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STRATIGRAPHY IN SOUTHWESTERN MAINE AND SOUTHEASTERN NEW HAMPSHIRE

BY

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STRATIGRAPHY IN SOUTHWESTERN MAINE AND SOUTHEASTERN NEW HAMPSHIRE.

By FRANK J. KATZ.

INTRODUCTION.

Area.—The region discussed in this paper includes some 1,500 square miles, most of which is in the southwest corner of Maine, in Cumberland and York counties, the remainder being in the adjacent parts of Strafford and Rockingham counties, N. H. The area lies between

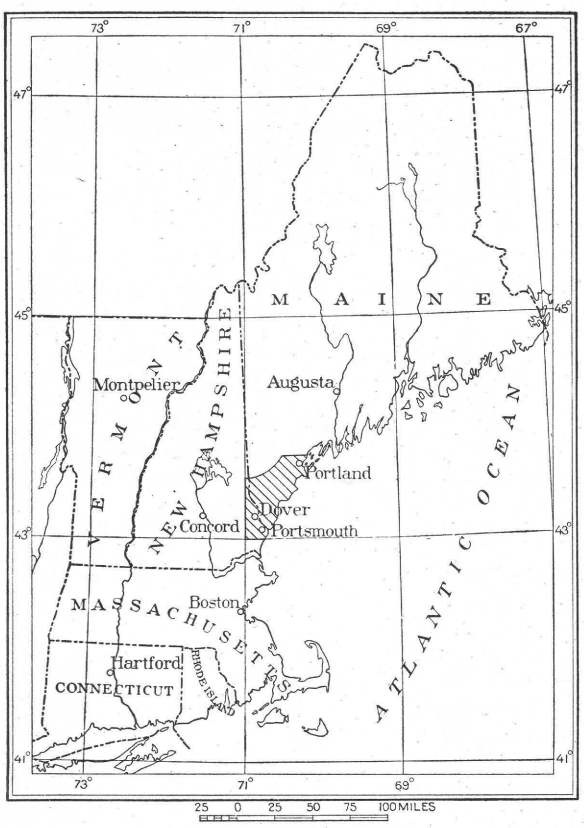


FIGURE 26.—Index map showing area in southwestern Maine and southeastern New Hampshire.

meridians 70° and 71° and parallels 43° and 43° 45′, which inclose the Casco Bay, Portland, Buxton, Newfield, Biddeford, Kennebunkport, Berwick, York, and Dover quadrangles of the United States Geological Survey topographic atlas. (See fig. 26.)

Field work.—The conclusions on this region here set forth are the result of work begun in July, 1911, and still in progress. The field work has included critical study and detailed mapping of about one-third of the area and reconnaissance examination of the remainder. This work was under the direction of Mr. Arthur Keith, who has conferred frequently in the field and office with the writer and whose encouragement and assistance contributed to its progress. Mr. Laurence LaForge, who has long been studying areas in New Hampshire and Massachusetts southwest of the region here considered, has also contributed to the results by field conferences and by critical discussions. The writer gratefully acknowledges indebtedness to both these geologists.

Previous work.—Little geologic work had been done previously in southwestern Maine and the adjacent part of New Hampshire, and there are no published conclusions of present interest except those of Charles H. Hitchcock,[1] which can be briefly summarized as follows:

Hitchcock elaborated the views of his father, Edward Hitchcock, on the geology of the vicinity of Portland, Maine, and following him divided the rocks of the region on the basis of lithology into a number of varieties of schists and assigned them to his Huronian and Cambrian, or Paleozoic (?). Furthermore, he recognized these sedimentary rocks of the Portland and Casco Bay region as distinct from those of adjacent areas. The gneisses to the north and west of the Portland rocks he assigned to the "Laurentian or Azoic," but later he correlated part of these gneisses with his Coos group (Paleozoic) of New Hampshire. He further

[1] Hitchcock, C. H., General report upon the geology of Maine: Maine Board Agr. Sixth Ann. Rept., pp. 146–328, 1861; The geology of Portland [Maine]: Am. Assoc. Adv. Sci. Proc., vol. 2, pt. 2, pp. 163–175, 1874; The geology of New Hampshire, pt. 2, Stratigraphical geology, and atlas; Concord, N. H., 1877; Geology of northern New England (Maine, with map), 1885; The geology of New Hampshire: Jour. Geology, vol. 4, pp. 44–52, 1896.

noted in York County, Maine, the continuation of his Merrimack slates ("flinty slates") of New Hampshire, and northwest of these in Maine and New Hampshire, in the vicinity of Rochester and elsewhere, he mapped and described the "Rockingham mica schists" and "Kearsarge group" (andalusite schists), both of which he stated to be more or less equivalent to his Merrimack slates and related to the Huronian as well as the Cambrian but referred doubtfully to the Paleozoic. The relation of Hitchcock's several subdivisions and his petrographic units can not be reconciled with those of the present paper. An attempt is made, however, by means of footnotes in the stratigraphic table to indicate so far as possible the correspondence of his subdivisions.

STRATIGRAPHY.

GENERAL FEATURES.

The region under discussion is a part of the New England coastal lowland, here a belt 10 to 25 miles wide, whose rock surface is abundantly mantled with glacial drift and over broad areas deeply buried under outwash deposits, both terrestrial and marine, of late Pleistocene age.[1] This condition, with the further handicap that the sedimentary rocks so far as known are nonfossiliferous and are metamorphosed to an extent which makes the discovery of fossils improbable, is a considerable hindrance to stratigraphic work. However, over a large part of the region outcrops are found at intervals short enough for positive correlation on the basis of pronounced lithologic characteristics, and furthermore, although the structure is complex in detail, the region shows a dominant and simple major structure—that of elongated folds on approximately parallel northeast axes—which is of assistance in tracing and correlating stratigraphic units. The rocks include (1) an assemblage of more or less severely deformed and metamorphosed sediments, with which are associated some volcanic materials, and (2) a number of types of intrusive rocks, some of which also are metamorphosed. None of the rocks have been sufficiently altered by mashing and recrystallization to lose their original character completely.

[1] Katz, F. J., and Keith, Arthur, The Newington moraine, Maine N. H., and Mass.: U. S. Geol. Survey Prof. Paper 108, pp. 11–29, 1917 (Prof. Paper 108–B).

The differentiation of the sedimentary formations and their classification and mapping have been based upon recognition of a general and characteristic lithologic facies for each formation, upon careful consideration of their petrographic similarities and differences, upon cautious use of character and degrees of deformation and metamorphism as criteria, and upon areal distribution as interpreted in the light of distinguishable structure. Thus eight cartographic units have been recognized. The igneous rocks are roughly grouped by means of their obvious petrographic features, areal distribution, and relation to the sediments. The resulting classification of the rocks and their stratigraphic relations and equivalences are shown in the accompanying table.

The map (Pl. LXI), on account of its small scale and the lack of precise data in a large part of the area, is very much generalized as to position and minor features of the formation boundaries. Because of lack of outcrops the following parts are wholly arbitrary and inferential: The southwest termination of the Towow formation in Lebanon, Maine; the approximately north-south line which bounds part of the Berwick gneiss and cuts off the Carboniferous rocks in Rollinsford and Somersworth, N. H.; and the line between the Casco Bay group and the Kittery quartzite in Biddeford and Saco, Maine. The igneous rocks are represented as continuous over some areas, and their boundaries are drawn with solid and smooth lines where they have most irregular outlines and partly or wholly include large blocks of sediments. Furthermore, the relations of formations at contacts, whether of intrusion, faulting, conformable succession, or otherwise, are nowhere indicated by the character of the lines on the map. With these exceptions, however, the map is presented with considerable assurance that it conforms generally with the facts.

SEDIMENTARY ROCKS.

PRE-CARBONIFEROUS ROCKS.

BERWICK GNEISS.

The Berwick gneiss, named from the town of Berwick, Maine, occupies a continuous belt in the central and northeastern parts of the region here discussed and extends both northeast and southwest for undetermined distances. The

Sedimentary rocks.		Igneous rocks.	
		Triassic.	Gabbro, diabase, and other dikes.
		Post-Carboniferous.	Gneissoid biotite-muscovite granites and pegmatites in Milton, Lebanon, Acton, Sanford, etc. Biotite granites in Lyman, Alfred, Dayton, and Rochester. The assemblage in Mount Agamenticus; biotite granites, gabbros, and other differentiates in Wells, South Berwick, and York. *Biddeford granite:* Medium-grained biotite granite and pegmatite in Biddeford, Kennebunk, etc. *Exeter diorite:* Fine to medium grained light-gray diorite in Rollinsford, Dover, Newmarket, Exeter, etc. Medium to coarse, partly gneissoid diorite in Saco.
Carboniferous (Pennsylvanian(?).	*Casco Bay group:*[a] *Mackworth slate:* Quartzites and quartz slates, 200 feet (?). *Jewell phyllite:*[b] Siliceous and argillaceous slates and phyllites, 500 feet (?). *Spurwink limestone:* Limestone and phyllites, 200 feet (?). *Scarboro phyllite:* Black and gray argillaceous phyllite, 200–600 feet. *Diamond Island slate:* Black carbonaceous quartz slate, 75–150 feet. *Spring Point greenstone:* Hornblende schists, etc., 0–600 feet. *Cape Elizabeth formation:* Graywacke, siliceous slates, and argillaceous slates and phyllites, 600 feet (?). *Eliotslate:*[c] Gray slates, calcareous argillite (lydite), and black phyllite. *Towow formation:* Black carbonaceous quartz slate and phyllite, 200–300 feet (?). *Rindgemere formation:*[d] Dark-gray carbonaceous phyllites, slates, graywacke, and quartzite, 1,000 feet (?). *Gonic formation:*[e] Graywacke schists, mica schists, and phyllites, 500 feet (?). *Kittery quartzite:*[f] Quartzite, argillite, slate, and schist, 1,500 feet (?).	Late Carboniferous (?).	Basic dikes. *Cushing granodiorite:* Fine-grained porphyritic gneissoid granodiorite.
Pre-Carboniferous.	Quartzites with rhyolite flows and tuffs; slates, schists, and hornblende schists; quartzite and graywacke gneisses of Algonkian (?) age.[g]	Unknown (probably pre-Carboniferous).	White (tourmalinic) pegmatites. Fine-grained muscovite granites. Coarse biotite granites, augen gneiss. Fine-grained diorite, etc.
		Unknown (post-Berwick).	*Westbrook granite and Falmouth pegmatite:* Gneissoid biotite granite and white tourmaline-garnet pegmatite.
	Berwick gneiss:[h] Graywacke gneisses and schists and quartzite.		

[a] C. H. Hitchcock's Huronian and Cambrian in the vicinity of Portland, except as indicated in note [b].
[b] Part of this formation in Saco is C. H. Hitchcock's Cambrian slate.
[c] Included in C. H. Hitchcock's Merrimack slates.
[d] Approximately equivalent to C. H. Hitchcock's Kearsarge group in the vicinity of Rochester (a part of his Huronian and Cambrian or Paleozoic?).
[e] Included in C. H. Hitchcock's Rockingham schist (a part of his Huronian and Cambrian or Paleozoic?).
[f] Included in C. H. Hitchcock's Merrimack slates and Rockingham schist (a part of his Huronian and Cambrian or Paleozoic?).
[g] Included in C. H. Hitchcock's Merrimack slates.
[h] That part in New Hampshire and York County, Maine, placed by C. H. Hitchcock in his Merrimack slates and Rockingham schist (a part of his Huronian and Cambrian or Paleozoic?); that in the Portland region partly in his Laurentian or Azoic and partly in his Coos group or Paleozoic.

100330°—17. (To face page 166.)

belt ranges in width from 2½ miles at the southwest, on the west side of the Dover quadrangle, to at least 9 miles at the northeast, where it occupies the northwest corner of the Casco Bay quadrangle, the northwest half of the Portland quadrangle, and the east half of the Buxton quadrangle.

The formation is composed chiefly of graywacke gneiss but contains also clean quartzites, micaceous quartzites, mica schist, and argillite schist and slate. The beds range from about an inch to a few feet in thickness. Almost all the rocks are moderately fine grained and delicately banded. Their colors are medium to dark gray, bluish gray, and brown. In the Portland quadrangle a few layers, 1 to 3 inches thick, of light-blue and white crystalline limestone have been found. The most abundant and characteristic rocks are moderately fine grained banded gray and bluish-gray graywacke or quartz-feldspar-biotite gneiss and micaceous quartzite. The formation is marked by a high degree of crystallinity, by an abundance of metamorphically developed biotite, and in places by actinolite in graywacke and quartzite. Many of the beds are flecked with metacrysts of black biotite. The most distinctively characteristic alteration is a recrystallization of the graywacke into nonfoliate diorite-like aggregates which contain chiefly quartz, feldspar, and hornblende and in some places also garnet and which have the form of seam selvages or bands, lenses, and small spheroidal and irregular patches. On the northwest end of the belt, in parts of the Buxton, Portland, and Casco Bay quadrangles and farther north, where this formation is heavily injected by granite and pegmatite, it is metamorphosed to wholly crystalline quartz-biotite and quartz-feldspar-biotite gneisses of fine to medium grain.

The thickness of the Berwick gneiss is not determinable.

From the prevailing northeast strikes, which range, however, from nearly north to nearly east, with dips generally moderate to steep toward the northwest but in some places steep toward the southeast, and from intricate crumpling and close folding on northeasterly axes discernible only in some exposures of thin-bedded members, the Berwick gneiss is inferred to be closely folded and overturned toward the southeast on approximate parallel northeasterly axes. In very small areas a few wide departures from the prevailing attitude indicate local intricacies in structure.

Along its southeast border the Berwick gneiss within this region is in contact with the Casco Bay group, with the partly equivalent slates in Dover, Madbury, and Lee, and with the Kittery quartzite. Its north and northwest boundaries have not been determined except in the Dover, Berwick, and Kennebunkport quadrangles, where it is adjoined on the northwest by the Gonic formation. Several bodies of massive granitic and dioritic rocks are intrusive in the Berwick and also cut younger formations. In the northwestern part of the region there are bodies of intrusive gneissic granite and pegmatite, which are restricted to the area of the Berwick. Its greater deformation and more complex structure, its notably greater metamorphism, and the presence in it of deformed intrusives not known to invade other formations show that the Berwick gneiss is older than the sedimentary formations which adjoin it. Evidence is lacking to determine whether the juxtapositions are due to unconformity or to faulting. There are also no data on the relative stratigraphic positions of the Berwick gneiss and the other pre-Carboniferous sediments. The age of the Berwick gneiss is unknown.

ALGONKIAN (?) COMPLEX.

In the southeastern part of the region a greatly metamorphosed crystalline complex occupies a belt 1½ to 4½ miles wide trending northeast to east-northeast along the coast in Gerrish Island, Maine, the islands in the mouth of Piscataqua River, New Castle, and Rye, and parts of Portsmouth, North Hampton, and Greenland, N. H. Among the stratiform rocks of this complex there have been recognized fine-grained gray and whitish quartzites associated with rhyolite flows and breccias, seemingly overlying dark-colored banded slate and schist, including abundant hornblendic schist, which in turn appear to overlie medium to coarse grained micaceous quartzite and graywacke. In these rocks the cleavage is almost uniformly vertical or has a very steep dip; it seems to be parallel

to the bedding wherever that is discernible, and the strike of both cleavage and bedding swings from northeast on the south end of the belt to nearly east on the north end. All these rocks are intruded by large masses and interleaved with layers of a variety of granitic and some dioritic rocks, which are generally deformed and more or less foliated.

The stratiform rocks of this complex lie in the general trend of the belt of outcrops of presumed pre-Cambrian (Algonkian?) formations, the Westboro quartzite and Marlboro formation of eastern Massachusetts,[1] and are very probably counterparts of those formations. The areal relations and the similarities [2] in lithology and association of the rocks in Rye and Portsmouth, N. H., to those of the Algonkian(?) in eastern Massachusetts afford the basis for tentative assignment of these rocks in Maine and New Hampshire to the Algonkian.

CARBONIFEROUS ROCKS.

KITTERY QUARTZITE.

The Kittery quartzite, named from the town of Kittery, Maine, in which typical exposures abound, occupies a 45-mile belt from Exeter, N. H., to Saco, Maine. This belt is 7 to 13 miles wide and lies along the coast, except for about 11 miles in the southeastern part, in Kittery, Portsmouth, Greenland, Rye, and North Hampton, where pre-Carboniferous rocks intervene, and thence continues inland southwestward beyond the region here considered. Within this belt, especially along the coast, the exposures of the quartzite are practically continuous, being interrupted only by two very large and several small areas of granitic rocks and an area of slate described on pages 169–170. Within the granite areas, particularly along their coastward sides, are many inclusions and large engulfed blocks of Kittery quartzite, which assist in establishing the continuity of the formation.

This formation consists of banded flinty and vitreous quartzites, subordinate amounts of argillitic and micaceous quartzites, some argillite, and very thin beds of micaceous slate and schist. All these rocks are very fine grained. The formation is characteristically thin bedded, few of the beds exceeding 2 feet in thickness, and the thicker beds are generally marked parallel to the bedding by thin layers of different colors. The most striking feature of the formation is a fine interbanding of various tones of dark gray, bluish, chocolate-brown, and black with a little light gray and white. On weathered surfaces there is an equally characteristic and more pronounced interbanding of white, drab, green, blue, and chocolate-brown. The dark-gray and brownish beds in particular are in many places banded, mottled, and intricately patterned in drab shades as the result of leaching and silicification, and argillitic beds are commonly dotted with small variously colored spots. The Kittery quartzite is only slightly metamorphosed; except in relatively few included thin beds of micaceous schist, recrystallization and foliation are weakly developed.

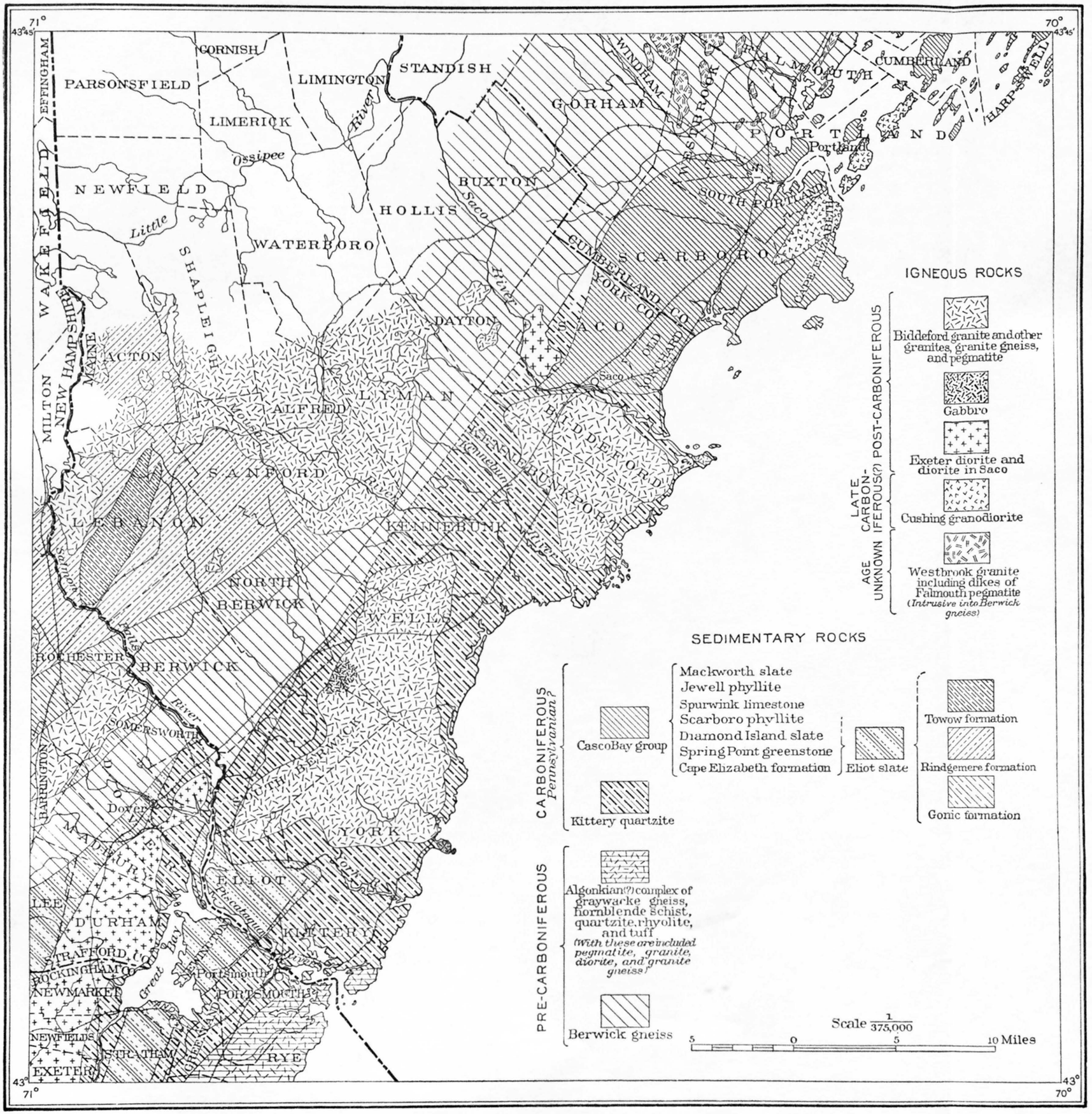
Several exposures of the Kittery quartzite show that it has been folded into a great number of small open to moderately close rolling folds that trend northeast in most places but east-northeast in Kittery and nearly east near Biddeford Pool. Generally, however, the only observable structure is a northeasterly strike and vertical or high dips. Over small areas, notably near Ogunquit, Maine, and thence northward along the coast, and on Fox Point in Newington, N. H., there is considerable irregularity and departure from the normal strike and dips. The few data obtained along the west border of the granite in the Dover quadrangle indicate that the quartzite lies vertically against the granite or dips away from it. A few observations made in Portsmouth and Eliot along the east side of the Eliot slate (see p. 169) indicate that the quartzite dips toward (under) the slate.

No reliable measurement of the thickness of the Kittery quartzite is possible. The best estimate, made at York Harbor, where there is no evidence of repetition of beds, indicates a minimum of 1,500 feet at that place.

The Kittery quartzite is bounded by diorite, granite, and gabbro, which intrude it; by the slate in Eliot, Newington, Dover, Stratham, and Exeter, and the rocks of the Casco Bay group, which conformably overlie it; along most of its northwest boundary by the Berwick gneiss,

[1] Emerson, B. K., Geology of Massachusetts and Rhode Island: U. S. Geol. Survey Bull. 597 (in press).

[2] Laurence LaForge, who has examined the rocks in both regions, has in personal communications reported these similarities.



GEOLOGIC SKETCH MAP OF SOUTHWESTERN MAINE AND SOUTHEASTERN NEW HAMPSHIRE.

against which it is either faulted or is in unconformable superposition; and by the other pre-Carboniferous sediments, with which its relations are unknown. The intrusive contacts are exhibited and conclusively established in several exposures. The conformable relation of the overlying slate in Eliot and elsewhere is inferred from two facts—(1) the greater abundance of argillite in the Kittery quartzite near the exposures of Eliot slate in Eliot Neck and in the vicinity of York River, which suggests transition of lithologic character from one to the other, and (2) the areal distribution and the apparent attitude of the quartzite with relation to the slate. The quartzite surrounds the slate with approximately parallel strike and seems to dip toward it. The areal distribution of the quartzite and slate with respect to the granitic masses—that of successive surrounding belts—also indicates the same relation. (See map, Pl. LXI.) For similar reasons the rocks of the Casco Bay group are inferred to overlie the Kittery quartzite, probably conformably, because the basal formations of that group are probably equivalent to the Eliot slate. According to Mr. LaForge, outcrops across the Newburyport and Haverhill quadrangles, Mass., indicate that the belt of Kittery quartzite and overlying slate extends southwestward to Merrimack River and is continuous with the Carboniferous Merrimack quartzite.[1] The quartzite facies in the vicinity of Lowell, Mass., and in Kittery, Maine, are lithologically identical, but the Merrimack quartzite as defined and mapped in the work cited includes some slate and phyllite, which are very probably equivalent to those in the Eliot slate. By correlation with the Merrimack quartzite, the Kittery quartzite and overlying slate are assigned to the Carboniferous period.

ELIOT SLATE.

The Eliot slate, named from the town of Eliot, Maine, occupies two parallel belts trending southwest through about 13 miles—one in Eliot and Kittery, Maine, and extending thence through Dover and Newington into Stratham and Exeter, N. H.; the other in Dover, Madbury, Durham, and Lee, N. H. Both extend southwestward for undetermined distances beyond the limits of the region here considered. These belts are 2 to 5 miles and half a mile to 3 miles wide, respectively, and are separated by a 3 to 5 mile belt of Kittery quartzite and intruded diorite.

The rocks of both belts are identical in all respects, comprising an assemblage of gray sericitic and siliceous sericitic slates; beds of light-gray and drab argillo-quartzitic rocks, some of which are also calcareous; thin laminae of light-bluish limestone; and thin layers of black carbonaceous sericite phyllite. Almost the whole formation is uniformly fine grained and thin bedded. In the central part of the eastern belt, and presumably at the highest horizons in the formation, the black sericite phyllite layers are more abundant and thicker than elsewhere.

The thickness of the Eliot slate is not determinable; there are no formations overlying it, and its top may be absent.

The Eliot slate has the appearance of greater deformation and schistosity than the Kittery quartzite, but this appearance is due to the fact that the formation is predominantly thin bedded and argillaceous; deformation has produced about the same degree of metamorphism in the Eliot slate as in the similar thin-bedded argillaceous rocks in the Kittery quartzite. The Eliot slate is somewhat less deformed structurally and less well recrystallized than the Casco Bay group.

Where discernible the strike of the bedding of the Eliot slate is almost uniformly northeast and the dip vertical or very high to the northwest; small folds pitch gently southwest. In a few areas there are easterly strikes indicating local folds. The structure of the eastern belt is inferred to be synclinal, the slate being infolded in the Kittery quartzite, as indicated in the discussion of that formation.

The Eliot slate is in contact with the Berwick gneiss along a straight northeastward-trending boundary of unknown structural significance; with a diorite by which it is intruded in Dover and Exeter, N. H., and intervening towns; and with the Kittery quartzite, which it overlies conformably. It is therefore of Carboniferous age. The Eliot slate is correlated with the lower part of the Casco Bay group, more particularly with the Cape Elizabeth formation, on the basis of very close lithologic similarity, expressed not only in the colors, texture, and composition of the various rocks but also roughly in the proportions of each and the manner of inter-

[1] Emerson, B. K., op. cit.

lamination of the thin layers of black phyllite and calcareous beds. There is, however, a greater abundance of black phyllite in the upper part of the Eliot slate, which gives it an approach in character to the Scarboro portion of the Casco Bay group. Hence the Eliot slate does not appear to be precisely equivalent to the Cape Elizabeth formation but may represent also a part of the Scarboro phyllite. It is therefore given a separate name.

CASCO BAY GROUP.

General features.—The Casco Bay group derives its name from Casco Bay, Maine, in and around which its parts are well developed. The rocks of the group are limited in their distribution to the northeastern part of the region here considered, where they occupy a compact area about 30 miles long and 12 miles wide, including the extreme northeast corner of the Kennebunk quadrangle, the north edge of the Biddeford quadrangle, the southeast half of the Portland quadrangle, and all but the northwest corner of the Casco Bay quadrangle. From the central part of this area is excluded a strip, occupied by intrusive granodiorite, some 16 miles long and as much as 3 miles wide, in Cape Elizabeth and the central islands of Casco Bay.

The Casco Bay group has an aggregate thickness of 1,500 to 2,000 feet and consists of slate, phyllite, and schist, dominantly of argillaceous origin; siliceous slate, graywacke, and quartzite; calcareous beds; and some greenstone and associated schist, probably of volcanic origin. These rocks are divided into seven formations, as described below.

Cape Elizabeth formation.—The Cape Elizabeth formation, the lowest unit in the Casco Bay group, is named from Cape Elizabeth, Maine, where it is best and most completely exposed. The formation crops out in many other places throughout the area occupied by the Casco Bay group. The Cape Elizabeth formation is an assemblage of mostly thin-bedded light-gray siliceous and sericitic slates, heavier beds of graywacke slate, schist, and quartzite, and it contains at short intervals thin layers or laminae of black micaceous phyllite and light-bluish calcareous schist or slate. Near High Head, on Cape Elizabeth, the lowest exposed parts contain about 10 feet of massive drab graywacke or quartzite, succeeded by 12 to 15 feet of gray slate and sericite phyllite, with calcareous laminae, followed by about the same thickness of gray sericite-quartz phyllite containing thin layers of blackish phyllite. Above these are thin layers of fine gray sericite-quartz slate interbedded with coarse-grained graywacke slate in beds 1 to 2 inches thick. These beds are succeeded by a considerable thickness (not measurable) made up chiefly of gray sericite slate and schist, which are finer grained, darker colored, and more micaceous toward the top. In other localities the formation contains beds of gneissic micaceous (biotite) quartzite, 1 to 3 or 4 feet thick; garnetiferous mica schist; and finely intermingled micaceous and siliceous schists. The thickness of the Cape Elizabeth formation is difficult to estimate but seems to be about 600 feet, which is sufficient to account for all exposures, for although they cover large areas the dips are in the aggregate very low.

Spring Point greenstone.—The Spring Point greenstone, which lies above the Cape Elizabeth formation, is named from Spring Point, South Portland, Maine. It is made up of gray to dark-green actinolite schist, in part thoroughly schistose and in part somewhat massive; chloritic schists; and some schistose rocks that still show their original coarsely and irregularly fragmental texture and contain secondary felts of small actinolite needles and small blebs of blue quartz. In composition and texture the more massive phases resemble moderately mafic igneous rocks and the schistose fragmental varieties resemble tuff, agglomerate, or flow breccia. The formation is very probably volcanic material locally but conformably intercalated between the Cape Elizabeth formation and the Diamond Island slate. Its distribution is not so wide as that of the other formations—that is, it is not found in all places where its horizon is exposed but chiefly only in the central part of the Portland region in parts of Portland, South Portland, Cape Elizabeth, and southeastern Scarboro. Its thickness is irregular but attains a maximum of probably 600 feet.

Diamond Island slate.—The Diamond Island slate is named from Great Diamond Island and Little Diamond Island, in Casco Bay, where it is typically exposed. It conformably overlies the Spring Point greenstone but is more extensive than that formation and also overlies directly the Cape Elizabeth formation in the northeastern part of Casco Bay and in the

southern part of Cape Elizabeth Township. The Diamond Island slate seems to be continuously developed in a tract 6½ miles wide and 18 miles long within the region examined and to extend for an undetermined distance northeast; but the formation is not known and is seemingly not developed at its horizon in Richmond Island and in the western part of the area occupied by the Casco Bay group. The formation is made up in major part of a black pyritiferous, graphitic, and slightly micaceous quartz slate of very fine grain and in lesser part of a black or bluish-black, somewhat graphitic and also pyritiferous quartz-sericite phyllite. The rock is characteristically black and studded with small masses and crystals of pyrite, which weather out on the surface of exposures and give rise to abundant copperas and rust coatings. Equally characteristic of the Diamond Island slate are intricate crumpling on a small scale and an abundance of small crumpled quartz veins. Estimates based on width of outcrops where the beds are vertical indicate a thickness between 75 and 150 feet.

Scarboro phyllite.—The Scarboro phyllite takes its name from the town of Scarboro, Maine, in which it crops out abundantly, particularly in the vicinity of Scarboro Beach, where the several phases of the phyllite are exposed. The Scarboro phyllite overlies the Diamond Island slate and the Cape Elizabeth formation. It consists of uniformly fine-grained sericite phyllite, for the most part dark bluish gray to black from the presence of biotite and carbonaceous matter, but locally light gray and white in the upper half of the formation. The rocks are typically not siliceous. They are in places somewhat garnetiferous, and the dark-colored parts are in general heavily impregnated with pyrite. The presence of vein quartz in chunky lenticles and irregularly contorted seams is characteristic, as are also knobby and undulatory rather than plane cleavage surfaces. Estimates of thickness based on width of outcrops of vertical beds indicate 200 to 600 feet.

The Scarboro phyllite and Diamond Island slate are connected by rocks of intermediate and transitional lithologic type. In some sections both formations are present, the slate at the bottom; in other sections, in western Scarboro, Old Orchard, and Saco, the slate is absent. The phyllite is thus more widely distributed than the slate and may be regarded as overlapping on the Cape Elizabeth formation because of local failure of deposition of the Diamond Island slate or a change from siliceous (Diamond Island) to argillaceous (Scarboro) sedimentation.

Spurwink limestone.—The Spurwink limestone conformably overlies the Scarboro phyllite. It is named from Spurwink River, in Scarboro and Cape Elizabeth, Maine, where it crops out. The formation is exposed in the eastern and southern parts of the Portland region but is probably also present under a heavy drift cover in the western part. It is composed of thin interlaminated lenses of fine-grained white and light-bluish crystalline limestone, fine-grained dark-gray calcareous mica schist, and fine gray siliceous mica phyllite. The layers of pure limestone which predominate in the lower and middle parts of the formation are from a small fraction of an inch to 2 or 3 inches thick. The gray phyllite bands of similar thickness are more abundant in the higher than in the lower parts and seem to dominate in the upper 50 feet. The formation is pyritiferous, in places richly so. Weathering produces ribbed and rugose surfaces on the ledges and reddish soils. Deformation has developed a characteristic intermingling of the fragments of disrupted limestone beds with the laminae of phyllite and slate. The Spurwink limestone is about 200 feet thick.

Jewell phyllite.—The Jewell phyllite conformably overlies the Spurwink limestone. It is named from Jewell Island, in Casco Bay, and is geographically coextensive with the Casco Bay group as mapped. The formation is an assemblage of alternating gray and bluish to black fine-grained sericite phyllites in thin beds (a few inches to a few feet thick) containing also interbedded gray siliceous slate and very thin layers of quartzite. In some places the formation is dominantly light colored; in others it is dark, resembling the black phase of the Scarboro phyllite. It is also like that formation in that its dark-colored parts are in some places heavily impregnated with small grains and crystals of pyrite. However, the Jewell phyllite is distinguished by the dominance of very fine grained medium-gray phyllite of silky luster and by the abundance in this rock of metacrysts, chiefly of garnet, but including

ottrelite, staurolite, magnetite, and other minerals, which commonly range from those of minutely microscopic size to some measuring an eighth of an inch. In some places crystals of ottrelite and andalusite (?) an inch in length are abundant.

No reliable measurement of the thickness of the Jewell phyllite is possible in view of the crumpling and repetition of the beds, but 500 feet seems more than ample to account for all the outcrops, and the actual thickness may be much less than that.

Mackworth slate.—The Mackworth slate, named from Mackworth Island, Casco Bay, probably overlies the Jewell phyllite conformably. It is the uppermost formation of the Casco Bay group and is known only in and around the northern and northeastern parts of of Casco Bay. The formation is composed of quartzite and quartz-chlorite-mica slate in beds ranging from less than an inch to 2 or 3 feet in thickness. The rocks are dominantly siliceous and laminated and are characterized by abrupt alternations in lithologic character from flinty to chloritic slate. In color they range from white through drabs and light grays to dark grays and browns. Probably a thickness of 100 feet is shown by the several exposures in and around Casco Bay. The top and whole thickness of the formation are unknown.

Relations of the Casco Bay group.—The metamorphism of the Casco Bay group is moderate and of the regional or dynamic type. It has resulted from the complex folding and intricate plication of its weaker members. All its parts except the nearly pure quartzitic beds are thoroughly deformed, recrystallized, and foliate.

In structure the Casco Bay group is as a whole synclinal, with a slight northeasterly pitch at the southwest end. In the longitude of Portland at least three secondary anticlines and two synclines are indicated, in which all the formations are involved, and throughout the area there are many series of parallel minor folds that pitch northeast or southwest and involve one or several formations.

The area mapped as occupied by the Casco Bay group is bordered on the south and southwest by an area of Kittery quartzite and on the northwest by the Berwick gneiss. On the south and southwest the Cape Elizabeth formation, the lowest one of the group, approaches but is not in visible contact with the Kittery quartzite and the Berwick gneiss. Farther northeast the Jewell phyllite and Mackworth slate are the areally marginal members of the Casco Bay group and closely approach the Berwick gneiss. The relation to the Berwick gneiss thus indicated is structural or stratigraphic discordance (fault or overlap). By correlation of the Cape Elizabeth formation with the Eliot slate the conformable superposition of the Casco Bay group on the Kittery quartzite is indicated. This inference is supported by the structure in the southwestern part of the area occupied by the Casco Bay group, where the rocks lie in a northeastward-pitching syncline and where the surrounding quartzite strikes east on the south side and northeast on the northwest side of this syncline. The age of the Casco Bay group is therefore Carboniferous.

GONIC FORMATION.

The Gonic formation, named from the village of Gonic, N. H., near which it is exposed, occupies a southwesterly belt 2 to 6 miles wide and 18 miles long from Sanford, Maine, to Barrington, N. H.

This formation is made up of arenaceous (graywacke) and argillaceous materials, metamorphosed to schist and phyllite, which are for the most part rather thin bedded, fine grained, and whitish or light gray to dark gray. The rocks include mica schist and phyllite and interbedded fine to medium grained micaceous graywacke schists in beds as much as 2 feet thick; fine-grained light and dark gray phyllites abundantly studded with dark staurolite crystals, some minute, others an inch or more long, or with red or brown garnets, commonly in dodecahedrons about one-eighth to one-fourth inch in diameter, or with both minerals; and a little coarse muscovite schist composed almost wholly of mica and very thin laminae of quartz. The beds of argillaceous origin that have developed into garnetiferous and staurolitic phyllites and mica schist predominate, but the arenaceous beds (graywacke) are prominent.

The metamorphism of the formation is regional or dynamic and has progressed little further and produced only slightly more general crystallinity than in the Casco Bay group. There is no evidence of significant contact metamorphism, although the granitic intrusive

masses in the formation are large. The development of garnet and staurolite has no apparent relation to the granite.

The beds of the Gonic formation are in general minutely crumpled, but folding on a large scale is not discernible. The strike is uniformly about northeast and the dip vertical or steep to the northwest. The thickness of the formation is unknown. About 100 to 150 feet of the coarser-grained phyllite and graywacke schist is shown in the hill northwest of Gonic village, and there may be two or three times as much in the rest of the formation.

The Gonic formation is in contact on the southeast with the Berwick gneiss along a seemingly straight line. The inferred relation, on the assumption of greater age of the Berwick, is either fault contact or unconformable overlap. The northwest boundary of the belt of the Gonic formation, as drawn on the map, is a line between outcrops of rocks of dominantly Gonic type on the one side and of Rindgemere type on the other. The Gonic formation is intruded by biotite granite and pegmatite at both ends of the belt here considered.

Discussion of the stratigraphic relations and age of the Gonic formation follows the description of the Rindgemere and Towow formations.

RINDGEMERE FORMATION.

The Rindgemere formation is named from Rindgemere station (East Rochester), N. H., on the Worcester, Nashua & Portland division of the Boston & Maine Railroad, at Salmon Falls River. The formation is exposed in the central and northern parts of the Berwick quadrangle in an area at least 12 miles wide and 15 miles long. On the northeast it is cut off by granite and gneiss in Sanford and Acton, Maine, and it extends southwest from Rochester, N. H., for an undetermined distance beyond the region examined. Within this area it surrounds a belt 3 miles wide by 10 miles long occupied by the Towow formation, described below.

The rocks of the Rindgemere formation are slate, phyllite, and schist derived from somewhat carbonaceous shale and argillite, with subordinate amounts of interbedded argillaceous quartzite, graywacke, and limestone. They are generally thin bedded—few beds exceed 2 feet in thickness—and fine grained. The colors range from white and light gray or bluish in the quartzite, graywacke, and limestone beds to dark bluish, gray, and black in the argillaceous beds. The rock varieties found in this region are light and dark gray micaceous slates and sericite phyllite associated with very fine grained micaceous graywacke schist, all abundantly speckled with small to minute sporadic phenocryst-like minerals; fine-grained gray sericite slate and phyllite which are pyritiferous and studded with chiastolite; interbanded light and dark gray and black carbonaceous quartz-sericite phyllites speckled with biotite flakes and abundantly filled with large crystals of chiastolite in the dark-gray and black bands; coarse mica schist with chiastolite crystals measuring 6 to 8 inches by one-half to three-fourths of an inch; dark-gray ferruginous chiastolite-bearing phyllite with which are interbedded dense quartzite and graywacke; and (in Acton and Shapleigh, Maine) some thin layers of white to bluish crystalline limestone.

Andalusite and chiastolite in large prismatic forms, in places with well-developed "crosses," are abundant in certain beds, notably in Rochester, 1½ miles north of the center of the city, and in East Rochester, N. H., and on the summit and upper east slope of Bauneg Beg Mountain in North Berwick, Maine.

In the central part of the area occupied by the Rindgemere formation, and therefore, because of the structure, toward its top, the fine-grained carbonaceous and argillitic sediments are the most abundant, although thin beds of quartzite and graywacke are present. At South Lebanon, however, very near exposures of the Towow formation, there is a zone of thin-bedded light-gray slate and quartzite. In the outlying parts of the area, as in the northeast corner of Rochester and the eastern part of Lebanon, and therefore near the base of the Rindgemere formation, quartzitic and graywacke beds are dominant; but as a whole the Rindgemere is made up dominantly of argillaceous and somewhat carbonaceous rocks.

The incomplete sections afforded by isolated outcrops provide no basis for a measurement of thickness. Several hundred feet is indicated for each of the different rock facies in East Lebanon, East Rochester, and North Rochester. The aggregate thickness of the formation is therefore considerable and may be about 1,000 feet.

The data on the structure of the Rindgemere formation in the Berwick quadrangle are

meager. The observed strikes are, in general, northeast, with high northwest or vertical dip, except between Rochester and West Lebanon, where there is an easterly strike and a lower dip, thus indicating a large major syncline inclosing the elongate oval area of the Towow formation. Another fold of considerable size is suggested by the west-northwest strike and high northwest dip in East Lebanon, and many subordinate folds are shown by crumpling of the beds. Northwest dips in the hill 5 miles north of Rochester suggest that the major syncline may be overturned to the southeast.

The Rindgemere formation surrounds the Towow formation areally and is in contact with the Gonic formation along an approximately straight northeast line on the southeast. The northern, northeastern, and northwestern limits of the Rindgemere have not been determined, because in those directions numerous masses of granite and pegmatite have disrupted and extremely metamorphosed the sediments, so that their delineation is not yet possible. Besides these intrusives on the border of the mapped area of the Rindgemere formation there are granitic intrusives in North Berwick, Maine, and in Rochester, N. H.

Discussion of the stratigraphic relations and age of the Rindgemere formation follows the description of the Towow formation.

TOWOW FORMATION.

The name of the Towow formation is derived from the original name of the first settlement in the town of Lebanon, Maine. The formation has been found only within that town, where it occupies a northeasterly belt about 10 miles long and 2 to 3 miles wide. It is composed of uniformly very fine grained and thin-bedded dark-gray to black carbonaceous or graphitic siliceous slates and sericitic slate or phyllite. Except for some light-gray siliceous sericitic slate in North Lebanon and South Lebanon and for some interbedded layers of light-gray quartzite a few inches thick in South Lebanon, the formation is richly carbonaceous and in places graphitic and is impregnated with pyrite in small individual crystals and lenticular masses. These rocks are lithologically identical with the Diamond Island slate and the black pyritiferous part of the Scarboro phyllite of the Casco Bay group. The light-gray and quartzitic phases of the Towow formation were seen near its contact with the Rindgemere formation and are therefore at the base of the Towow. The top of the Towow formation is presumably not present, and no overlying formations are known.

There is no means of determining the thickness of the part of the formation present in this region, but it seems to be a few hundred feet.

The beds of the Towow formation are severely crumpled, and the formation as a whole is probably intricately folded. Its relation to the Rindgemere formation indicates that the Towow formation here lies in the trough of a large syncline, whose east end is split by a secondary anticline that pitches southwest.

STRATIGRAPHIC RELATIONS AND AGE OF THE GONIC, RINDGEMERE, AND TOWOW FORMATIONS.

The Towow formation is surrounded by the Rindgemere formation, which occupies the area between the Towow and Gonic formations. Between these three formations there are intermediate or transitional phases, and all three show a general lithologic similarity in being dominantly fine grained and thin bedded and containing an abundance of argillaceous material. They are, furthermore, allied by a content of fine carbonaceous matter, inconspicuous in the Gonic formation but increasing to abundance in the Rindgemere formation and to dominance in the Towow formation. They are structurally conformable and show no differences in degree of metamorphism between beds of similar character. For these reasons and, furthermore, because there are no data to indicate the contrary, they are assumed to form a stratigraphically conformable succession, of which the Gonic, on the basis of the structural data present, is the lowest and the Towow the highest.

These formations are assigned to the Carboniferous period and are approximately equivalent to the lower formations of the Casco Bay group—the Cape Elizabeth, Diamond Island, and Scarboro—and so also to the Eliot slate and to the Carboniferous Worcester phyllite in the Worcester Basin, Massachusetts. This correlation rests on the following considerations: (1) The Towow formation and the Diamond Island slate are of identical character. (2) The three groups correspond closely in lithologic facies—that is, all three contain basal thin interbanded gray arenaceous (graywacke) and

argillaceous beds with abundant black carbonaceous laminae, succeeded by increasingly argillaceous beds, which in turn are followed by black carbonaceous and pyritiferous siliceous slates and sericite phyllite. Furthermore, the data on the thickness of the several members and formations, though not sufficient to establish close resemblance, nevertheless indicate comparable thicknesses or at least measurements compatible with the argument for correlation. Thus the maximum aggregate thicknesses of the formations compared are about 1,300 and 1,800 feet, of both of which the far larger parts are in the lower arenaceous and gray argillaceous members and much smaller parts in the black carbonaceous slates. (3) Similarity in structure and in type and degree of metamorphism indicate identical history for both. (4) In lithology, deformation, and metamorphism these formations are similar to a formation of Carboniferous age (Worcester phyllite) in the Worcester Basin, described by Emerson.[1] Mr. Keith and Mr. LaForge[2] report that these formations of the Worcester Basin extend northeastward into New Hampshire within 30 miles of Rochester, in a belt trending approximately toward the area of the equivalent Eliot slate. They are on the northwest side of a belt of graywacke and other gneisses that Mr. LaForge[2] reports to be, in part at least, continuous with and equivalent to the Berwick graywacke gneiss, which is in similar relation to the Gonic formation.

IGNEOUS ROCKS.

The relations of the igneous rocks of this region to the surrounding sediments have been determined so far as opportunity for field observation permitted. Very few of the igneous rocks have yet been studied petrographically. The following statements are made merely to point out the areal distribution of the larger associated groups of igneous rocks and to indicate roughly their stratigraphic relations.

Westbrook granite and Falmouth pegmatite.—In Westbrook, Falmouth, and Portland, Maine, granite and pegmatite intrude the Berwick gneiss and, so far as is known, are restricted to the northeast part of the gneiss belt. These rocks are named the Westbrook granite and Falmouth pegmatite, after the towns in which they are well developed and exposed.

The Westbrook granite protrudes through the Berwick gneiss in a number of bodies elongated in northeasterly and northerly directions and ranging in size from those that are very small to some 5 miles or more long and 2 or 3 miles wide. It is a gneissoid granite of medium-gray color and fine, even texture and contains conspicuous crystals of biotite. Its essential components are microcline or orthoclase, quartz, oligoclase, and biotite, named in the order of abundance. Some very small masses of gneissoid granodiorite and diorite are included with the Westbrook granite.

The Falmouth pegmatite occurs as dikes ranging from about an inch to many hundred feet in thickness and from a few feet to 3 or 4 miles in length. They are generally parallel to the northeasterly trend of the gneiss, although some of the smaller dikes transect or irregularly invade the gneiss they intrude. The Falmouth is a normal medium to very coarse grained pegmatite composed of perthitic microcline, quartz, muscovite, and albite, in places carrying abundant crystals of black tourmaline and red garnet. With it is associated a fine-grained white or light-gray garnetiferous aplite. The pegmatite and aplite in many places have diffuse contacts with each other and with the Westbrook granite, indicating transition or intimate relation between them, although the Westbrook granite is cut by the pegmatite and aplite and is very evidently somewhat older. Some of the larger pegmatite dikes in Falmouth have been slightly crushed.

The age of the Westbrook granite and Falmouth pegmatite is post-Berwick and presumably pre-Carboniferous, because they are not known to intrude the near-by rocks of the Casco Bay group.

Igneous rocks of the Algonkian (?) complex.—An assemblage of igneous rocks restricted in distribution to the area of the Algonkian (?) complex includes chiefly several varieties of fine to medium grained, evenly granular and porphyritic pink or buff-colored muscovite granites which are generally free of or deficient in biotite. They are very commonly gneissoid

[1] Emerson, B. K., Geology of Massachusetts and Rhode Island: U. S. Geol. Survey Bull. 597 (in press).

[2] Personal communications.

in texture. The series also includes fine-grained dark-gray diorite, a gneissoid coarse porphyritic biotite granite (augen gneiss), and a very coarse white feldspar-quartz-muscovite pegmatite which in places contains black tourmaline and some of which is crushed. The small masses of granitic rocks and the pegmatites very closely parallel the trend of the sedimentary bands and are injected along the cleavage. Larger masses are elongate and have the same or approximately the same trend, as the result of injection along the beds or of infolding with them, or probably both.

Except that they are presumably pre-Carboniferous, because they do not invade the Kittery quartzite, the age of these intrusives has not been determined. However, a small body of white or buff fine-grained muscovite granite and aplite that intrudes the Kittery quartzite at Brave Boat Harbor, though not deformed, is otherwise not unlike some of the fine muscovite granites in Rye and New Castle. This rock at Brave Boat Harbor makes the assignment of the similar rocks in Rye and New Castle doubtful.

Cushing granodiorite.—The Cushing granodiorite, named from Cushing Island, in Casco Bay, occupies a single northeasterly belt extending for 16 miles from Scarboro, Maine, across Casco Bay to the northern limit of the region here discussed. It is narrow at its ends and has a maximum width of about 3½ miles. The granodiorite is thoroughly gneissoid, of light to dark gray color, and for the most part finely and evenly but only slightly porphyritic in texture. Its principal components are albite-oligoclase as phenocrysts and quartz, feldspar, biotite, and hornblende in the groundmass. Muscovite or sericite, probably all of secondary origin, is abundant, but in proportions differing from place to place. Along part of the northwest border there is a white aplite-like facies. In places toward the southwest end of the belt the granodiorite is dark gray, very biotitic, and richer in hornblende than elsewhere. At the northeast end it is very light gray and deficient in biotite.

The Cushing granodiorite is infolded in and deformed with the rocks of the Casco Bay group. It is known to be in contact chiefly with the Cape Elizabeth formation but also with the Jewell phyllite and rocks doubtfully referred to the Mackworth slate. The visible contacts are so badly mashed and recrystallized that the intrusive nature there indicated is not decisively shown. This nature is, however, further indicated by transgression of the bedding of the formations and by the aplite-like border facies. The Cushing granodiorite, though younger than the Carboniferous Casco Bay group, is not improbably late Carboniferous, because it is older than undeformed post-Carboniferous granite, which in turn is older than supposed Triassic dikes. (See below.)

Altered basic dikes.—A considerable number of small black and dark-green dikes of basic rocks (all less than 10 feet wide) are abundant in the rocks of the Casco Bay group and the Cushing granodiorite. They are now severely altered schistose biotite-hornblende and hornblende-garnet rocks. They may be closely related in age to the Cushing granodiorite.

Diorite in Saco.—The diorite in Saco, Maine, is an irregular elliptical body about 3 miles long and 1½ miles wide. The rock is medium to dark gray, moderately coarse grained, and in some places massive, in others gneissoid; it is composed essentially of orthoclase (?), andesine, hornblende, biotite, and subordinate amounts of quartz. This rock invades the Berwick gneiss and the Kittery quartzite and is therefore post-Carboniferous. An argillaceous quartzite in contact with the diorite is slightly altered to a rock somewhat like hornfels.

Exeter diorite.—The Exeter diorite, in Exeter, Newmarket, Durham, Madbury, Dover, and Rollinsford, N. H., occupies an area 15 miles long and from half a mile to 5 miles wide. The small area of diorite in Greenland, N. H., is a similar and probably related rock. The rock is a generally even, medium-grained light to medium gray hornblende-biotite diorite or quartz diorite, which changes in composition considerably but gradually from place to place. In Newmarket, N. H., both aplitic and basic varieties are present. These dioritic rocks are intrusive in the Kittery quartzite and Eliot slate and are therefore post-Carboniferous.

Biddeford granite.—The Biddeford granite, in Biddeford, Kennebunkport, Kennebunk, and Dayton, Maine, is a generally even or slightly porphyritic medium-grained biotite granite of light-gray or pinkish-buff color, composed of white microcline or orthoclase,

quartz, oligoclase, biotite, and in some places also a little muscovite. A few very small dikes of pegmatite and aplite are associated with it. The rock is intrusive in the Kittery quartzite and is post-Carboniferous.

Other granites.—The granitic mass in Wells, York, South Berwick, and Eliot, Maine, is an assemblage, including chiefly a granite of the Biddeford type and several more mafic varieties, probably differentiates, among which are the gabbros of Cape Neddick and South Berwick. These rocks are intrusive into the Kittery quartzite and are of post-Carboniferous age.

The granite in Rochester, Dover, and Barrington is generally a fine or medium and even-grained but in places somewhat porphyritic and moderately coarse grained biotite-muscovite granite containing orthoclase and plagioclase and in places garnetiferous. In it are abundant large bodies of coarse pegmatite, consisting of microcline, quartz, muscovite, and albite.

In North Berwick, Maine, there is a small body of very fine grained muscovite-biotite granite surrounded by and probably intrusive into the Rindgemere formation. It is, therefore, probably post-Carboniferous.

The large area of granitic rocks in Lyman, Alfred, Sanford, and Shapleigh, Maine, contains many included patches of gneiss (metamorphosed sediments) and a variety of granites, the most conspicuous of which are large masses of granite of the Biddeford type; some quartz diorite, composed of oligoclase, biotite, quartz, dark hornblende, and magnetite; and somewhat gneissoid coarse-grained biotite-muscovite granite, with which is associated abundant coarse pegmatite. These rocks are intrusive in the Berwick gneiss and the Gonic and Rindgemere formations and are post-Carboniferous. The assemblage may include also some older but as yet unrecognized granitic rocks.

The areas of granitic rocks in Milton, N. H., and Acton and Lebanon, Maine, shown on the map, are occupied chiefly by medium to coarse grained gneissoid muscovite-biotite granites and coarse pegmatite. Included with these are various other granitic rocks and many patches of metamorphosed sediments.

Trap dikes.—Throughout this region there are large numbers of small to moderately large trap dikes, for the most part of fine-textured gabbroic, diabasic, or doleritic habit. A few of the larger dikes are coarse grained, and many are in part glassy. They have been observed in all the other rocks of the region and many are themselves cut by others. Most if not all of them are younger than the post-Carboniferous granitic intrusives and are tentatively correlated with the Triassic eruptions of Nova Scotia and southwestern New England.