Bedrock Geology of the Chepachet Quadrangle Providence County Rhode Island

By ALONZO W. QUINN

CONTRIBUTIONS TO GENERAL GEOLOGY

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ABSTRACT

The Chepachet quadrangle in northwestern Rhode Island is underlain by three groups of metamorphic and plutonic rocks. The first group, older(?) gneisses of Precambrian(?) age, includes a feldspathic gneiss, the Nipsachuck Gneiss, and the Absalona porphyroblastic biotite gneiss. These rocks are in the eastern and southeastern part of the quadrangle. The second group, in the northeastern part of the quadrangle, is the Precambrian(?) Blackstone Series of metamorphic rocks, which includes quartzite, quartz-mica schist, amphibolite, and epidosite. These two groups are metamorphosed to the staurolite-almandine subfacies of the almandine-amphibolite facies. The third group, consisting of a large variety of younger plutonic rocks, ranges in composition from diorite to granite and in structure from strongly foliated and lineated gneisses to weakly foliated granitic rocks. This third group underlies the west half of the quadrangle and is mostly included in the Ponaganset Gneiss. It may have resulted from one major syntectonic intrusive episode, in which the earliest, more mafic members intruded under great stress and the later more felsic members intruded under diminished stress. The late stages of metamorphism changed the plagioclase of these rocks to less calcic plagioclase and epidote. Included among the third group are amphibolite, Ponaganset Gneiss, gneiss of Herring Pond vicinity, Scituate Granite Gneiss, and Esmond Granite. This third group seems to be Mississippian(?) or older. The two older groups show variable and complex trends of structure including a large area of northwesterly trend. Structure of the third group is generally simple and consists of north trends and near-vertical dips.

INTRODUCTION

This report on the bedrock geology of the Chepachet quadrangle is one of a series of reports describing the bedrock and surficial geology of Rhode Island. These geological studies resulted from a cooperative project of the Rhode Island Development Council and the U.S. Geological Survey.

The Chepachet quadrangle, near the northwest corner of Rhode Island, is one of the highest parts of the State. The topography is characterized by large smooth hills, such as Wolf Hill, Sprague Hill, Durfee Hill, and Tourtellotte Hill. There are a few swampy areas and several ponds and lakes, largest of which are Ponaganset Reservoir, Burlingame Reservoir, Wilson Reservoir, Pascoag Reservoir, Sucker Pond, Herring Pond (now generally called Spring Lake), and Smith and Sayles Reservoir. Most of these lakes were formed wholly or in part by artificial dams.

Outcrops are sparse on the smooth uplands and almost completely absent from several lowland areas of glacial outwash, but there are several fairly large areas of abundant exposure. One such area is around Pascoag and southward, and a second is along U.S. Route 44 (Putnam Pike) near the east margin of the quadrangle. Smaller areas of closely spaced outcrops and single exposures are scattered evenly in the quadrangle so that the main features of bedrock distribution and relations have probably been determined correctly. However, in some areas of sparse exposures some relationships of rock units to each other could not be definitely determined. One of these areas is along the valley of the Chepachet River from Gazzaville northward to the vicinity of Oakland. Extensive glacial deposits covering this valley make it impossible to determine the nature of the contact between (1) the Precambrian(?) Absalona and Nipsachuck gneisses of Absalona Hill and Cooper Hill and (2) the Precambrian(?) Blackstone Series east and south of Whipple. Glacial cover also prevents more detailed mapping of the Mississippian(?) or older Ponaganset Gneiss in the central and the western parts of the quadrangle. Several varieties of gneiss are exposed, and at least some of them could probably be mapped separately if the glacial cover were less extensive. The geologic map (pl. 1) shows the distribution of exposures by special marks for outcrops and areas of closely spaced outcrops and also by structure symbols.

During the writing of this report, in 1965, Rhode Island Route 102 was being relocated, and several extensive roadcuts were being excavated. Further road work probably will change these to some extent before publication of the report.

ACKNOWLEDGMENTS

Several of my former graduate students at Brown University mapped parts of the Chepachet quadrangle. The following left partial or complete copies of their maps: Mr. James W. Nagle III, Mr. Glenn C. Prescott, and Mr. Amos M. White. Mr. John Francis Wosinski wrote a Master's thesis, "Bedrock Geology of the Southern Half of the Chepachet Quadrangle, Rhode Island," in 1958. I have used all these maps in preparing the present report, but I have made field checks of almost all outcrops. Thanks are extended to these men, but I bear responsibility for any errors or omissions in the report. I am grateful also to George E. Moore, Jr., and Roberta Dixon, U.S. Geological Survey, for field conferences concerning their adjacent quadrangle studies (Clayville and Thompson, respectively). Mr. Willard S. Winslow, Jr., of North Providence, supplied data on mines, quarries, and mineral localities in the quadrangle.

PREVIOUS WORK

A few earlier reports dealt with some features of the geology of the Chepachet area. Jackson (1840) and Emerson (1917) included geologic maps of the Chepachet and adjacent areas. Quinn and Swann (1950) prepared a bibliography on the geology of Rhode Island. Hawkins (1918) included this area in his geologic map, and also described (1922) epidote crystals at Pascoag. Flagg (1937) made reference to amethyst crystals of Burrillville, about halfway between Harrisville and Sucker Pond. The minerals of the Durfee Hill gold mine were listed by Fisher and Doll (1927). Hahn and Hansen (1961) presented a map showing the ground-water resources of the Chepachet quadrangle.

GEOLOGIC FORMATIONS

The bedrock formations of the Chepachet quadrangle are divided into three groups.

1. Older(?) gneisses of uncertain relationships and origins, including the Nipsachuck Gneiss, the Absalona Formation, and a fine-grained gray gneiss.
2. The Precambrian(?) Blackstone Series of metamorphosed sedimentary rocks, and possibly including some metamorphosed igneous rocks.
3. A large variety of younger (Mississippian(?) or older) plutonic rocks ranging in composition from diorite to granite and in structure from strongly gneissic to massive. The last group may constitute one differentiated intrusive sequence or it may include representatives of two or more episodes of plutonic activity; it includes amphibolite, the Ponaganset Gneiss, the gneiss of Herring Pond vicinity, the Scituate Granite Gneiss, and the Esmond Granite. A major part of the metamorphism of the first two main groups of rocks occurred before the intrusion of the third group of plutonic rocks, but less severe metamorphic conditions prevailed during the intrusion of at least the oldest members of the younger plutonic rocks than during the metamorphism of the first two groups.

OLDER(?) GNEISSES

NIPSACHUCK GNEISS

The Nipsachuck Gneiss was named by Richmond and Allen (1951, p. 11) for exposures near Nipsachuck swamp in the Georgiaville quadrangle, Rhode Island. It was named and described again by Richmond (1952). Exposures of the Nipsachuck in the Chepachet quadrangle along Cooper Hill are contiguous with Nipsachuck exposures in the adjacent Georgiaville quadrangle.

The rock is gray to light tan fine- to medium-grained gneiss, with prominent lineation of biotite and prominent foliation. Indistinct compositional layering appears to be bedding. The main constituents are feldspars, quartz, biotite, and muscovite. Microscopic examination reveals that the porphyroblasts are quartz and microperthite. Main constituents of the matrix are quartz, microperthite, albite-oligoclase, biotite, and muscovite. Minor and accessory constituents include clinozoisite, chlorite, a carbonate mineral, magnetite, and zircon. One mode of this rock from the south end of Cooper Hill indicated: quartz, 50.0 percent; potassium feldspar, 31.2 percent; plagioclase, 0.8 percent; biotite, 14.6 percent; muscovite, 1.0 percent; carbonate, 1.5 percent; and accessories, 0.3 percent. This composition, texture, and structure indicate that the gneiss originated by the metamorphism of graywacke, feldspathic sandstone, or volcanic rock.

Richmond interpreted the Nipsachuck Gneiss in the Georgiaville quadrangle as an older rock exposed in the core of an overturned anticline; the overlying, younger Absalona Formation is exposed on both sides. The exposures in the Chepachet quadrangle are consistent with such an interpretation, but they may be equally consistent with an interpretation of the Nipsachuck Gneiss as a lens within the Absalona Formation. In this latter interpretation the thickness of the Nipsachuck Gneiss here would be approximately 1,000 feet.

ABSALONA FORMATION

The Absalona Formation was named for exposures on Absalona Hill, on the border between the Georgiaville and Chepachet quadrangles (Richmond and Allen, 1951, p. 11; Richmond, 1952). Richmond and Allen (1951) stated that this formation in the Georgiaville quadrangle is chiefly porphyroblastic biotite gneiss, but Richmond (1952) also described quartz-biotite schist, biotite gneiss, amphibolite, and feldspathic quartzite within this formation. In the Chepachet quadrangle, the formation is predominantly porphyroblastic biotite gneiss, but a thick north-trending lens of light-gray feldspathic gneiss has been mapped within the porphyroblastic gneiss near the southeast corner of the quadrangle. This lens is distinguished from the typical Absalona gneiss by its lighter color and less porphyroblastic texture.

The light-gray feldspathic gneiss has a maximum thickness of about 1,450 feet. The darker, porphyroblastic biotite gneiss above the light-gray gneiss, including some in the Georgiaville quadrangle to the east, is about 1,250–1,550 feet thick. This gives a total thickness of 2,550–3,000 feet. This does not take into account the porphyroblastic biotite gneiss west of (below) the light-gray gneiss; no estimate of the thickness of this part is made here because of the scarcity of outcrops and the variable structure.

Porphyroblastic biotite gneiss.—The porphyroblastic biotite gneiss is gray to dark gray, medium to coarse grained, distinctly foliated, and commonly lineated. Feldspars, quartz, and biotite are the chief minerals. Epidote and hornblende are also common. Characteristic of the rock are feldspar porphyroblasts 2–3 cm long; most of these are discordant to the foliation, but a few are parallel to it. Most porphyroblasts intersect the foliation sharply without deflection, but biotite flakes are slightly warped around some porphyroblasts. Zoning is observed in many porphyroblasts, especially on weathered surfaces. The quartz is generally fine grained, but near the south end of Woonsocket Hill in the north-central part of the Georgiaville quadrangle and at some other localities, there are quartz grains 5 mm or more across. Some of these are distinctly bluish and some are colorless or milky. Lenses of light-colored fine-grained quartz-mica schist and of dark biotite schist and knots of epidote are typical of this formation. Most of these lenses and knots are a few inches to a foot long and are parallel to the foliation. Small pegmatites and irregular masses of vein quartz are also common.

Microscopic examination reveals that the gneiss consists chiefly of microcline, microcline-microperthite, oligoclase-albite, quartz, and biotite. At most places the rock also contains hornblende. Minor constituents typical of this rock are scattered grains and crystals of clinozoisite and aggregates of small grains and separate small grains of sphene. Other minor constituents and accessories are magnetite, ilmenite, pyrite, garnet, a carbonate mineral, zircon, apatite, and allanite.

Wosinski (1958) made a special study of zircon from one sample of Absalona porphyroblastic gneiss. The zircon crystals of this sample were long, sharp, and angular.

Porphyroblasts include microcline, microcline-microperthite, and plagioclase. The plagioclase of porphyroblasts, which ranges from An_{10} to An_{17}, is antiperthitic; it is also intergrown with quartz. Different zones of the zoned plagioclase porphyroblasts seem, on the basis of refractive indices, to have almost the same composition but slightly different optical orientations.

Apparently, most of the porphyroblasts formed after the development of schistosity, for the relationship between schistosity and porphyroblasts is sharply discordant. The minor amount of wrapping of biotite around porphyroblasts may indicate that either some stresses continued after the formation of porphyroblasts or the growing porphyroblasts pushed some biotite flakes out of line. Zoned porphyroblasts of feldspar are somewhat unusual, but they are not unique (Coombs, 1950, p. 377; Misch, 1949, p. 384). They may have grown during either the rise or the fall of metamorphic temperature. Each change in temperature might cause the composition and also the orientation of the plagioclase to vary.

Light-gray feldspathic gneiss.—A light-colored gneiss facies within the Absalona Formation underlies an area 3 miles long and half a mile wide in the southeastern part of the quadrangle. This rock is well exposed along Putnam Pike near the east margin of the quadrangle, on the hills just east of Spring Grove, and to a lesser extent along Douglas Hook Road.

The rock of this facies is chiefly light-gray medium-grained granitic gneiss. Microcline-microperthite, albite, and quartz are the chief constituents. Biotite and muscovite are common. Minor and accessory minerals are sphene, zircon, clinozoisite, garnet, a carbonate mineral, magnetite, pyrite, and fluorite. The rock differs from typical porphyroblastic biotite gneiss because it has a finer texture, a scarcity or absence of porphyroblasts, less biotite, and no amphibole, and does have muscovite. The rock also has less sphene and clinozoisite than the typical porphyroblastic gneiss.

At a point 3,100 feet west of the east margin of the quadrangle and 1,000 feet south of Douglas Hook road interbeds of feldspathic quartz-rich gneiss and fine-grained quartz-mica schist are exposed. These are concordant with the foliation of the light-gray feldspathic gneiss. The compositions and the interlayering are evidence of an origin as interbedded sediments or volcanic debris.

The contact of the light-gray feldspathic gneiss is concordant with the foliation of the porphyroblastic biotite gneiss. Apparently the light-gray gneiss originated as less mafic sedimentary or volcanic material interbedded with the more abundant mafic parts of the Absalona Formation.

Relationship of Absalona Formation to other formations.—The relationship of the Absalona Formation to other formations of the area has not been determined with certainty. The Absalona Formation is older than the Scituate Granite Gneiss, as the Scituate is intrusive into the Absalona at Snake Hill. Whether the Absalona is older than, younger than, or equivalent to the Blackstone Series is not shown by any known and reliable geological evidence. Richmond (Richmond and Allen, 1951; Richmond, 1952) concluded that in the Georgiaville quadrangle the Absalona Formation, together with the Nipsachuck Gneiss and the Woonsquatucket Formation, is overlain by the younger rocks of the Blackstone Series. His map of the vicinity of Woonsocket Hill, in the north-central part of the Georgiaville quadrangle, suggests that there is an unconformity beneath the Blackstone Series; the critical area, however, is completely covered by glacial drift. Richmond mapped the older(?) gneisses in the Georgiaville quadrangle as having complicated folds overturned to the west. No comparable structures are known in the rocks of the Blackstone Series. This suggests that the gneisses were involved in folding before the Blackstone Series was deposited. However, comparable structures could be present in the Blackstone Series but be undetected because the series here does not have any key stratigraphic horizons that can be traced far enough to reveal comparable structures. Within the Chepachet quadrangle, scattered exposures a mile southwest of Mapleville and to the north of Oakland seem to indicate that the Absalona Formation dips underneath the Blackstone Series and, thus, is older than the Blackstone. Metamorphic grade yields no evidence concerning relative ages here, as all of these rocks are in almost the same grade, the almandine-amphibolite facies.

Origin of the Absalona Formation.—The mineral composition of the Absalona Formation suggests that the formation was originally either volcanic material of dacite or quartz latite composition or feldspathic and iron-rich sediment. The mixture of blue quartz grains and other types of quartz grains indicates that these grains were derived by erosion of different source rocks. If the formation had an igneous origin the quartz grains would all be the same color, regardless of whether the blue color was a primary igneous character or was induced by metamorphism. This color mixture is not typical, however, and a sedimentary origin is not indicated for the whole formation. The light-gray feldspathic gneiss appears to have been a more felsic volcanic layer or a sedimentary layer having lower iron content. The more quartzose layers within the light-gray feldspathic gneiss may have been layers of quartz-rich sand, and the micaceous layers may have been layers of shale.

Wosinski (1958, p. 9) made a study of zircon in a sample of the Absalona porphyroblastic biotite gneiss. Both the angularity and the elongation of the zircon crystals are indicative of either an igneous origin or of little sedimentary transport and abrasion.

FINE-GRAINED GRAY GNEISS

An area of fine-grained gray gneiss about a mile wide extends from the south margin of the quadrangle northward about 3 miles to Chepachet. In much of this area the gneiss is covered, but good exposures can be seen on Snake Hill Road just south of the quadrangle, on the hills north and northeast of Lake Aldersgate, and on Pound Road approximately 1,000 feet southeast of its intersection with Victory Highway.

The rock is gray to light gray, fine to medium grained, and distinctly foliated in most places. Megascopically, it appears to be a fine-grained gray quartz-feldspar-biotite gneiss. At the exposure on Snake Hill Road the rock looks almost like quartzite, but feldspar is more abundant than is apparent. Microscopic examination reveals that the rock is composed chiefly of quartz, microcline, microcline-microperthite, oligoclase, and biotite. Hornblende porphyroblasts are prominent locally, as at the exposures on Pound Road. Some of the plagioclase does not show twinning. Minor and accessory constituents include muscovite, magnetite, zircon. apatite, allanite, and fluorite. The mineral composition indicates that the original unmetamorphosed rock was probably either a feldspathic and quartzose sediment or a felsic volcanic rock.

This rock is less mafic than the Absalona porphyroblastic gneiss, and it does not have prominent porphyroblasts. It is rather similar to, but finer grained than, the large lens of light-gray feldspathic gneiss within the Absalona Formation. It differs from the Nipsachuck Gneiss by the absence of prominent biotite lineation and the presence of hornblende porphyroblasts. From available evidence, the fine-grained gray gneiss may be older than, younger than, or a member of, the Absalona Formation.

BLACKSTONE SERIES

A large area in the northeast corner of the quadrangle is underlain by metamorphic rocks that are correlated with the Blackstone Series of the Pawtucket quadrangle (Quinn and others, 1949; Quinn and others, 1948, p. 9, 10). Also present are several smaller masses of Blackstone Series enclosed by gneissic rocks; one of these smaller masses is at the intersection of Lapham Farm Road and Rhode Island Route 100, and another underlies the peninsula extending southward into Smith and Sayles Reservoir.

Westward from the type locality in the Blackstone River valley in the Pawtucket quadrangle are several patches of Blackstone Series rocks exposed in the Georgiaville quadrangle. The westernmost of these is contiguous with the exposures in the Chepachet quadrangle.

In both the Georgiaville and the Chepachet quadrangles these rocks are more highly metamorphosed, more feldspathic, and more abundantly cut by stringers of granitic and pegmatitic material than in the type locality. The Blackstone Series was assigned a Precambrian(?) or an early Paleozoic age in the reports on the Pawtucket quadrangle. Subsequent mapping and study have not discovered evidence to alter that indefinite age assignment. The relationship of the Blackstone Series to the older(?) gneiss was discussed above. The Blackstone Series was intruded by the younger plutonic rocks.

The Blackstone Series of the Chepachet quadrangle has not been divided into separate formations, as was done in the Pawtucket quadrangle. Some quartzite, a few layers of amphibolite, and a lens of epidosite were mapped separately in the Chepachet quadrangle; otherwise, the rocks are shown as Blackstone Series undivided.

Most exposures of the Blackstone Series include medium-grained thin beds of quartzite, feldspathic quartzite, quartz-mica schist, biotite schist, and muscovite schist. The main constituents, in varying proportions, are quartz, biotite, muscovite, microcline, and plagioclase. Minor and accessory constituents include chlorite, epidote, zoisite, hornblende, tremolite, garnet, staurolite, magnetite, ilmenite, pyrite, apatite, sphene, allanite, zircon, and fluorite. During the relocation of Rhode Island Route 102 in 1964–65 roadcuts, especially just north of Oakland, exposed Blackstone Series rocks that contained a considerable variety of minerals, including those listed above and also pink zoisite, apatite crystals, epidote crystals, chabazite, stilbite, and beryl. These rocks probably originated as sandy and shaly sediments.

QUARTZITE

The ridges just north of Harrisville are composed mostly of quartzite. The area of quartzite is more than a mile long and as much as a quarter of a mile wide. Several layers of quartzite have also been mapped near the northeast corner of the quadrangle. The quartzite is light gray, fine grained, and massive and contains a few thin layers of schist. A thin layer of mica-staurolite schist within the quartzite is exposed on the ridge 0.2 mile southwest of the south end of Herring Pond. In addition to quartz, these rocks contain minor amounts of muscovite, biotite, tremolite, garnet, magnetite, ilmenite, pyrite, and zircon.

AMPHIBOLITE

A few layers of amphibolite are exposed along the west margin of the quartzite north or Harrisville and also at the north margin of the quadrangle. These amphibolites are dark gray, medium to coarse grained, and schistose. The chief minerals are hornblende, plagioclase, quartz, and biotite. Clinozoisite is common as small inclusions in the plagioclase, and epidote forms a few separate grains. Minor and accessory constituents include magnetite, zircon, ilmenite, and sphene. The amphibolite layers are concordant with and gradational into quartzite and schist. The amphibolites were probably layers of volcanic debris or iron-rich shale interbedded with the rest of the Blackstone Series. Similar amphibolites are interbedded with the Blackstone Series elsewhere.

EPIDOSITE

About 0.7 mile north of Glendale along a little-used road off Joslin Road are exposures of an unusual epidote rock. The rock is light gray, fine to medium grained, and mostly massive, although there is some layering parallel to that of the surrounding Blackstone Series. The rock has the megascopic appearance of an ordinary quartzite. However, microscopic examination reveals that it is composed almost wholly of iron-poor epidote. Minor constituents include labradorite, quartz, biotite, muscovite, chlorite, and rutile. This rock is a lens within the Blackstone Series and appears to have originally been a lens of calcareous shale or similar sediment that, when metamorphosed, became epidote rock, whereas the layers above and below became quartzite and schists.

YOUNGER PLUTONIC ROCKS

AMPHIBOLITE

Several masses of amphibolite are exposed in a broad strip extending from the south margin of the quadrangle northward through the middle of the quadrangle almost to Bridgeton.

The amphibolite is mostly medium grained, although grain size and most other characteristics are variable. The structure ranges from massive to moderately schistose; the schistosity is mostly along and parallel to the borders. The color ranges from light gray, where plagioclase and quartz predominate, through medium gray to dark gray, where amphibole and biotite are more abundant.

The chief minerals are amphibole, plagioclase, quartz, and biotite. (See table 1.) Accessory minerals and minor constituents include clinozoisite, sphene, magnetite, pyrite, ilmenite, apatite, chlorite, zircon, allanite, and rutile. Amphibole, which ranges from 8 to 86 percent of the rock, appears to be hornblende. There is some variation in the optical properties of the amphibole, but the following are common: $\alpha=1.670$, $\beta=1.680$, $\gamma=1.687$; X, light tan; Y, green; Z, blue-green; $Z=>Y>X$; $Y=b$; $Z\Lambda c$ 16°. Plagioclase is variable in both composition (An_{12} to An_{57}, mostly about An_{40}) and abundance (12–54 percent). All plagioclase was altered from a more calcic composition, as is indicated by numerous crystals and grains of clinozoisite within the plagioclase; some plagioclase grains were almost completely replaced by clinozoisite. Biotite composes as much as 22 percent of some specimens of this rock, but it is absent from others. It is pleochroic from almost colorless to dark brown. Some of it has formed by the alteration of hornblende. Much of the clinozoisite is in small grains within plagioclase, but some forms larger grains not enclosed by plagioclase. Quartz, which composes as much as 17 percent of the rock, forms both small round grains and medium-sized interstitial grains.

TABLE 1.—*Modes of amphibolite*

[In volume percent]

Minerals	West and south of Pascoag				Oak Hill and south			South-central part of quadrangle			
	1	2	3	4	5	6	7	8	9	10	11
Quartz	1.1	0.7	------	2.2	1.3	7.0	2.4	1.3	13.1	16.9	9.7
Plagioclase	38.0	35.2	12.5	22.7	30.5	21.1	24.0	28.6	54.3	51.0	46.5
Amphibole	59.4	63.9	86.0	73.9	56.1	66.0	66.4	69.5	8.1	15.7	34.7
Biotite	.1	------	------	.6	10.9	3.1	3.5	------	21.7	15.4	7.1
Accessories	1.4	.2	1.5	.6	1.2	2.8	3.7	.6	2.8	1.0	2.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Composition of plagioclase	An_{12}	An_{52}	An_{53}	An_{38}	An_{57}	An_{26}	An_{28}	An_{49}	An_{22}	An_{40}	An_{45}

SAMPLE LOCALITY

1. Pascoag, High Street, 0.22 mile west of center of Pascoag.
2. Main peninsula in Pascoag Reservoir, on road 0.5 mile south of High Street.
3. Main peninsula in Pascoag Reservoir, 1.05 mile south of High Street.
4. Putnam Pike, 0.2 mile east of Pine Hill Schoolhouse Road.
5. Oak Hill, 0.05 mile east of summit.
6. Rhode Island Route 100, 0.34 mile northwest of intersection with Lapham Farm Road.
7. 0.4 mile south of No. 6; or 0.3 mile southwest of intersection of Rhode Island Route 100 with Lapham Farm Road.
8. West side Pine Hill Schoolhouse Road, 0.1 mile north of Joe Sweet Road.
9. East side of Victory Highway, 0.6 mile north of south margin of quadrangle.
10. West side of Victory Highway, 0.1 mile north of south margin of quadrangle.
11. Clayville quadrangle, roadcut on Rhode Island Route 101, 1.0 mile west of Victory Highway.

All the amphibolite bodies are completely enclosed by the Ponaganset Gneiss. The contact zones are marked by stringers and other small intrusions of the gneiss into the amphibolite, and by sparse inclusions of the amphibolite within the gneiss. Along most of these contacts both the amphibolite and the gneiss are more foliated than they are away from the contacts, and the foliations are about parallel to each other. These structural relations, which probably are due to the syntectonic intrusion of gneissic magma against already solid amphibolite, indicate that the amphibolite is older than the Ponaganset Gneiss. These intrusive relations can be seen in exposures along Victory Highway west of Lake Aldersgate, along the road north of Shingle Mill Pond, just west of the intersection of Putnam Pike and Reservoir Road, and on the west slope of the hill about 0.4 mile northeast of Wescott Beach.

Some of the less calcic plagioclase of the amphibolite contains many small crystals of clinozoisite, which indicates retrograde alteration of a more calcic plagioclase. The alteration probably was due to heating by the intrusion of the Ponaganset Gneiss.

Near some contacts the amphibolite contains inclusions of quartzite, schistose amphibolite, and mica schist that appear to belong to the Blackstone Series. This evidence indicates that the amphibolite is younger than the Blackstone Series and that at least some of the amphibolite originated as intrusive diorite. Sample 1 of table 1 is from such an amphibolite inclusion. These inclusions can be seen along Victory Highway west of Lake Aldersgate and in the small amphibolite mass just west of the intersection of Putnam Pike and Reservoir Road.

The genesis of rocks composed chiefly of amphibole, plagioclase, and clinozoisite, like the amphibolite here, has long been problematical. The chief origins proposed have been (a) retrograde metamorphism of dioritic igneous rock, (b) metamorphic recrystallization of impure calcareous and dolomitic sediments, and (c) metamorphism of such extrusive rocks as basalt flows or pyroclastics. The evidence in the Chepachet quadrangle seems to favor an intrusive igneous origin. The amphibolite is generally massive and uniform in texture and composition. However, foliation and some streaks are conspicuous along most of the margins of, and also within, the amphibolite bodies. The foliation and streaks do not suggest an intrusive igneous origin, although some streaks may have been caused by flowage and multiple intrusion within an intrusive body. However, the absence of sedimentary layers, limestone lenses, and relicts of clastic texture suggest an igneous intrusive origin, as do the slablike inclusions of quartzite, amphibolite, and schist.

It is concluded that this amphibole-plagioclase-clinozoisite rock is of igneous intrusive origin; it may have been either an earlier dioritic rock unrelated to the Ponaganset Gneiss or an early member of the Ponaganset sequence—diorite to tonalite to granodiorite to quartz monzonite to granite.

GARNET ROCK

Near the east margin of the Oak Hill mass of amphibolite are two areas of garnet-staurolite schist. This schist is unusual because parts of it contain as much as 50 percent garnet in large crystals. One area, too small to show on the map, is 1,100 feet northeast of the north summit of Oak Hill; and another, which is more than 400 feet long and 30 feet wide, is just north of the intersection of Rhode Island Route 100 and Lapham Farm Road. In both areas the garnet rock is within the strongly foliated marginal facies of Ponaganset Gneiss. The rock is indistinctly layered and contains chiefly garnet, staurolite, muscovite, biotite, hornblende, and quartz, in varying proportions. Minor constituents include oligoclase, chlorite, magnetite, ilmenite, and zircon. The index of refraction of the garnet is 1.804. Many of the garnets are about a quarter of an inch across, and some are more than an inch across.

PONAGANSET GNEISS

More than half the quadrangle is underlain by gneissic rocks, here named the Ponaganset Gneiss for exposures around Ponaganset Reservoir, the type locality. These rocks vary considerably in composition (table 2; fig. 1) and in general appearance. Although differences be-

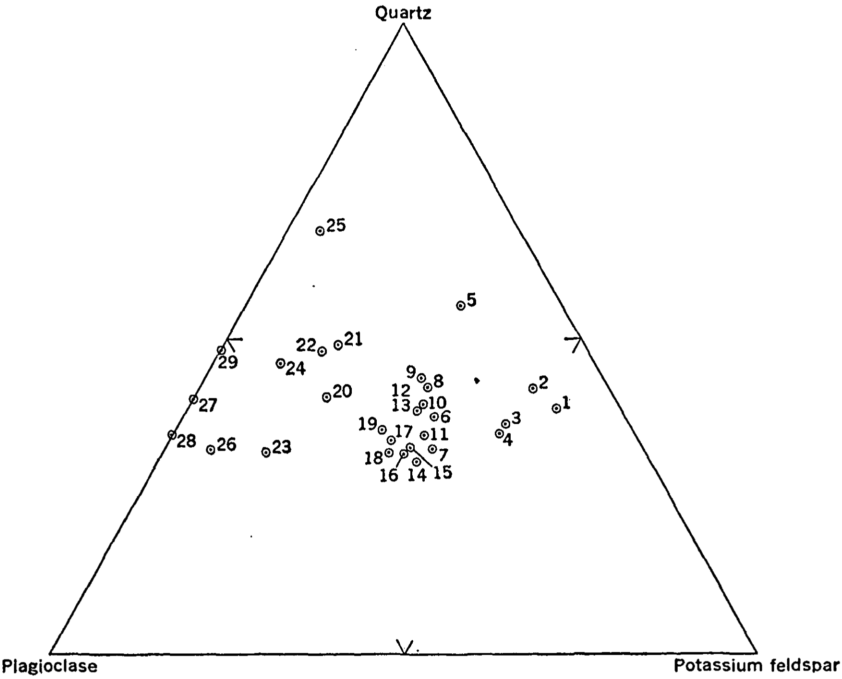

FIGURE 1.—Modes of Ponaganset Gneiss plotted on quartz–potassium feldspar–plagioclase diagram.

tween hand specimens and between small outcrops are readily apparent, the scale and gradational character of variation, together with the distribution of exposures, made it impractical to show much of the variation on the map. The general pattern of variation is one of north-trending lenses.

TABLE 2.—*Modes of the Ponaganset Gneiss*

[In volume percent]

Mineral	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Quartz	38.1	36.4	35.4	33.0	53.8	36.6	29.9	40.2	41.7	37.0	33.3	32.7	35.6	25.9	29.0
Potassium feldspar	51.6	40.7	45.3	43.3	29.9	34.4	35.2	30.5	29.5	30.8	34.0	27.3	29.6	31.5	31.2
Plagioclase	9.0	9.3	17.0	17.9	13.9	26.2	27.7	24.4	24.5	25.6	28.5	24.2	26.4	28.3	29.4
Biotite	.8	11.2	1.9	4.7	2.1	.9	6.2	4.5	3.7	6.1	3.8	13.4	5.0	11.0	7.7
Hornblende	----	1.0	----	----	----	----	----	----	----	----	----	.8	2.0	----	----
Epidote	----	----	----	----	----	----	----	----	----	----	----	.7	----	----	----
Muscovite	.3	----	----	----	----	----	----	----	----	----	----	----	----	----	.2
Accessories	.2	1.4	.4	1.1	.3	1.9	1.0	.4	.6	.5	.4	.9	1.4	3.3	2.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Composition of plagioclase	An_{14}	An_{22}	An_{32}	An_{28}	An_{30}	An_{12}	An_{30}	An_{19}	An_{15}	An_{18}	An_{13}	An_{18}	An_{23}	An_{20}	An_{18}
Potassium feldspar-plagioclase ratio	5.73	4.38	2.66	2.41	2.15	1.31	1.27	1.25	1.20	1.20	1.19	1.13	1.12	1.11	1.06

Mineral	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Quartz	28.6	29.9	29.7	33.8	35.3	35.0	38.5	27.5	41.9	58.4	24.5	25.0	26.1	36.5
Potassium feldspar	30.9	28.0	29.8	27.7	16.4	11.5	11.5	12.4	8.7	4.3	4.9	----	----	----
Plagioclase	31.1	31.2	33.9	33.5	34.8	24.9	30.3	46.3	40.5	24.4	46.3	36.8	49.2	39.4
Biotite	6.6	9.1	5.2	3.4	10.0	21.5	16.5	12.0	7.9	5.5	21.4	15.3	13.2	12.7
Hornblende	----	.6	----	----	1.2	----	----	----	----	3.9	----	20.9	9.0	7.3
Epidote	----	.6	.6	----	.6	----	2.7	----	----	2.3	2.1	----	----	2.7
Muscovite	.6	----	----	----	.3	----	----	----	----	.3	----	----	----	----
Accessories	2.2	.6	.8	1.6	1.4	7.1	.5	1.8	1.0	.9	.8	2.0	2.5	1.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Composition of plagioclase	An_{20}	An_{20}	An_{17}	An_{15}	An_{25}	An_{31}	An_{27}	An_{33}	An_{31}	An_{24}	An_{33}	An_{35}	An_{33}	An_{23}
Potassium feldspar-plagioclase ratio	.99	.90	.88	.83	.47	.46	.38	.27	.21	.18	.11	0	0	0

SAMPLE LOCALITY

1. Northeast of Bridgeton; 0.7 mile E. 5° S. of north end of North Road.
2. 0.15 mile southwest of outlet of Ross Pond.
3. Northeast of Bridgeton; 0.25 mile south of No. 1.
4. West of Burlingame Reservoir; 1.15 miles south of U.S. Route 44.
5. 0.17 mile southeast of outlet of Shingle Mill Pond.
6. 0.46 mile north of south margin of quadrangle, 0.05 mile east of west margin of quadrangle.
7. Road intersection 0.15 mile south of Ross Pond.
8. 0.42 mile east of intersection of Hill Road and West Road.
9. Pascoag, 0.23 mile northeast of BM 422.
10. Garvy Ledges quarries, 0.50 mile south of center of Pascoag (Q63-20G of table 3).
11. "Old Railroad Grade," 0.27 mile southeast of west margin of quadrangle.
12. "Old Railroad Grade," 0.93 mile east of west margin of quadrangle.
13. Jackson Schoolhouse Road, 0.24 mile south of Wallum Lake Road (Rhode Island Route 100).
14. East side of Ponaganset Reservoir, 0.65 mile north of south margin of quadrangle.
15. Elbow Rock.
16. Elbow Rock.
17. Putnam Pike (U.S. Route 44) at west margin of quadrangle.
18. Eagle Peak Road, 0.58 mile southwest of High Street.
19. Garvy Ledges, quarry 0.34 mile south of center of Pascoag.
20. Putnam Pike (U.S. Route 44), 0.05 mile west of Jackson Schoolhouse Road.
21. Durfee Hill gold mine.
22. Elbow Rock.
23. 0.50 mile west of Chepachet, 0.17 mile south of Putnam Pike (U.S. Route 44).
24. Gas pipeline excavation, 0.39 mile south of intersection of West Road and Round Top Road.
25. Chestnut Hill Road, 0.25 mile northeast of Old Wade Cemetery.
26. Durfee Hill gold mine.
27. 0.23 mile northeast of north summit Oak Hill.
28. Reservoir Road, 0.08 mile north of Putnam Pike (U.S. Route 44).
29. West foot Durfee Hill, 0.16 mile east of west margin of quadrangle.

The color of the Ponaganset Gneiss ranges from light gray through light pink to medium dark gray. The rock is mostly medium grained, but it ranges from coarse to fine grained; some is strikingly porphyroblastic. All types are distinctly gneissic, and most are lineated by prominent lines of biotite flakes in the foliation planes. The more mafic types have more obvious foliation and lineation. In most places there is a steep foliation striking northward, and commonly there is a lineation plunging northward. At some places, a second foliation strikes more to the west and dips gently northward.

The range in mineral composition is shown in table 2 and in figure 1. Most of the rock is feldspar, quartz, and biotite. The modes are arranged in the table according to the various ratios of potassium feldspar to plagioclase. Most of the potassium feldspar is finely twinned microcline, and some of this is perthitic. Hornblende is common in a few places, and muscovite is common in most places. Minor and accessory constituents include chlorite, epidote, clinozoisite, magnetite, ilmenite, pyrite, garnet, sphene, leucoxene, zircon, allanite, apatite, and fluorite.

According to O'Connor's (1965) classification of quartz-rich igneous rocks based on feldspar ratios, the Ponaganset modes in table 2 include 3 tonalites (Nos. 26–28), 4 granodiorites (Nos. 20–23), 1 quartz monzonite (No. 7), 3 adamellites richer in potassium feldspar than quartz monzonite (Nos. 3–5), 3 trondhjemites (Nos. 24, 25, 29), and 15 granites (Nos. 1, 2, 6, 8–19).

Light-colored facies.—Although different varieties of the Ponaganset Gneiss have generally not been mapped separately, a light-colored facies was mapped separately in four places: (a) west of Hemlock Hill Road near the north margin of the quadrangle; (b) half a mile north of Bridgeton; (c) from Pascoag southward through Garvy Ledges (especially well exposed in a prominent ledge in Pascoag); and (d) east and southeast of Shingle Mill Pond. Even at these four localities the separation is somewhat uncertain, owing to internal variations in the light-colored facies and to outward gradational relations with other varieties of the Ponaganset Gneiss.

The distinguishing characteristics of the light-colored gneiss are lighter, commonly pink color, a greater amount of microcline and quartz, and a smaller amount of plagioclase and biotite. In places, as at the prominent ledge in Pascoag, the rock resembles the Hope Valley Alaskite Gneiss. Gneiss in the northernmost area, west of Hemlock Hill Road, is finer grained than most of the Ponaganset Gneiss.

Relicts at Garvy Ledges quarries.—At the abandoned quarries a third of a mile south of Pascoag, the Ponaganset Gneiss encloses many lenses of different rock, most of which are fine grained and light colored but some are dark. Foliation and lineation of the enclosing gneiss extend without deflection into the lenses, which are generally parallel to the foliation. The contacts between the lenses and the gneiss are sharp.

These lenses might be fragments of older rock caught up in the intruding magma of the Ponaganset Gneiss. As such, they would be called xenoliths. Alternatively, the Ponaganset Gneiss might have formed, not as a magmatic rock, but by metasomatism or recrystallization of older gneissic rocks. Under this alternative, the lenses would be parts of older rocks that escaped the recrystallization or metasomatism, and they would be relicts.

Structural relations can usually be used for distinguishing between xenoliths and relicts. For xenoliths, the foliation of the enclosing gneiss is parallel to the foliation of the xenoliths along the long sides of the xenoliths, but the foliation of the gneiss is parallel to the sides of the xenoliths and discordant to the ends. This is not the relation at Garvy Ledges. Instead, the foliation of the gneiss extends without deflection into and across the lenses; this structure indicates that the lenses are relicts.

The darker relicts represent more mafic rock that has been metasomatized to form Ponaganset Gneiss. This alteration implies that the chemical composition was changed during the metasomatism. The lighter relicts appear to be more quartzose than the Ponaganset Gneiss, and this would also imply chemical change. To learn about this supposed chemical change, one sample from a light-colored relict and one sample from the adjacent gneiss were taken for chemical analyses. Table 3 shows that the relict and the gneiss are virtually the same. The gneiss formed by the recrystallization of an older fine-grained gneissic rock without significant addition or subtraction of chemical material. Most relicts contain feldspar porphyroblasts that must have formed in the first stages of recrystallization.

Age and correlation of Ponaganset Gneiss.—Emerson's map (1917) showed some of the rock here called the Ponaganset Gneiss as Northbridge Granite Gneiss. He wrote (p. 155), "It is considered Archean because the Algonkian (?) quartzite overlaps it normally and the Milford granite cuts both." The "Algonkian (?) quartzite" is the Westboro Quartzite of the Pawtucket quadrangle and elsewhere in Rhode Island (Quinn and others, 1948; 1949). The Ponaganset Gneiss intruded the Blackstone Series, which includes the Westboro Quartzite. Therefore, the gneiss cannot be older than the quartzite. Because of this contradiction, it seems best not to use the name Northbridge Granite Gneiss for the rocks in the Chepachet quadrangle.

TABLE 3.—*Chemical analyses, norm, and modes of gneiss and relict at Garvy Ledges quarry*

[Analysts: P. Elmore, S. Botts, G. Chloe, L. Artis, and H. Smith, U.S. Geol. Survey]

Chemical Analyses [1]

	Gneiss Q63-20G	*Relict Q63-20R*		*Gneiss Q63-20G*	*Relict Q63-20R*
SiO_2	75.9	75.7	H_2O+	.44	.34
Al_2O_3	13.4	13.3	TiO_2	.14	.20
Fe_2O_3	.37	.34	P_2O_5	.04	.06
FeO	.48	.78	MnO	.04	.04
MgO	.28	.28	CO_2	<.05	<.05
CaO	.94	1.1			
Na_2O	3.4	3.4	Total	100	100
K_2O	4.8	4.8	Powder density	2.72	2.70
H_2O-	.08	.06			

CIPW norm Gneiss Q63-20G

Quartz	34.86	Anorthite	4.73	Corundum	.82
Orthoclase	28.36	Magnetite	.70	Hypersthene	1.46
Albite	28.82	Ilmenite	.30		
				Total	100.05

Modes of gneiss

[Samples from table 2]

	19	*10*		*19*	*10*
Quartz	33.8	37.0	Biotite	3.4	6.1
Potassium feldspar	27.7	30.8	Accessories	1.6	0.5
Plagioclase An_{15}, An_{18}	33.5	25.6	Total	100.0	100.0

[1] Analyses by methods of Shapiro and Brannock (1962).

Moorbath and others (1962) obtained a rubidium-strontium age of 535± million years (Cambrian) for the Northbridge Granite Gneiss in Massachusetts. Correlation with the Northbridge cannot be supported, however, and this Cambrian age cannot now be assigned to the Ponaganset Gneiss.

Origin of Ponaganset Gneiss.—The Ponaganset Gneiss, where it is in contact with the Blackstone Series, grades from Ponaganset Gneiss through migmatitic rock to the Blackstone Series. Within the contact zone of the northern part of the quadrangle, some small outcrops are almost completely gneiss, some are mostly schist, and some are migmatite and consist of small pieces of schist and quartzite enclosed in gneiss. In some of the migmatite outcrops, relations similar to those at Garvy Ledges definitely indicate that the schist and quartzite have been greatly metasomatized and that granitization has occurred. In other migmatite outcrops the schist and quartzite pieces are definitely xenoliths enclosed in granitic gneiss. This is indicated by the fact that the schist and quartzite pieces have been rotated and by the fact that the gneiss foliation wraps around the pieces of schist and quartzite.

The contacts of the Ponaganset Gneiss with amphibolite are sharp. The gneiss intruded the amphibolite as stringers and dikes and is clearly younger. There are some xenoliths of amphibolite within the gneiss.

Marginal areas of the Ponaganset Gneiss show both magmatic intrusive relations and metasomatic granitization. This indicates that masses of Ponaganset magma invaded the area and that emanations from this magma made the Blackstone schist and quartzite into a more granitic rock. The strongly developed gneissic structure indicates that the gneiss is syntectonic. The earlier, more mafic parts are more strongly foliated, and the slightly younger, more felsic parts are more massive. The magma may have formed by the melting, or partial melting, of geosynclinal sediments, and it need not have moved very far to its present position.

GNEISS OF HERRING POND VICINITY

The gneiss exposed south and west of Herring Pond apparently underlies an area that is approximately 1 mile wide and extends for 2 miles northward to the quadrangle margin. The rock is well exposed at several rather large quarries south, west, and northwest of Herring Pond. To the north and east, exposures are sparse and the underbrush is dense. An additional mass of this rock is exposed on Cooper Hill, 0.8 mile southeast of Mapleville.

Megascopically, the rock is light gray, with some light tan feldspar grains, and is medium to coarse grained. Some of the feldspar grains are as much as 1 centimeter across. Both quartz grains and biotite flakes are arranged in linear aggregates so that the rock has a pronounced lineation. Foliation is conspicuous at some places and faint at others.

Microscopic examination revals that the rock consists of microcline, microperthite, oligoclase, quartz, and biotite. The microcline has unusually fine twinning. Some myrmekite is present. The biotite is pleochroic from dark brownish green to light tan. Muscovite is present in scattered flakes. Minor and accessory constituents include chlorite, epidote, magnetite, sphene, zircon, apatite, garnet, fluorite, and allanite. The composition is mostly within the range of quartz monzonite (table 4).

This rock is intrusive into the Nipsachuck Gneiss and the Blackstone Series. On the basis of general lithologic characteristics, it is tentatively correlated with the Ponaganset Gneiss.

SCITUATE GRANITE GNEISS

Prominent exposures on Snake Hill, northeast of Mapleville, have been correlated with the Scituate Granite Gneiss. This gneiss is an

TABLE 4.—*Modes of gneiss of Herring Pond vicinity*

[In volume percent]

	1	2	3	4
Quartz	39.3	44.2	39.1	34.7
Potassium feldspar	22.5	30.5	37.6	47.8
Plagioclase	31.9	22.9	20.8	13.9
Biotite	5.0	1.3	1.8	2.9
Muscovite	.3	.3	.3	.2
Accessories	1.0	.8	.4	.5
Total	100.0	100.0	100.0	100.0

SAMPLE LOCALITY

1. Quarry 0.4 mile south of Herring Pond.
2. Quarry 0.23 mile northwest of Herring Pond.
3. Quarry 0.08 mile west of Herring Pond.
4. Cooper Hill 0.8 mile southeast of Mapleville.

extension of a body of gneiss mapped by Richmond (1952; Richmond and Allen, 1951) in the Georgiaville quadrangle to the east.

The rock is pink to light tan and medium to coarse grained and has both a distinct lineation and a foliation. The main constituents are microperthite, quartz, albite-oligoclase, and biotite. Minor and accessory constituents include muscovite, chlorite, epidote, magnetite, ilmenite, pyrite, garnet, zircon, and fluorite (table 5).

TABLE 5.—*Modes of Scituate Granite Gneiss of Snake Hill*

[In volume percent]

	1	2	3
Quartz	39.0	45.9	38.8
Microperthite	50.5	39.6	52.6
Albite-oligoclase	4.7	8.1	2.8
Biotite	4.4	5.5	5.3
Muscovite	.5	.7	.2
Accessories	.9	.2	.3
Total	100.0	100.0	100.0

SAMPLE LOCALITY

1. Northwest slope of Snake Hill.
2. Southwest slope of Snake Hill.
3. 0.3 mile east of summit of Snake Hill.

On the southern slopes of Snake Hill and on the small hill 0.5 mile east of Snake Hill, the contact between the Scituate Granite Gneiss above and the Absalona Formation below is exposed. The Scituate Granite Gneiss is clearly younger; dikes and stringers of Scituate intrude the Absalona, and, locally, the Absalona has been granitized. Structures in the two rocks, above and below the contact, are nearly concordant; thus, the Scituate probably intruded along the foliation of the Absalona. Concordance over a short distance does not necessarily imply concordance everywhere, however. This contact appears to have been the floor of a Scituate intrusive that came from the north and moved gently upward toward the south, as is suggested by the north-plunging foliation of the Scituate. Emanations from this Scituate intrusive granitized the underlying Absalona.

ESMOND GRANITE

About half a mile northwest of Herring Pond is an inactive quarry in what appears to be Esmond Granite. The area underlain by this rock is only partly known, owing to extensive glacial cover in this vicinity. The granite is intrusive into the Blackstone Series; sharp angular inclusions of schist and quartzite are exposed in the northeastern part of the quarry. The random orientation and the arrangement, with different lithologic types grouped together, are strong evidence that these inclusions settled in a liquid magma.

The rock here is light pink, medium grained, and massive to foliated. It is less foliated than either the gneiss at Herring Pond or the Scituate Granite Gneiss. It is composed chiefly of microcline, albite, quartz, biotite, and muscovite. Minor constituents include chlorite, magnetite, garnet, and clinozoisite. The plagioclase has been altered so that it now has many fine inclusions of muscovite and clinozoisite. Much of the biotite has been altered to chlorite. These alterations of plagioclase and biotite are typical of the Esmond Granite. A mode of a typical rock from the quarry gave: microcline, 35.9 percent; albite, 27.0 percent; quartz, 35.3 percent; biotite, 0.6 percent; muscovite, 0.8 percent; and accessories, 0.4 percent.

STRUCTURE AND METAMORPHISM

The structure in the Chepachet quadrangle is dominated by steep north-striking foliation and north-plunging lineation. Most of the formation contacts also trend northward. However, there are other structures that trend in different directions. Geologic evidence in the Chepachet quadrangle, as well as in nearby areas, indicates that the area had a complex structural and metamorphic history involving a succession of deformations.

The structure of the older(?) gneisses, as indicated by exposures in this quadrangle and in the Georgiaville quadrangle (Richmond and Allen, 1951; Richmond, 1952), appears to be an overturned anticline that trends northwestward. The Nipsachuck Gneiss along Cooper Hill is the core of this anticline. This anticline appears to plunge beneath the Blackstone Series to the north, thereby suggesting an unconformity beneath the Blackstone Series. The presence of albite-oligoclase, hornblende, garnet, and epidote indicates that the older(?) gneisses were metamorphosed to the lower part of the almandine-amphibolite facies.

The Blackstone Series trends northward over much of its outcrop area, but it has many divergent trends north of Oakland. The sparse exposures suggest that this series is folded on a small scale and perhaps on a large scale, but the structural details cannot be determined because traceable stratigraphic units are lacking and outcrops are scarce. For example, the supposed unconformity beneath the Blackstone Series cannot be definitely accepted or rejected. The new roadcut on Rhode Island Route 102 just north of Oakland shows small-scale structural complexity of the Blackstone Series. The Blackstone Series appears to be in the almandine-amphibolite facies—more specifically, the staurolite-almandine subfacies. There is no significant difference in metamorphic intensity between the Blackstone Series and the older(?) gneisses, and the metamorphic grade neither supports nor opposes an unconformity.

Both the older(?) gneisses and the Blackstone Series were folded and metamorphosed before the instrusion of the younger plutonic rocks. This folding and metamorphism may have occurred in one episode, or there may have been two episodes: (1) folding and metamorphism of the older(?) gneisses, followed by erosion, then deposition of the Blackstone Series; (2) folding and metamorphism of the Blackstone Series. This one deformation, or these two deformations, occurred in Mississippian(?) or earlier time.

The younger plutonic rocks were involved in the waning stages of the last mentioned deformation and metamorphism. The amphibolite and the Ponaganset Gneiss especially show steep north-trending foliation. The contacts of Ponaganset Gneiss against amphibolite are steep and trend northward, and the contacts between the many different varieties of the gneiss have the same attitude. The foliation and layering of the Ponaganset Gneiss are interpreted as original flow structures, formed when the gneiss was being intruded under stress. The gneiss of Herring Pond vicinity, the Scituate Granite Gneiss, and the Esmond Granite are gneissic, but are progressively less gneissic in the order named. This decrease in intensity of foliation and lineation appears to have resulted from the intrusion of the Herring Pond rock during strong tectonic stress and the intrusion of the Esmond Granite last after tectonic activity had diminished. The main metamorphic effects on the younger plutonic rocks were a retrograde effect of changing plagioclase to less calcic varieties having small inclusions of muscovite and clinozoisite.

The Ponaganset Gneiss, especially in the western part of the quadrangle, has, in addition to the north-trending foliation, a second foliation that strikes more to the west and dips north. This seems to be a later structure, as it cuts across contacts between different kinds of gneiss. In some places this second foliation is more apparent than the primary north-trending flow structure. The geologic age of this structure is not known.

The next younger episode of geologic activity in a nearby area was the Mississippian(?) intrusion of the Quincy Granite and related granite porphyry in the Pawtucket quadrangle about 9 miles east of the Chepachet quadrangle (Quinn and others, 1948; 1949). No Mississippian(?) folding is known to have accompanied the intrusion in the Pawtucket quadrangle, but the Mississippian(?) Spencer Hill Volcanics of the East Greenwich quadrangle (Quinn, 1952), 15 miles southeast of the Chepachet quadrangle, were folded before deposition of Pennsylvanian sediments in the Narragansett basin. The geographic extent of this deformation is not known, and none of the structures of the Chepachet quadrangle can be definitely assigned to it.

A still later deformation, of considerable intensity and geographic extent, involved folding, faulting, and metamorphism of the Pennsylvanian rocks and it also included intrusion of granitic rocks (Quinn and Oliver, 1962; Nichols, 1956). Eleven miles east of the Chepachet quadrangle, the Pennsylvanian rocks in the northern part of the Narragansett basin, which is at the same latitude as the Chepachet quadrangle, were folded but only slightly metamorphosed. Metamorphism increased to the south, attaining at least the staurolite-almandine subfacies. Near the mouth of Narragansett Bay pegmatites and Narragansett Pier Granite intersect the Pennsylvanian rocks (Nichols, 1956). Nearer by, only 4 miles east of the Chepachet quadrangle, probable Pennsylvanian rocks in the Woonsocket basin were more greatly deformed than the Pennsylvanian rocks in the Narragansett basin, at the same latitude further east. In the Woonsocket basin the beds are tightly folded, and pebbles in conglomerate are greatly elongated—1.0:2.5:13.5 (Hall, 1963, p. 54). Probably this Pennsylvanian or post-Pennsylvanian deformation extended into the Chepachet quadrangle, but any structural effects have not been distinguished from structural effects of older deformations.

SUMMARY OUTLINE OF GEOLOGIC HISTORY

Precambrian(?):

1. Accumulation of feldspathic sediments and volcanic rocks; possible thickness 11,000 feet, including rocks of Georgiaville quadrangle.

   Rocks included: Nipsachuck Gneiss, Absalona Formation, Woonasquatucket Formation, and light-gray gneiss.
2. Folding and metamorphism of sediments and volcanic rocks; to form older(?) gneisses.
3. Uplift and erosion.
4. Deposition of sand, shale, calcareous shale, and volcanic rocks; possible thickness 20,000 feet.

   Rocks included: Blackstone Series.

Mississippian(?) or older:

5. Folding and metamorphism of sediments and volcanic rocks to form Blackstone Series.
6. Intrusion and minor granitization to form younger plutonic rocks; the first stages of these rocks were mafic and the later stages were felsic; metamorphism of No. 5 continuing into early stages.

   Rocks included: Amphibolite, Ponaganset Gneiss, gneiss of Herring Pond vicinity, Scituate Granite Gneiss, Esmond Granite.
7. Formation of second foliation of Ponaganset Gneiss.

Pennsylvanian:

8. Pennsylvanian or post-Pennsylvanian deformation and metamorphism in Narragansett and Woonsocket basins; may or may not have affected Chepachet area.
9. Erosion.

Pleistocene:

10. Glaciation.

Folding and metamorphism of older(?) gneisses and the Blackstone Series may have occurred during one episode rather than the two shown above; if so, erosion in No. 3 may not have occurred.

Younger plutonic rocks (No. 6), may all have formed during the late stages of folding and metamorphism of the Blackstone Series (No. 5), or they may have formed during more than one episode of plutonic activity.

ECONOMIC GEOLOGY

Granite and granite gneiss were once quarried extensively in the northeastern part of Chepachet quadrangle, but none of the several quarries was active in 1965. The largest quarries are listed below. Several small ones are omitted.

1. 0.55 mile northwest of Herring Pond; Esmond Granite; approximate size, 300 × 150 × 20 ft; operated within the last 10 years.
2. 0.23 mile northwest of Herring Pond; gneiss of Herring Pond vicinity; approximate size, 300 × 200 × 30 ft.
3. 0.08 mile west of Herring Pond; gneiss of Herring Pond vicinity; approximate size, 100 × 100 × 20 ft.
4. 0.4 mile south of Herring Pond; gneiss of Herring Pond vicinity; two quarries each approximately 100 × 100 × 20 ft.
5. 0.35 mile northeast of Wilson Reservoir; fine-grained granite gneiss of Ponaganset Gneiss; approximate size, 200 × 100 × 20 ft.

6. Along abandoned railroad line near northwest corner of quadrangle; granite gneiss of Ponaganset Gneiss; several quarries each approximately 100 × 100 × 20 ft.
7. Garvy Ledges, 0.35 mile south of Pascoag; light-colored granite gneiss of Ponaganset Gneiss; large quarry (300 × 200 × 30 ft) at north end of ridge and several other quarries to the south on same ridge.
8. 1.15 mile southwest of Chepachet, just southeast of east end of Shingle Mill Pond; light-gray gneissic granite included with Ponaganset Gneiss; approximate size, 100 × 40 × 20 ft.

At all these quarries a large amount of rock remains that would be satisfactory—with respect to durability, strength, ease of working, and appearance—for building stone. Presumably the quarries ceased operation because of the general change from use of building stone to use of less expensive building material.

The Durfee Hill gold mine is on the south slope of Durfee Hill, just east of Ponaganset Reservoir, 0.78 mile northeast of the southwest corner of the quadrangle. There are four shafts within 100 feet in a north-south direction. Present exposures indicate that these workings are in a vertical quartz vein 10 feet or more wide extending in a northerly direction. Minerals observed in the vein and on the small dumps include quartz, epidote, a carbonate mineral, pyrrhotite, molybdenite, and ferrimolybdite. This mine has been abandoned for some years, and there is little reliable information about when it was worked or about the amount and value of ore removed.

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