The Russell Mountain Formation, a New Stratigraphic Unit in Western Massachusetts

By NORMAN L. HATCH, JR., ROLFE S. STANLEY, *and* STEWART F. CLARK, JR.

CONTRIBUTIONS TO STRATIGRAPHY

GEOLOGICAL SURVEY BULLETIN 1324-B

Prepared in cooperation with the Massachusetts Department of Public Works

A thin unit of calc-silicate rock and quartzite is defined and assigned a Middle Silurian age

UNITED STATES DEPARTMENT OF THE INTERIOR
WALTER J. HICKEL, *Secretary*

GEOLOGICAL SURVEY
William T. Pecora, *Director*

Library of Congress catalog-card No. 73–608173

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON: 1970

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 10 cents (paper cover)

CONTENTS

ILLUSTRATION

CONTRIBUTIONS TO STRATIGRAPHY

THE RUSSELL MOUNTAIN FORMATION, A NEW STRATIGRAPHIC UNIT IN WESTERN MASSACHUSETTS

By NORMAN L. HATCH, JR., ROLFE S. STANLEY, and STEWART F. CLARK, JR.

ABSTRACT

A thin discontinuous unit of calc-silicate granulite and quartzite has been mapped on the east limb of the Berkshire anticlinorium in southern Massachusetts and is here named the Russell Mountain Formation. It overlies rocks continuous with the Hawley Formation of Middle Ordovician age and underlies the Goshen Formation of Middle Silurian to Early Devonian age. Largely on the basis of a correlation with the Shaw Mountain Formation of Vermont, the Russell Mountain Formation is assigned a Middle Silurian age.

INTRODUCTION

Mapping of stratified Paleozoic rocks on the east limb of the Green Mountain–Berkshire anticlinorium from the Vermont State line southward across most of western Massachusetts has shown that in southwestern Massachusetts a thin discontinuous unit of calc-silicate granulite and quartzite occurs between the Goshen Formation of Middle Silurian to Early Devonian age and rocks of probable Middle Ordovician age that correlate with the Hawley Formation in northwestern Massachusetts. It is herein proposed that this calc-silicate-quartzite unit be named the Russell Mountain Formation after exposures on Russell Mountain in the Woronoco quadrangle, Massachusetts (fig. 1).

The fieldwork was done in cooperation with the Massachusetts Department of Public Works.

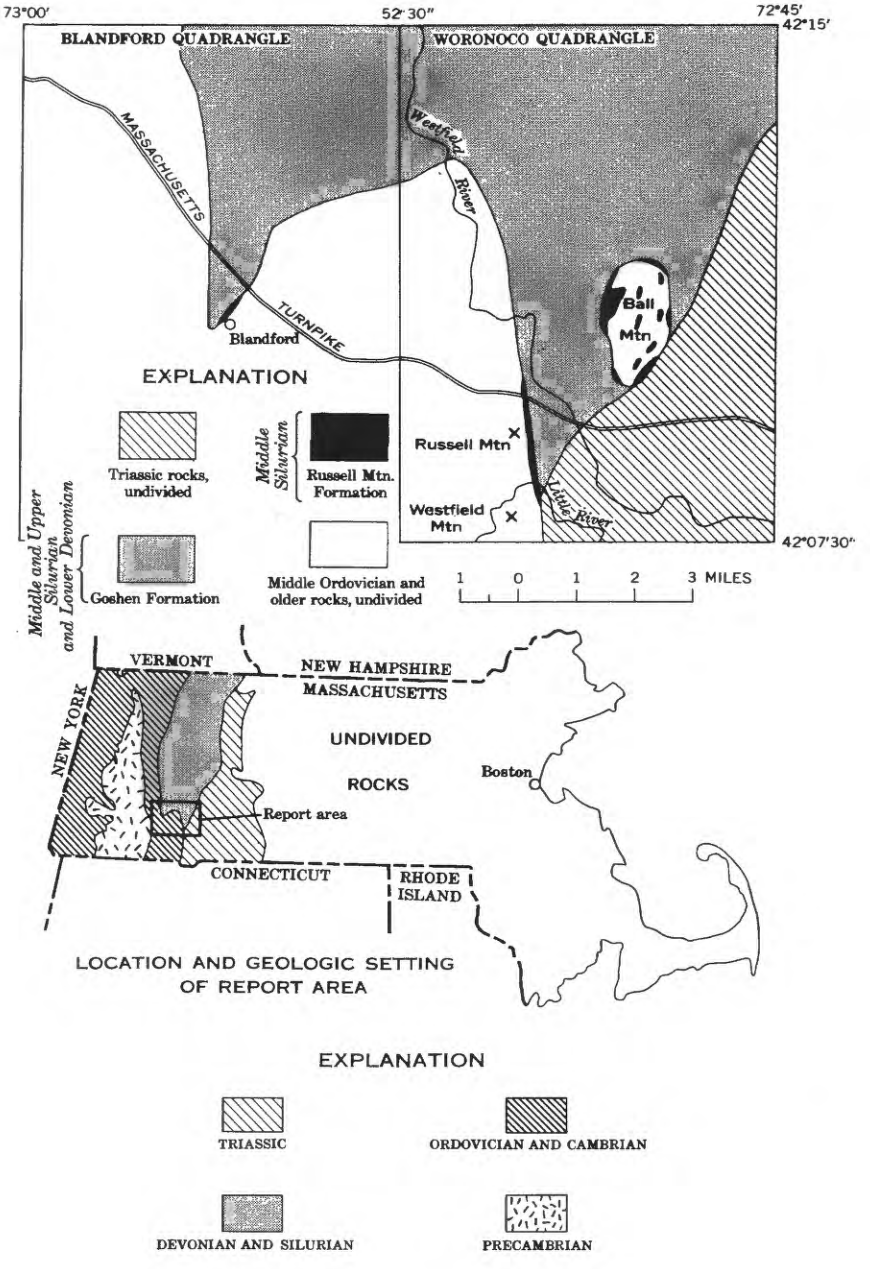

FIGURE 1.—Generalized geologic map of the Blandford and Woronoco quadrangles showing distribution of the Russell Mountain Formation and surrounding rocks. Width of outcrop of Russell Mountain Formation locally exaggerated.

DISTRIBUTION

The present known distribution of the Russell Mountain Formation is shown in figure 1. The formation is exposed in the center of the racetrack at the fairground in the village of Blandford in the Blandford quadrangle. In the Woronoco quadrangle, it is well exposed on the Massachusetts Turnpike, in the north-south series of outcrops on Russell Mountain between the Massachusetts Turnpike and the Little River, in a group of outcrops about 1,000 feet south of Little River on the northeast end of Westfield Mountain, and on Ball Mountain.

LITHOLOGY

In the Blandford and Woronoco quadrangles, the Russell Mountain Formation consists of calc-silicate granulite, carbonate-calc-silicate rock, and quartzite. These rock types are interbedded in proportions that vary from one exposure to another. Calc-silicate granulites constitute all the exposed rock at some localities where they form beds a few inches to a few feet thick. Carbonate-calc-silicate rock, in beds a few feet or more thick, is the only rock at a few exposures and forms beds 6 inches to a foot thick intercalated with calc-silicate granulites at other exposures. Quartzite is the only exposed lithology at the Blandford fairgound. At other localities it generally forms no more than 50 percent of the exposed rock and is in beds a few inches to a foot thick intercalated with calc-silicate granulites.

The calc-silicate rocks are medium grained, generally massive, locally compositionally banded, and greenish gray and consist predominantly of variable proportions of quartz, feldspar, garnet, zoisite, tremolite, diopside, and carbonate minerals. The sizes of most mineral grains are within the range of 1 to 3 mm (millimeters), but some minerals such as tremolite form blades or aggregates as much as 15 cm (centimeters) long. In the roadcut on the north side of the Massachusetts Turnpike, alternating light and dark beds are distinctive. Carbonate minerals may constitute as much as 40 percent of some beds and less than 5 percent of others. Where carbonate minerals were originally abundant, outcrop surfaces commonly have a porous brown-weathered crust. Two good exposures of this carbonate-calc-silicate rock in the Woronoco quadrangle are on the northeast end of Westfield Mountain, 2,500 feet S. 72° W. of the intersection of Northwest Road and Western Avenue, and on Ball Mountain, 3,600 feet S. 2° W. of the airway beacon. The rock consists primarily of quartz and carbonate minerals and minor amounts of zoisite, diopside, tremolite, plagioclase, and

other calc-silicate minerals. In general, where carbonate is minor or absent, the rock is harder than carbonate-rich rocks and does not have the porous brown-weathered crust.

The quartzites in the Russell Mountain Formation are white, very light gray, or light brown where fresh and commonly weather slightly rusty. They generally form irregularly distributed beds 1 to 10 in. thick within the calc-silicate granulites. Individual quartz grains are generally colorless and 1 to 4 mm in diameter. Boundaries between grains are generally distinct in hand specimen, and weathered surfaces commonly show a marked flattening of grains parallel both to bedding and, where present, to mica foliation. Grains of clear quartz 3 to 5 mm in diameter or larger strongly suggest that some beds are metaconglomerate. Muscovite in plates 2 or 3 mm across is the most common accessory mineral and locally may form conspicuous partings that constitute as much as 10 percent of the rock. At some localities quartzite constitutes as much as 50 percent of the exposed rock; at others no quartzite was observed. Typical quartzites interbedded with calc-silicate rocks can be seen 250 ft N. 30° W. of the point where the Westfield corporate boundary crosses General Knox Road, at the south end of Russell Mountain, Woronoco quadrangle (800 ft north of where the formation crosses the Little River, fig. 1.). The quartzite exposed at the racetrack in the fairgound at Blandford village is 10 to 30 feet thick and contains abundant muscovite. The rock consists essentially of grains of glassy quartz and white muscovite 2 to 3 mm in diameter. Quartz pebbles as much as 2 cm in diameter are scattered throughout the quartzite. Small pits between quartz grains suggest the former presence in some beds of a few percent of carbonate minerals.

TYPE AREA

The type area for the Russell Mountain Formation is on Russell Mountain, where, in a series of outcrops, calc-silicate granulites and quartzites are interbedded. The most accessible exposure is near General Knox Road, as mentioned above, at the south end of Russell Mountain. There typical quartzites and calc-silicate granulites are interbedded on a scale of 6 in. to a few feet in a ratio of about one part quartzite to two parts calc-silicate granulite. Bounding outcrops of pre-Silurian medium-grained muscovite-quartz-biotite-garnet schist and gray cyclically bedded quartz-muscovite-biotite-garnet-staurolite-kyanite schist and quartzose schist of the Goshen Formation (Hatch, 1967, p. 12–15) are about 70 feet apart; exposures of Russell Mountain rocks are only about 50 feet across

strike. Other less accessible exposures of the formation in the type area form a narrow band of outcrops north to the top of Russell Mountain and contain the same lithologies in approximately the same proportions and in about the same exposed width as at the south end of the mountain.

UPPER AND LOWER CONTACTS

Both the top and the bottom of the Russell Mountain Formation are readily defined on the basis of the presence of calc-silicate granulite, carbonate-calc-silicate rock, and quartzite in the Russell Mountain Formation and the absence of these rocks, except as noted, in the underlying and overlying formations.

The Russell Mountain Formation is overlain by gray, somewhat rusty-weathered carbonaceous cyclically bedded schists of the Goshen Formation (Hatch, 1967). The contact is sharp and is readily drawn where both units are exposed; no interbedding of the lithologies characteristic of the two formations was observed. Attitudes of bedding and schistosity in adjacent exposures of Russell Mountain and Goshen rocks are generally parallel within the limits of observation, and no evidence of unconformity of this contact has been seen. Although minor calc-silicate rocks are present in the Goshen, they have not been recognized in the basal few hundred feet of the formation and where present typically occur only as thin lenses and isolated beds, 6 inches to 2 feet thick, that are mineralogically zoned with respect to the surrounding aluminous schists. This zoning, which presumably results from reaction between contiguous calcareous and aluminous beds during regional metamorphism, commonly consists of outer darker hornblende-rich zones around an inner lighter zone rich in quartz and feldspar with diopside, zoisite, and garnet. Quartzites in the upper part of the Goshen (Hatch, 1967, p. 14) are distinctly different from the coarser grained muscovite-rich Russell Mountain quartzites. They are finer grained and grittier, generally contain garnet and more biotite than muscovite, and form beds a few feet to tens of feet thick.

Underlying the Russell Mountain Formation is a sequence of fine- to medium-grained silvery-gray to gray-brown schists and gneisses that intertongue with the Hawley Formation (Hatch, 1967) to the north (Hatch and Stanley, 1970). This contact is also sharp and readily recognized where exposed; it involves no interbedding of characteristic lithologies, and attitudes of bedding and schistosity in adjacent exposures of the two formations are generally parallel within the limits of observation. The underlying

rocks have been temporarily and informally designated units 4 and 5 by Stanley (1967). They contain no quartzites having a grain size coarser than about 0.5 mm and no calcareous quartzites or carbonate-calc-silicate rocks. They do locally contain beds of plagioclase-hornblende amphibolite of presumed igneous origin that are mineralogically and texturally distinct from the calc-silicate granulites of the Russell Mountain Formation. Pods a few inches thick and 6 to 10 inches long of medium-grained massive carbonate-free calc-silicate rock are present in a few places but are readily distinguished from the calc-silicate granulites of the Russell Mountain Formation by their pod shape and by the medium-grained gray or gray-brown muscovite-quartz-biotite-garnet schists with which they are associated. Thus, the change across this contact is from metagraywackes and metashales and minor metavolcanic material to metamorphosed sandy dolomites and quartz sandstones.

The Hawley Formation underlies the Goshen Formation in the northern part of the Blandford quadrangle and the quadrangles on strike to the north (Hatch and others, 1970). No rocks like those of the Russell Mountain Formation have been recognized along this contact. The Hawley contains quartzites, but they are much finer grained than the Russell Mountain quartzites, are generally gray, black, or pink and commonly are finely laminated in shades of gray and pink. Many of them may be metacherts. Rocks associated with the Hawley quartzites are generally gray, rusty-weathered carbonaceous schist and plagioclase-hornblende amphibolite of presumed igneous origin. Although rare scattered pods a few inches across of calc-silicate rock have been seen in the Hawley Formation, they are generally associated with the carbonaceous schist rather than with the quartzites. Thus, the Hawley and Russell Mountain quartzites are lithologically distinctly different. The calc-silicate rocks of the two formations are also readily distinguished both by their pod shape in the Hawley, as contrasted with their bedded character in the Russell Mountain, and by the rocks with which they are associated. For this reason the rocks of the Russell Mountain Formation could not reasonably be considered Hawley Formation or correlative therewith.

Although attitudes of bedding and schistosity in adjacent exposures of Russell Mountain and underlying rocks are generally parallel within the limits of observation, an unconformity is inferred at the base of the Russell Mountain. If the correlations and age assignments of the Hawley and Goshen Formations are correct (Hatch, 1967), the contact between these two units represents a hiatus between Middle Ordovician and at least Middle Silurian and

is the Taconic unconformity. The Russell Mountain Formation crops out along this unconformity in southern Massachusetts. Although the evidence is not conclusive, detailed mapping of thin stratigraphic units in the rocks below the Russell Mountain Formation in the vicinity of Russell Mountain suggests some truncation of these units by the Russell Mountain. This relationship, the evidence from correlations presented below, and the change in depositional environment from a relatively deep-water assemblage of graywacke, shale, volcanic rocks, and chert to a shallower water carbonate-quartzite assemblage all point to the Taconic unconformity being at the base of the Russell Mountain.

THICKNESS

At the northeast end of Westfield Mountain, 110 feet of nearly vertical beds of the Russell Mountain Formation is exposed. At the south end of Russell Mountain near General Knox Road, the Russell Mountain Formation is no more than 70 feet thick. Other exposures indicate minimum thicknesses of 10 to 100 feet. Beds in the Russell Mountain Formation on Ball Mountain commonly have gentle dips, and in places a few tens of feet of beds appear to underlie areas a few hundred feet across. The structure in this area is complex, however, and stratigraphic thicknesses in excess of 110 feet may be present locally.

The formation is known to be absent at a number of well-exposed localities along the contact between the pre-Silurian rocks and the Goshen Formation in the area of figure 1. North of the Blandford racetrack the formation is missing in Massachusetts. Thus, on the basis of the mapping in the area of figure 1, the thickness of the Russell Mountain Formation is 0 to 110 feet.

CORRELATION AND AGE

No fossils have been found in the Russell Mountain Formation, nor have any been found in any of the pre-Triassic rocks on the east limb of the Berkshire anticlinorium in Massachusetts or Connecticut. The Russell Mountain Formation is younger than units 4 and 5 of Stanley (1967), which are correlated with the Hawley Formation by Hatch and Stanley (1970) on the basis of intertonguing facies relationships. The age of the Hawley, based on correlations with Vermont, is considered by Hatch (1967, p. 12) to be Middle Ordovician.

The Russell Mountain Formation is overlain by the Goshen Formation which "may . . . include rocks that range in age from Middle Silurian to [Early] Devonian" (Hatch, 1967, p. 15). The Russell

Mountain thus cannot be older than Middle Ordovician or younger than Middle Silurian.

Although no rocks in the stratigraphic position of the Russell Mountain Formation have been seen in Massachusetts north of Blandford village, similar rocks do crop out in this stratigraphic position as a discontinuous series of lenses throughout much of eastern Vermont, where they are called the Shaw Mountain Formation (Doll and others, 1961). The Shaw Mountain Formation, as originally described by Currier and Jahns (1941, p. 1496–1501). contains a variety of rocks including quartz conglomerate and quartzite, soda rhyolite tuff, and crinoidal limestone. In the Plainfield quadrangle, Vermont, Konig (1961, p. 30) states that "most of the [Shaw Mountain] section is composed of thin-bedded calcareous quartzite which locally grades into fine-grained metamorphosed quartz conglomerate." In describing this calcareous quartzite, he says (p. 30), "On a fresh exposure this rock is light gray, but upon weathering develops a light-tan to dark-brown cellular rind which may be as much as one to two inches thick." This description applies equally well to the porous brown-weathered carbonate-calc-silicate rock of the present area described on page 3. Although Currier and Jahns (1941, p. 1497) describe stretched pebbles in the Shaw Mountain conglomerate with long axes as much as 11 inches long, Konig (1961, p. 31) describes the conglomerate in the Plainfield quadrangle as having pebbles with "diameters ranging from 4 to 25 millimeters." Konig's pebbles are thus comparable in size to the pebbles observed in the Russell Mountain rocks. The two principal lithologies of the Plainfield, Vt., area, calcareous quartzite and quartz conglomerate, are thus very similar to two of the principal lithologies of the present area.

Greenstones, soda rhyolite tuff, crystalline limestone, and cummingtonite schist have been reported by Currier and Jahns (1941, p. 1496–1501), Konig (1961, p. 31), and Doll, Cady, Thompson, and Billings (1961) as local minor lithologies in the Shaw Mountain Formation. None of these rock types have been recognized in the Russell Mountain Formation, but their limited areal extent in Vermont and small size of the area of Russell Mountain rocks studied to date should rule out the use of this fact as an argument against correlating the Shaw Mountain and Russell Mountain Formations.

Boucot (1968) has assigned to the Shaw Mountain a Wenlock age apparently based on the following evidence. As reported by Boucot and Thompson (1963, p. 1318), the Shaw Mountain contains *Howellella* near Albany, Vt. The type of *Howellella* found

has a known stratigraphic range of C_3 (late Llandovery) to early Gedinnian (Manlius–Coeymans). Furthermore, according to Berry and Boucot (1970), the stratigraphic position of the Shaw Mountain just above the Taconic unconformity and the absence of Early Devonian strata along strike in Vermont or Quebec older than Siegen (Becraft–Oriskany) suggest that the Shaw Mountain is of Silurian age. In addition, the Peasley Pond Conglomerate, which is similar to the conglomerate in the Shaw Mountain, in the adjacent Memphremagog area of southern Quebec underlies strata of early Ludlow age. This reasoning suggests that the Shaw Mountain cannot be older than late Llandovery (C_3) nor younger than earliest Ludlow and presumably is the basis for Boucot's (1968, p. 84) assignment of the Shaw Mountain to a Wenlock age. On the basis of the similarity of the principal lithologies of the two formations and their similar stratigraphic position, the Russell Mountain Formation is believed to be the lateral equivalent of the Shaw Mountain Formation of Vermont. On the basis of this correlation, the Russell Mountain is assigned a Wenlock age, which is approximately equal to the middle part of the Middle Silurian of the American standard section. (For comparison of the European and American sections, see Pavlides and others, 1968, fig. 5–2, p. 66.)

Rocks present to the south in Connecticut are lithologically similar to, and may be stratigraphically correlative with, the rocks of the Russell Mountain Formation. Further study of these possible correlations is in progress.

REFERENCES

Berry, W. B. N., and Boucot, A. J., 1970, Silurian of North America: Geol. Soc. America Spec. Paper 102. (In press.)

Boucot, A. J., 1968, Silurian and Devonian of the northern Appalachians, *in* Zen, E-an, White, W. S., Hadley, J. B., and Thompson, J. B., Jr., eds., Studies of Appalachian geology—northern and maritime: New York, Interscience Publishers, p. 83–94.

Boucot, A. J., and Thompson, J. B., Jr., 1963, Metamorphosed Silurian brachiopods from New Hampshire: Geol. Soc. America Bull., v. 74, no. 11, p. 1313–1334.

Currier, L. W., and Jahns, R. H., 1941, Ordovician stratigraphy of central Vermont: Geol. Soc. America Bull., v. 52, no. 9, p. 1487–1512.

Doll, C. G., Cady, W. M., Thompson, J. B., Jr., and Billings, M. P., 1961, Centennial geologic map of Vermont: Montpelier, Vt., Vermont Geol. Survey, scale 1:250,000.

Hatch, N. L., Jr., 1967, Redefinition of the Hawley and Goshen Schists in western Massachusetts: U.S. Geol. Survey Bull. 1254–D, 16 p.

Hatch, N. L., Jr., Norton, S. A., and Clark, R. G., Jr., 1970, Geologic map of the Chester quadrangle, Massachusetts: U.S. Geol. Survey Geol. Quad. Map GQ–858. (In press.)

Hatch, N. L., Jr., and Stanley, R. S., 1970, Stratigraphic continuity and facies changes in formations of early Paleozoic age in western Massachusetts and tentative correlations with Connecticut [abs.]: Geol. Soc. America Abstracts with Programs, v. 2, no. 1, p. 23–24.

Konig, R. H., 1961, Geology of the Plainfield quadrangle, Vermont: Vermont Geol. Survey Bull. 16, 86 p.

Pavlides, Louis, Boucot, A. J., and Skidmore, W. B., 1968, Stratigraphic evidence for the Taconic orogeny in the northern Appalachians, *in* Zen, E-an, White, W. S., Hadley, J. B., and Thompson, J. B., Jr., eds., Studies of Appalachian geology—northern and maritime: New York, Interscience Publishers, p. 61–82.

Stanley, R. S., 1967, Geometry and age relations of some minor folds and their relation to the Woronoco nappe, Blandford and Woronoco quadrangles, Massachusetts, *in* New England Intercollegiate Geol. Conf., 59th Ann. Mtg., Oct. 13–15, 1967, Guidebook for field trips in the Connecticut Valley of Massachusetts: Amherst, Mass., p. 48–60.

☆U.S. GOVERNMENT PRINTING OFFICE: 1970 O—389–679