OF report

This report is preliminary and has not been edited or reviewed for conformity with U.S. Geological Survey standards and nomenclature.

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Bedrock Units and Structure

Geologic Setting, Correlation, Metamorphism

The crystalline rocks in the Hampden quadrangle lie along the western edge of the Bronson Hill Anticlinorium (Billings, 1956; Rodgers, 1971), a series of en-echelon gneiss domes mantled by Lower Paleozoic strata, that extends from northern New Hampshire to Long Island Sound. A recent composite stratigraphic column for rocks along the Bronson Hill anticlinorium in central Massachusetts and southern New Hampshire is given and discussed in a summary paper by Thompson and other, 1968, p. 205-207. The eastern border of the quadrangle lies approximately along the axis of the Glastonbury Dome, an elongate anticline with a core of granitic gneiss (Glastonbury Gneiss, Hertz, 1955) that extends from southern Massachusetts southward to the vicinity of Middle Haddam, Connecticut. Five formations of metamorphosed layered rocks are recognized as forming a west-dipping homoclinal sequence on the west limb of the dome. These include: the Ammonoosuc Volcanics, the Partridge Formation, the Clough Formation, the Erving Formation, and the Waits River Formation. All have type localities outside the quadrangle in New Hampshire, Southern Vermont, or north central Massachusetts. No fossils have been found in, nor radiometric age determinations done on rocks in the quadrangle. With the exception of the amphibolite unit of the Ammonoosuc Volcanics (unit Oaa), which can be traced in discontinuous outcrop along the north limb of the Glastonbury Dome (Hall ______) and onto the west limb of the Great Hill syncline in the Palmer and Monson quadrangles (Peper, 1966), none of the layered rock units can be traced north of the southern part of the Ludlow quadrangle. Rocks are assigned to a particular formation on the basis of litho-logical similarity and relative position in the stratigraphic succession. Table 1 shows the probable correlations of layered units in this report with named units in central Massachusetts and Connecticut.

The Triassic sedimentary rocks lie east of (structurally and stratigraphically above) the Hampden Basalt and are therefore assigned to the Portland Formation (Krjinine, 1950). Earlier named units used by Emerson for Ttiassic rocks in the quadrangle (Mt. Toby Conglomerate, Longmeadow sandstone, and Chicopee Shale) and shown on large scale maps are not used as they are not time-stratigraphic units (Larsen, 1972) and the separate units cannot be adequately distinguished.

Pelitic schists of the Erving Formation and aluminous schists in the Ammonoosuc Volcanics contain local kyanite and staurolite, suggesting that the layered crystalline rocks reached the middle grades of the amphibolite facies during regional metamorphism.

The Ammonoosuc Volcanics are represented by thick upper lenses of amphibolite and subordinate gneisses of chiefly mafic to intermediate composition (unit Oaa, 670 m. + unit Oap 0-135 m.) and thick lower lenses of gneiss chiefly of felsic and intermediate compositions (unit Oag 0-190 m. , unit Oam 0-190 m.). The thinly layered rocks in these units probably are metamorphosed water-laid and water worked tuffs and volcaniclastic debris, and some of the weakly layered rocks may represent flows or hypabbyssal sills. Rocks that were probably coarse clastics are rare, but are represented by (1) a thin (3 m.) lens in which amphibolite blocks (0.5m) occur in a more felsic matrix of plagioclase-quartz-hornblende-biotite rock on the north east side of Perkins Mountains; and (2) similarly irregular-textured amphibolite exposed on the slope east of Rattlesnake Mountain.

Rocks in the lower felsic lenses, west of Glendale Church, are the oldest rocks in the quadrangle and physically resemble some gneisses in the Monson Gneiss that underlies the Ammonoosuc to the east along the Bronson Hill anticlinorium (Thompson and others, 1968). They are assigned here to the Ammonoosuc, however, because they intertongue with the thick upper lens (unit Oaa) in the southern part of the Ludlow quadrangle (Leo and others - in preparation).

In the southeastern part of the quadrangle, Glastonbury gneiss has, progressively southward, intruded Ammonoosuc rocks that are progressively higher in stratigraphic position, in a series of semi-concordant sills. Lower parts of the thick upper lens (Oaa) are breached by a sill across the Rattlesnake Hill and the western slope of Pine Mountain. West of Gillete Brook this unit is locally breached entirely by a large sill. To the east, Ammonoosuc rocks appear in partial stratigraphic disarray as mapped roof pendants and inclusions, and many small unmapped (20 m. and less) schistose screens, enclosed by Glastonbury Gneiss. The inclusions typically underlie the highest elevations such as the ridges west of Culver and Goodwill Ponds, and the unnamed hill east of the Pinnacle. Most of the inclusions consist of amphibolite and thinly layered gneisses of intermediate composition. These are assignable on the basis of lithology to the lower part of thick upper lens (unit Oaa) or the pod-bearing unit (Oap). The lens mapped across the western slope of the Pinnacle (unit Oa), contains amphibolite and appreciable weakly and strongly layered felsic gneiss, with hornblende and garnet, that is texturally like the gneisses of the felsic units (Oag, Oam). Its position, relative to inclusions immediately to the east (Units Oap, and Oaa) suggests moreover, that it might be a lateral equivalent of the upper part of unit Oaa that has been simply shouldered aside.

Massive to weakly-foliated amphibolite and minor layered amphibolite (Oama) occur in small bodies east of Thrasher road and east-southeast of Culver Pond, near the eastern edge of the quadrangle. The thickly-parted to massive amphibolite has a destructive relict porphyritic texture. Euhoral crystals of plagioclase, (6-8mm) partly altered to epidote and overgrown by hornblende, are set in a matrix chiefly of hornblende, epidote and quartz. Similar bodies occur in the Glastonbury gneiss in the Monson, Stafford Springs and Ellington quadrangles. A similar rock, along with layered amphibolites and soapstone, was described and mapped as metagabbro by Collins (1955) in the Ellington quadrangle. Re-examination by the author of the rocks in Collins's metagabbro unit on Soapstone Hill in the Ellington quadrangle suggests that the massive amphibolite there occurs as probable metamorphosed hypabyssal sills or flows in metamorphosed volcaniclastic rocks similar to rocks of unit Oaa in the Hampden and Ludlow quadrangles. This occurrence, and contact relationships between the Glastonbury gneiss and Collin's metagabbro (Collins, 1955, p. 19, paragraph 2) suggest that the massive amphibolite bodies are probably metamorphosed intrusive or extrusive rocks, contemporaneous with the Ammonoosuc, that occur, locally with layered Ammonoosuc amphibolites as inclusions in the Glastonbury gneiss.

The Partridge Formation (Ops) is represented by two thin discontinuous lenses above Ammonoosuc rocks. A northern lens crosses the west slope of Mt. Vision, and a southern lens occurs west of Gillette Brook. The northern lens contains appreciable metamorphosed volcaniclastic rock (amphibolite and quartz-plagioclase gneisses) and subordinate rusty weathering pelitic schist (metamorphosed shales). The southern lens, however, contains chiefly rusty-weathering sulfidic schist with minor thin (5 cm.) beds of quartz-garnet rock (possibly metamorphosed cherts).

The Clough Formation (Sc) is recognized at three localities but mapped only in the northern part of the quadrangle where it is sufficiently thick to delineate (see Explanation). Where the unit is exposed, relict bedding in the quartzite and feldspathic quartzite is structurally conformable with relict bedding in the underlying and overlying rocks. The patchy distribution of the Clough may be due to originally patchy distribution in lows along the pre-Clough erosion surface and, possibly, to erosion in post-Clough pre-Erving time. The latter is suggested by an abrupt wedge-shaped termination of the upper part of a thin (4 m.) lens of Clough quartzite, northeastward along strike, by amphibolite of the overlying Erving Formation on the hill northwest of Worthington Pond.

The Erving Formation (De, Dea, Dev) is represented by a thick (715± m.) sequence of chiefly gray weathering mica schist and biotite granofels (unit De, metamorphosed sandy shales and feldspathic siltstones and sandstones). These rocks, lying above the Clough quartzite and resting unconformably on the Ammonoosuc and Partridge, are assigned to the Erving Formation because they more closely resemble the type Erving (Thompson and others 1968), than they resemble the pencil-lead gray, staurolite-garnet schist characteristic of the Littleton Formation along the southern parts of the Bronson Hill Anticlinorium.

Two subunits, consisting of layered amphibolites and including other layered rocks are mapped within the formation. The lowest of these, Dev, appears in four discontinuous lenses at or near the base of the unit. Along with layered amphibolites, the lenses contain a variety of layered (quartz)-plagioclase-biotite gneiss, with, hornblende and garnet that are in part rusty-weathering, and have highly variable quartz content. The irregular distribution of the lenses near and at the unconformity at the base of the unit, and their mixed compositions, suggests they might represent volcaniclastic and sedimentary material reworked locally from highs on the pre-Erving terrane. The lenses Dea south of Stafford Road contain minor fine-grained quartz-garnet rock along with layered amphibolite.

Thin (6 m.) lenses of foliated amphibolite (unmapped) occur in the schist north and south of the large pegmatite body northwest of Hampden. These are unlayered to weakly layered, and may represent metamorphosed hypabyssal sills or possibly flows.

The Waits River Formation is a thick (0-190 m.) lens of rock in which rusty-weathering muscovite schist and subordinate, but thick (10 cm.), beds of calc-silicate granofels are characteristic. These rocks are similar to rocks of the Waits River on the west side of the Connecticut Valley in the Whately area of Massachusetts (Peter Robinson, G.W. Leo, oral communication, 1972). In the Hampden quadrangle these rocks are coextensive with rocks that form chiefly the top of the layered rock sequence in the Ludlow quadrangle. The characteristic lithologies intertongue vertically, and southward, laterally, with the Erving Beds of gray-weathering schist and granofels, similar or identical to Erving schist and granofels occur in subordinate amounts throughout the Waits River of both quadrangles. The age of the Waits River in these quadrangles is thus probably the age of the Erving; Lower Devonian.

The Glastonbury Gneiss is a regionally foliated intrusive gneiss. The gneiss is texturally homogeneous in outcrop but varies in composition from place to place and samples from the Hampden quadrangle range from granite to granodiorite to quartz-rich quartz-diorite. The gneiss forms generally smooth rounded outcrops with widely spaced joints and weak partings parallel to the strike of inclusions. Inclusions, chiefly screens of schistose amphibolite with sharp boundaries and schlinen of plagioclase-biotite-quartz schist with indistinct boundaries are found in about half of Glastonbury outcrops. They are abundant in outcrops in the southern third of the quadrangle and in the outcrop areas north and west of Goodwill Pond, and much of the local variation in biotite content of the Glastonbury in these areas might be ascribed to assimilation of Ammonoosuc rocks.

A Devonian (355 m.y.) whole-rock, rubidium-strontium age was obtained by Brookins and Hurley (1965) on gneiss from the southern end of the Glastonbury dome in the Glastonbury quadrangle, Connecticut. Based on a recent study of rocks in the northern and central parts of the dome, however, Leo (1974) has pointed out that the origin of the gneiss in the dome is complex and may involve more than one intrusion. The Glastonbury gneiss in the Hampden quadrangle intrudes and therefore must be younger than the Ammonoosuc Volcanics (probably Middle Ordovician). The Glastonbury is not known to intrude Siluro-Devonian. The gneiss is regionally foliated and, if the last regional metamorphism is Acadian must be Acadian or older. On this basis the Glastonbury gneiss in the Hampden quadrangle is considered to be Middle Ordovician to Middle Devonian.

Pegmatites, in large mapped bodies and smaller sills, cut all crystalline units. Many of the larger bodies, such as that north of Goat rock, shoulder aside rocks of the Erving Formation and were emplaced later than the time of formations of regional foliation.

Folds of the first type are developed chiefly as tightly-oppressed assymetric folds. They tend to plunge at moderate angles, near the strike of regional foliation, and show both dextral and senestral movement sense. They formed contemparaneously with the dominant regional foliation and north-south folding, probably during the Acadian Orogeny.

Folds of the second type show a wider variety of styles than the first, and include assymetric folds, and open folds. Groups of northwest-plunging folds of the second type are abundant in the southern part of the quadrangle, particularly in rocks of the Erving on and around Goat Rock and on the west slope of Minnechoag Mountain. Open folds of the second type fold the axial plane foliation of the first type, in outcrops on the north side of Scantic Road near Goat Rock. Assymetric folds of the second type, fold foliation in the Glastonbury and an enclosed screen of hornblende schist in outcrops on both sides of Root Road, 695 m., S. 45° W. of Worthington Pond. The open dextral warping of foliationn and relictic bedding that is displayed by mapped contacts (for example, the Partridge-Erving contact at the general latitude of Mt. Vision) were probably formed at the time of formation of the second type of folds.

Northwest-plunging folds of the third type are most intensely developed on the west slope of Perkins Mountain. They are similar in strike and magnitude of plunge to folds of the second type but show a more brittle behaviour of the rocks than do the second-type folds and therefore might have been developed at a somewhat later time. The third type of folds are also similar in their brittle style to the two small faults that cut the Erving rocks 1650 m. N. 55° E. of North Summers. Like these small faults, and unlike the faults at the Triassic border, the third type of folds are not associated with extensive retrograde alteration.

Faults in crystalline rocks that trend northwest are mapped northeast and southwest of Mt. Vision and a series of northeast and northwest-trending faults are mapped near Perkins Mountain.

The fault northeast of Mt. Vision, a probable fault, follows a strong topographic liniament, and locally offsets the trend of regional foliation where it crosses the ridge crest. Abundant closely-spaced joints suggest that a splay crosses the ridge north of the fault. The fault southwest of Mt. Vision follows the narrow gully occupied by West Brook. A dike of pegmatite locally follows the fault trend. Movements along this fault zone probably continued after emplacement of the pegmatite, as gash-veins filled with vuggy quartz cut the pegmatite. Schist is locally chloratized in fractures parallel to the fault zone in an outcrop 305 m. S. 12° W. of the summit of Mt. Vision.

The northwest-trending faults across Perkins Mountain follow well-defined topographic liniaments. The northern-most fault, a probable fault, is not exposed, but apparently offsets unit Oap of the Ammonoosuc Volcanics. The southernmost fault forms the southeast slope of the ridge southeast of Hurds Lake and occupies a narrow gully on the ridge west of Perkins Mountain. Outcrops on this ridge, east of the fault, are broken by northwest-trending, west-dipping joints, suggesting that the fault also dips west, and transects the steeply eastward dipping axial plane cleavage of the abundant kink folds.

A zone of faulting along the Triassic Border extends through the center of the quadrangle. The zone consists of intersecting northeast and northwest trending faults. Associated cataclased, retrograded, and mineralized rocks locally separate Triassic sedimentary rocks on the west from crystalline on rocks on the East. The faults extend into both the crystalline and Triassic sedimentary rocks. Triassic rocks are exposed near the fault only in the northern part of the quadrangle, near Wilbraham, so that in most areas, the distribution of Triassic rocks must be inferred more or less closely on the basis of exposed silicified fault zones, liniaments or inferred extension of faults cutting crystalline rocks. Some well-logs (R.B. Colton - unpublished data) are useful also in this regard.

Southwest of Wilbraham, unbroken conglomerate and sandstone dip eastward into the fault. A prism of dark-grey mylonite, well-exposed in the unnamed brooks south of Woodland Dell Cemetary, is developed locally along the fault zone. This prism of cataclastic rock probably does not extend far north of the cemetary, as fractured Triassic sandstone appears to the north in an outcrop along Mountain Road.

A narrow (20 m.) ridge of silicified protomylonite, cut by veins of jasparoid quartz, trends N. 8° E. and locally marks the trace of the probable Triassic border 2.07 km. N. 13° E. of the intersection of Springfield and Stony Hill Roads. Well-logs suggest the zone of crushing and silicification hhme might extend as far west as Wilbraham Road. Outcrops of Erving schist on the hillside west of the narrow ridge contain abundant quartz veins and are cut by steep west-dipping joints.

A series of intersecting N.E. and N.W. and N. trending faults complicate the border in the area 3.5 km. north and south of the Massachusetts-Connecticut state line. A prism of silicified protomylonite is well-exposed in outcrops on the ridge east of North Somers (unit fg). Most cataclastic foliation in the crushed rock strikes parallel to the trend of adjacent fault borders. The contact of the protomylonite with Erving schist and granulite is visible in outcrops along a stream draining southward into Shanade Brook. The protomylonite transects the sericitzed pegmatite appear as lenses and screens in the protomylonite. Schist east of the crushed rock is generally unaltered, except for a zone of intense chlorization and seritization, 3-5 cm. wide, adjacent to the protomylonite.

ECONOMIC GEOLOGY

Minor Copper Sulfide Mineralization along the border of the Triassic rocks, was noted by R.B. Colton on boulders in the sand pit southeast of the intersection of Hampden and Stafford Roads, and in the Woodland Dell cematary in Wilbraham. Chalcopyrite, the primary copper-bearing mineral occurs as disseminated grains in late quartz veins that cut mylonite and silicified protomylonite exposed on the east flank of the sandpit. Thin coatings of malachite occur in local patches on a few sandstone boulders in the pit. Similar minor copper sulfide mineralization is present locally along exposures of the crushed rocks, but deposits of economic proportion were not detected, and are thought not to exist in the quadrangle.

Quarrying of both sandstone of the Portland Formation and the Glastonbury Gneiss is evidenced in the quadrangle but most of the quarrys were inactive or had been abandoned at the time of the investigaiton.

Joints and foliation planes parralel to steep slopes are found in several areas of great local relief, particularly on the west slopes of Minnechoag Mountain and the Wilbraham Mountains between Goat Rock and Mt. Vision. Locally, in areas such as the northwest slopp of Goat Rock, minor sliding of joint or foliation surfaces has taken place in recent times, evidenced by talus blocks along the slope and relatively un-weathered pavement-like outcrop surfaces. Although on site investigations are needed to determine the type and extent of possible instablility in a particular area, the extensive, joint and foliation data on the map should serve as a guide to sites of potential problem.

DESCRIPTION OF MAP UNITS

Trp FORTLAND ARKOSE (TRIASSIC) -- Chiefly moderate-reddish-brown weathering, thin to- medium-bedded, medium to coarse grained arkosic sandstone and minor siltstone. Subordinate lenses of conglomerate 0.5-1.0 meter thick.occur in exposures near Triassic border. Most conglomerate clasts are pebbles or cobbles of pegmatite (P below) or Glastonbury gneiss (DOgl below)

PROTOMYLONITE -- Chiefly pink-weathering, minor olive-gray-weathering, crush-rock composed of quartz, feldspar, and feldspar-quartz gragments (2-3 mm in diameter) in a foliated matrix of chlorite and epidote. Minor carbonate in matrix. Rock is irregularly but strongly foliated, and texturally and compositionally homogeneous over the area of several exposures. Rock locally intensely cut by veinlets (< 1 mm wide) and larger veins (1-6 cm. wide) of milky quartz.

MYLONITE -- Brown to dark-gray weathering, dark-gray, consisting of altered rock fragments, quartz, and feld-spars in an aphanidid groundmass, cut by thin veinlets of quartz calcite, and ultramylonite. Rock has sub-conchoidal hackly fracture. Outcrops are irregularly and intensely jointed.

P_2P PEGMATITE (POST LOWER DEVONIAN) -- White to light-gray, weakly foliated to unfoliated sills, dikes, and irregularly shaped bodies consisting of quartz and feldspars with accessory muscovite black tourmaline, sulfides, garnet, apatite, and rare beryl. Pegmatite bodies within Glastonbury Gneiss chiefly unfoliated. Locally they contain pink feldspar and smoky quartz crystals 16-25 cm. in longest dimension. Larger semi-discordant bodies in Erving Formation and Ammonoosuc volcanics contain schistose screens in marginal zones 1-30 meters wide. Many small bodies, chiefly sills 5 cm. - 8 m. wide, are present in crystalline rocks of the quadrangle but are not mapped for reasons of scale.

DOgl GLASTONBURY GNEISS (ORDOVICIAN-DEVONIAN) -- Medium to coarse-grained, weakly- to strongly foliated, homogeneous, plagioclase-quartz-pottasium feldspar-biotite-(epidote) gneiss with accessory muscovite, hornblende, and garnet. Gneiss is typically well-liniated, with thin patches of biotite and epidote strung out along foliation in bands 0.5-1 cm. wide. Color index typically 15 or less. Many outcrops contain one or more schlieren of fine-grained quartz-plagioclase gneiss rich in biotite or hornblende, or semi-concordant inclusions of fine-grained hornblende-plagioclase amphibolite.

Dw WAITS RIVER FORMATION (LOWER DEVONIAN) -- Chiefly rusty, dark-yellowish-orange weathering, fine- to coarse-grained, quartz-plagioclase-muscovite-biotite (garnet)-schist with accessory potassium feldspar, kyanite, chlorite, graphite, and sulfide. Rusty schist is interlayered with subordinate medium-grained, dark-yellowish-orange- and dark-greenish-gray- weathering (calcite)-diopside-(hornblende)-quartz-plagioclase-biotite-(garnet) granofels with accessory sphene, epidote, and graphite. Granofels, in beds 5-20 centimeters thick, makes up about 5 percent of the unit in exposures in the Hampden quadrangle. Unit contains minor (15 per cent) gray-weathering schist and granofels similar to schist and granofels of the Erving Formation described below.

De ERVING FORMATION of Thompson, Robinson, Clifford, and Trask, 1968, (LOWER DEVONIAN)

Dea

Dev

De -- Chiefly gray-weathering biotite granofels interlayered with locally more abundant gray and brownish-gray weathering muscovite-biotite schist. Very minor amounts of very-light-gray, quartz-plagioclase-hornblende-garnet-sphene, granofels and hornblende@plagioclase amphibolite.

Biotite granofels is thinly to thickly parted and medium-grained, with mineral percentages as follows: quartz (30-50), plagioclase (20-45), biotite (20-30), garnet (1-3), muscovite (1). Schist is medium- to coarse-grained, well-foliated, and consists of quartz (30-45), plagioclase (2-40), muscovite (15-35), biotite (5-20), garnet (1-3) and kyanite (3) with accessory potassium feldspar, chlorite, and apatite. Rectangular knots of very-pale-green muscovite and kyanite (0.6 mm. in width), and knots and stringers of translucent quartz, are characteristic of schist.

Dea -- Thinly to thickly parted, medium- to coarse-grained, hornblende-plagioclase amphibolite. Amphibolite contains minor amounts of epidote, sphene, and chlorite and in locally encloses minor thin layers of pink garnet-quartz rock (coticule) and plagioclase-quartz-biotite-hornblende-epidote gneiss.

Dev -- Chiefly hornblende-plagioclase amphibolite, interlayered with locally more abundant rusty-weathering quartz-plagioclase-biotite gneiss, and plagioclase-quartz gneisses with variable amounts of hornblende-biotite, and garnet.

Sc CLOUGH FORMATION (LOWER SILURIAN) -- White- to light-tan thin- to medium layered quartzite and quartz-muscovite gneiss. Exposed discontinuously for a distance of 100 meters, in a band about 10 meters wide, on the southwest slope of Mt. Marcy in the adjacent Ludlow 7 1/2 minute quadrangle. Rocks of the unit are exposed but not mapped for reasons of scale at two localities in the Hampden quadrangle. These include (1) a one-meter-wide band of quartz-feldspar-mica gneiss at an elevation of 810 feet on the east side of Old Hampden Road, and (2) a 1.5 meter wide band of quartzite discontinuously exposed at the base of amphibolite of the Erving Formation on the hill west and northwest of Worthington Pond.

Ops PARTRIDGE FORMATION (LATE MIDDLE ORDOVICIAN) -- Rusty-weathering quartz-plagioclase-muscovite-biotite-(kyanite)-(garnet) schist interlayered with subordinate but appareciable (30 percent) quartz-feldspar-biotite-(hornblende)-(garnet) gneiss, hornblende-plagioclase amphibolite (20 percent), and local quartz-garnet granofels. Schist is light-brown, medium to coarse grained, well-foliated and contains accessory chlorite, apatite, graphite, and sulfide. Gneiss is light-to medium gray, and rusty-weathering, medium grained, and occurs in thinly to thickly parted, slabby layers.

Oaa
Oap
Oa
Oas
Oag
Oam
Oama

AMMONOOSUC VOLCANICS (MIDDLE ORDIVICIAN) -- Oaa --

Chiefly hornblende-plagioclase amphibolite interlayered with subordinate medium- to dark-gray weathering, locally, rusty red-orange weathering quartz-plagioclase-hornblende-biotite-garnet gneiss and hornblende-plagioclase epidote amphibolite. Most gneiss is strongly foliated and thinly- to thickly layered. Unit includes minor coarse-grained weakly layered, thickly parted hornblende-plagioclase amphibolite with coarse (1 cm. long) hornblende laths in clots 3-4 cm. in diameter.

Oa-- Chiefly well foliated, thinly- to thickly layered, dark gray plagioclase-quartz-hornblende-(biotite)-(garnet) gneiss and amphibolite, Lens also contains appreciable plagioclase-quartz-biotite-(garnet) gneiss north of the Pinnacle.

Oas -- Rusty-red-to light-tan-weathering, quartz-feldspar-muscovite-chlorite-garnet schist. Schist well foliated. Locally contains thin layers of pink garnet-quartz rock (coticule).

Oap -- Chiefly thinly layered, medium grained, slabby hornblende-plagioclase-epidote amphibolite with concordant thin (0.5 cm-wide) veins, stringers, and thicker nodular masses of quartz-epidote rock, 4-8 cm. in largest dimension.

Oag -- Light-to medium gray, plagioclase-quartz-hornblende-garnet-(biotite) gneiss. Gneiss is strongly foliated, weakly banded and parted on a scale of 1 cm.-1 m. Color index 15-20, except in upper 15-25 m., where gneiss with color index of over 25 grades by interbedding into amphibolite of unit Oaa.

Oam -- Chiefly light-colored medium to coarse-grained quartz-plagioclase-biotite-(hornblende) gneiss interlayered with subordinate hornblende-plagioclase amphibolite. Gneiss typically consists of layers 1-5 cm. thick richer and poorer in biotite. Unit not exposed in Hampden quadrangle.

Oama -- Dark-gray, coarse-grained, hornblende-plagioclase-epidote-quartz amphibolite. Chiefly a weakly-foliated to massive, rock in which small (3X6 mm.) white ellipses of altered, fine-grained, anhedral plagioclase and epidote occur in a ground-mass of coarse dark-green hornblende. Locally encloses patches of actinolite-tremolite rock.

Symbols

Contact - Dashed where approximately located; querried where probable.

Fault - Dashed where approximately located. querried where probable. U, probable upthrown block; D probable downthrown block.

Syncline - showing axial trace and plunge direction

Planar and Liniar Features - where jointed, observation at point of intersection.

Bedding in Sedimentary Rocks

Inclined - symbol shows strike and dip

Horizontal

Foliation in Metamorphosed Rocks

Inclined - symbol shows strike and dip

Vertical

Parallel to relict bedding

Parallel to overturned relief bedding

Foliation in Cataclastic Rocks

Inclined

Mineral Liniation - Symbol shows direction and plunge; observation at base of arrow. Letter symbol shows elongate mineral: B, biotite; H-hornblende; Q, quartz.

Joints

Inclined - Symbols shows strike and dip

Vertical

Minor Folds

Fold will axial plane foliation - symbol shows map sense and magnitude of plunge.

Fold that folds foliation - symbol shows map sense and plunge.

Open Anticline

Open Syncline

Kink fold. Symbol shows map sense and plunge

Kink fold - Symbol shows map sense and plunge of fold, and strike and dip of axial-plane cleavage.

Protomylonite — Chiefly pink-weathering, minor olive-gray-weathering, crush-rock composed of quartz, feldspar, and feldspar-quartz fragments (203 mm in diameter) in a foliated matrix of chlorite and epidote. Minor carbonate in matrix. Rock is irregularly but strongly foliated, and texturally and compositionally homogeneous over the area of several exposures. Rock locally intensely cut by veinlets (< 1 mm. wide) and larger veins (1-6 cm. wide) of milky quartz.

Mylonite -- Brown to dark-gray weathering, dark-gray, consisting of altered rock fragments, quartz, and feldspars in an aphanidid groundmass, cut by thin veinlets of quartz calcite, and ultramylonite. Rock has sub-conchoidal hackly fracture. Outcrops are irregularly and intensely jointed.

Abandoned Quarry

Areas of thin surficial cover and abundant outcrops. Solid color shows outcrop visited in field. Many small outcrops shown only by structure symbol.

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