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# MAINE GEOLOGICAL SURVEY

JOSEPH M. TREFETHEN, State Geologist

## BULLETIN 3

Petrology of the Columbia Falls Quadrangle, Me.

By

Ruth D. Terzaghi



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no. 3

Maine Development Commission  
Augusta, Maine      March 1, 1946

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JOSEPH M. TREFETHEN, State Geologist

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**Petrology of the Columbia Falls Quadrangle, Maine<sup>1</sup>**

By

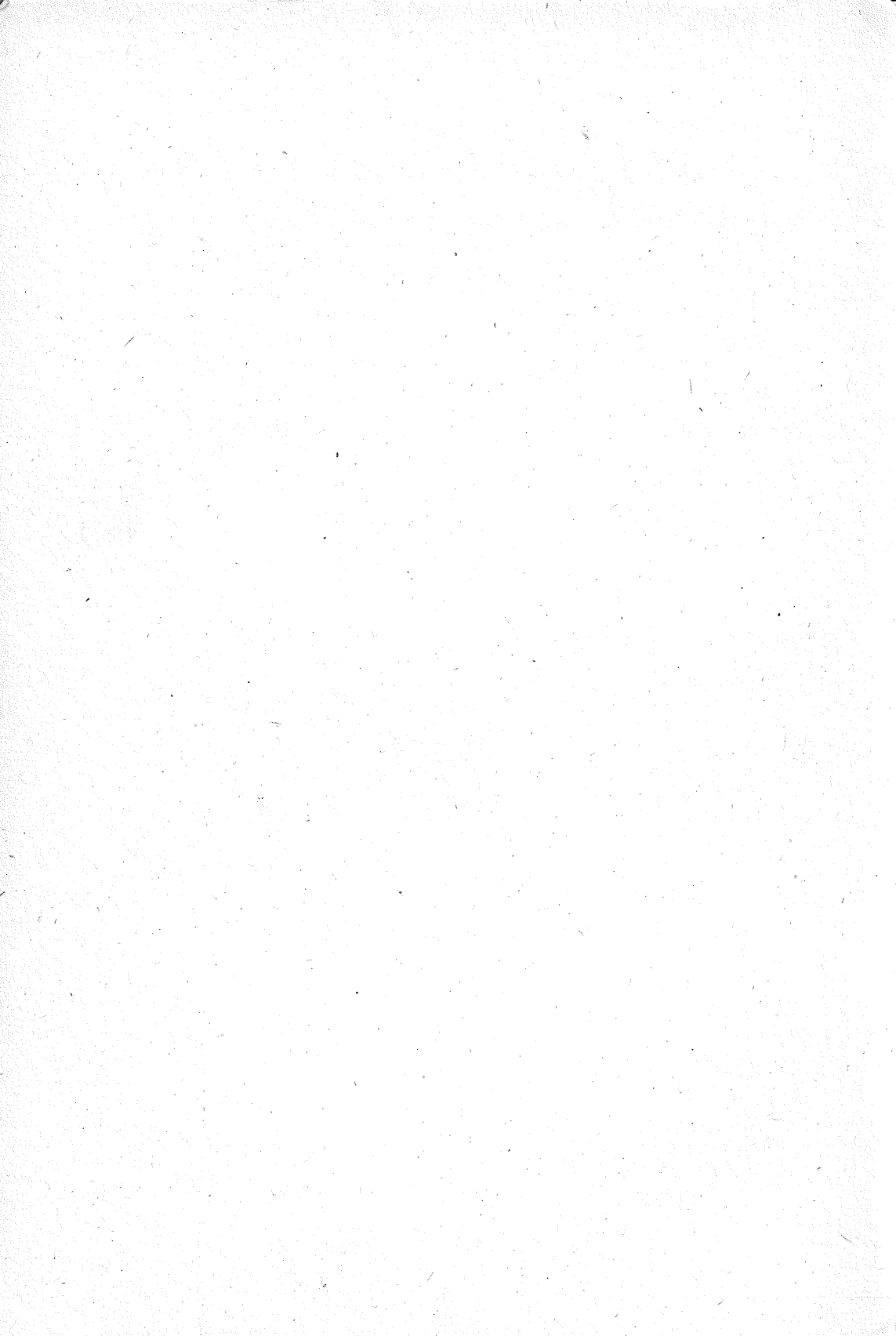
Ruth D. Terzaghi



**Maine Development Commission**

**Augusta, Maine      March 1, 1946**

<sup>1</sup>Based on a thesis submitted to the Division of Geological Sciences, Radcliffe College, in 1930, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.



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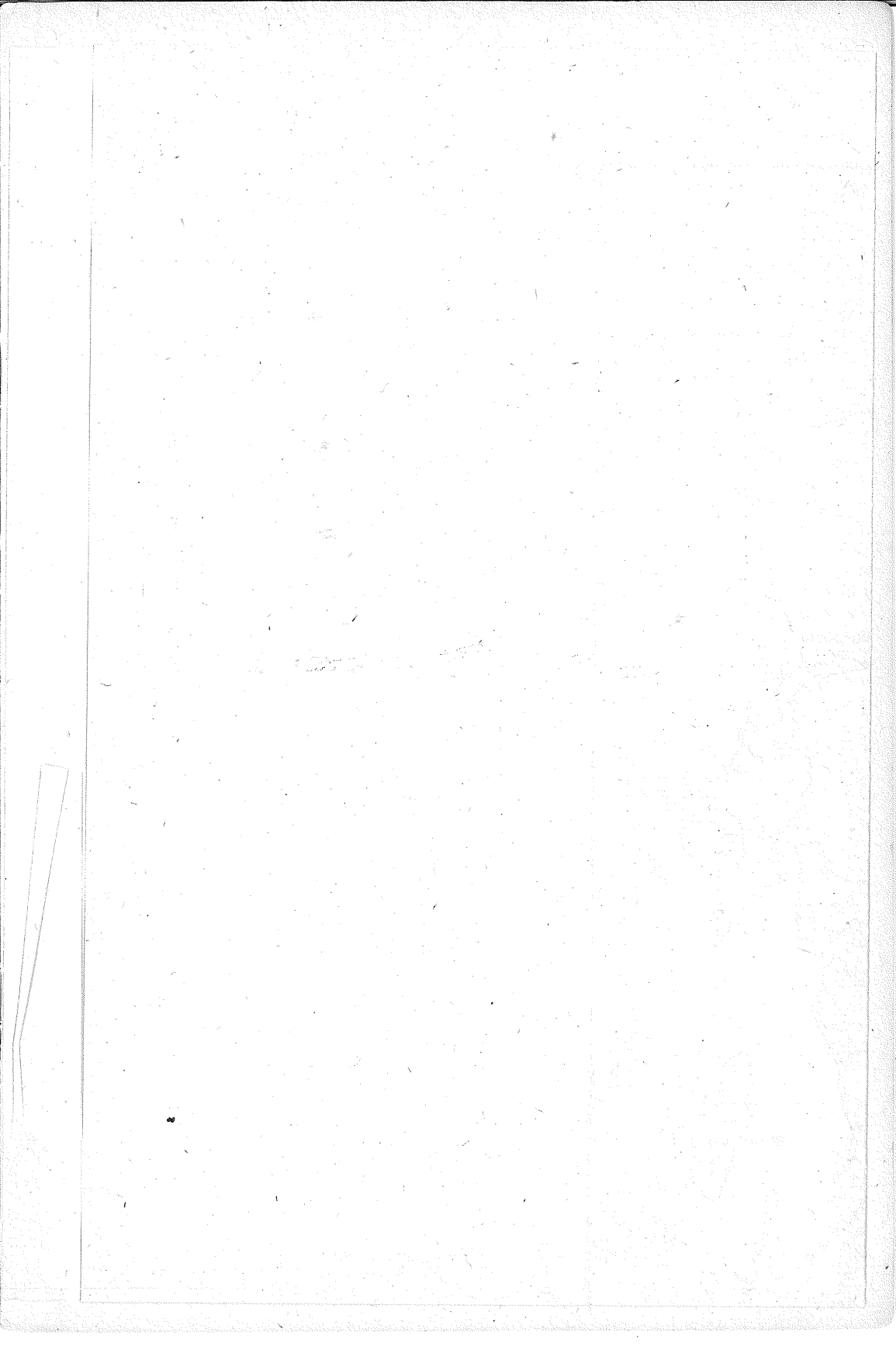
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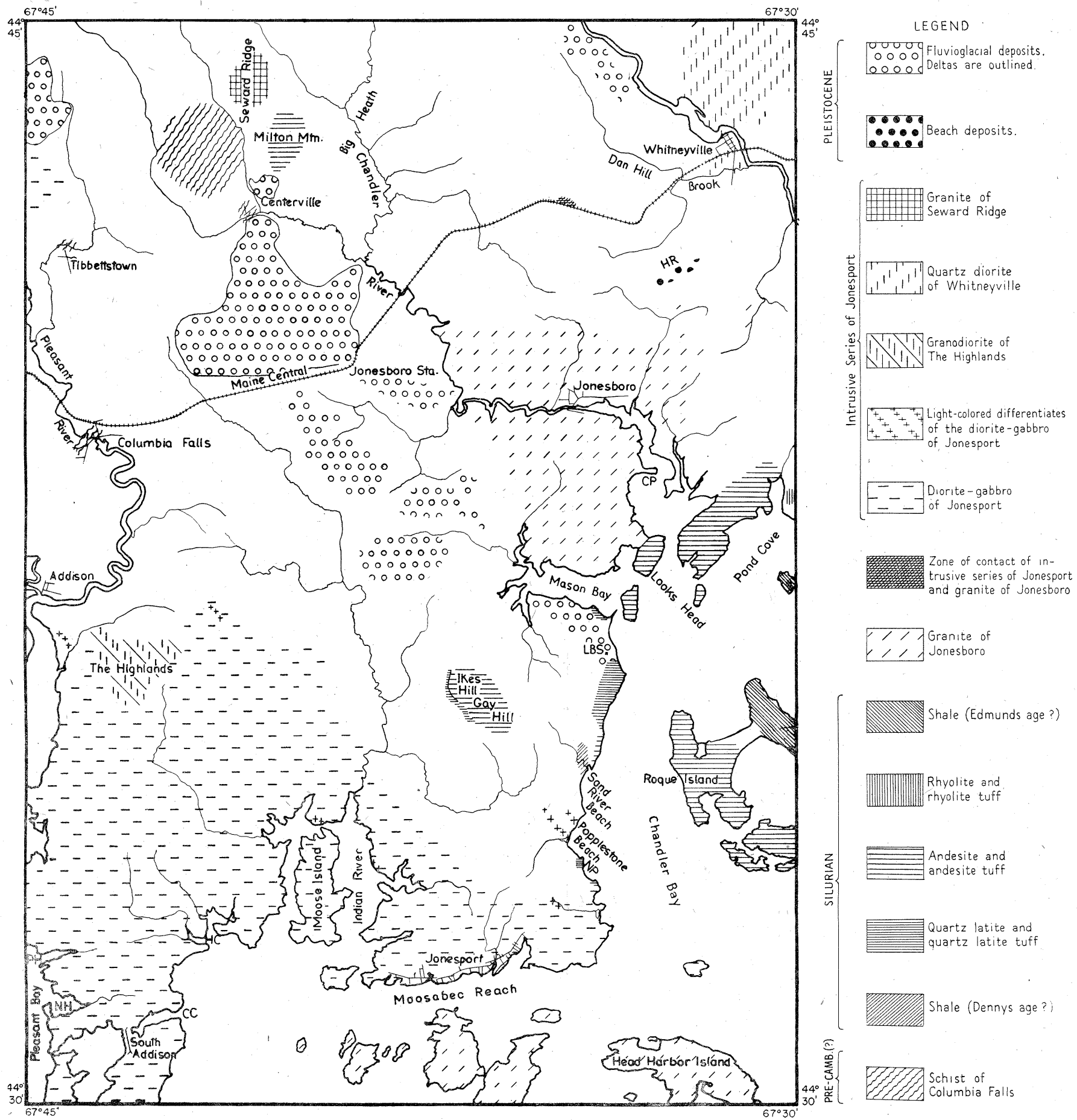


Plate 1—Map of the Columbia Falls quadrangle. Shows areas in which outcrops occur. Based on the topographic map published by the U. S. Geol. Survey. CC = Carryingplace Cove. CP = Calton Point. HC = Hicks Creek. HR = Hawkins Ridge. LBS = Lower Bay School. PH = Ports Harbor. NH = Nash Harbor. NP = Natts Point.

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1.

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## ABSTRACT

The oldest rocks of the Columbia Falls region, possibly pre-Cambrian, constitute a metamorphic series including a sericite-chlorite schist, a biotite schist and a hypersthene hornfels.

A younger, Silurian series of volcanic and sedimentary rocks is correlated with similar rocks outcropping in the nearby Eastport quadrangle. The gently dipping western end of an eastward plunging syncline includes practically all that remains of this series within the quadrangle.

The granite of Jonesboro, the age of which could not be determined with certainty, may be intrusive into the Silurian rocks. In typical specimens, the granite is of medium grain, whereas a minor rapakivi facies is very coarse. The granite consists essentially of quartz, pink perthite commonly idiomorphic and locally mantled by oligoclase even in the normal facies, white oligoclase and primary biotite.

The intrusive series of Jonesport, younger than the granite of Jonesboro, underlies a large area in the southern and southwestern portions of the quadrangle. All gradations between olivine gabbro on the one hand and quartz diorite, granodiorite, granite and pegmatite on the other are represented. Diorites are the commonest members of the series. Some of the pegmatites are practically identical with those generally associated with large uniform masses of granite, whereas others contain up to 99 per cent hornblende.

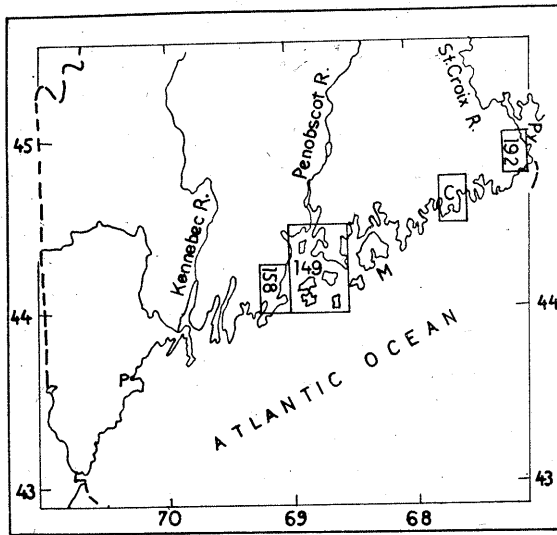


Fig. 1—Map of southern Maine.

State and international boundaries are indicated by dashed lines. 149 = Penobscot quadrangle (Folio 149, U. S. Geol. Survey). 158 = Rockland quadrangle (Folio 158). 192 = Eastport quadrangle (Folio 192). C = Columbia Falls quadrangle. M = Mt. Desert Island. P = Portland. Py = Passamaquoddy Bay.

## INTRODUCTION

The location of the Columbia Falls quadrangle is shown in Fig. 1, an index map of southern Maine. The topographic map of this quadrangle (scale 1:62,500), published by the U. S. Geological Survey in 1921, furnished a base for this report.

The area is one of slight relief; the highest hills, located in the northwestern part of the quadrangle, rise to an altitude of about 400 feet. There are numerous broad marshy areas at low altitudes which apparently represent tidal flats of post-glacial age. The coast is deeply indented by estuaries whose channels are delineated by the submarine contours down to about 80 feet below sea level. Islands are numerous along the coast, and soundings show that the sea floor itself is extremely irregular.

Much of the surface is mantled by Pleistocene deposits, chiefly marine sands, silts and clays, with some deposits of fluvio-glacial gravel in the northern half of the area. The location of the most conspicuous fluvio-glacial deposits is shown on the map, Pl. 1.

The northernmost part of the region is thickly wooded, whereas farther south the land has been partially cleared. Outcrops of bedrock are rare in much of the inland portion of the area, but the exposures along the seacoast are unusually good.

The field work was done during the summers of 1927 and 1929. Approximately three months were spent in the Columbia Falls quadrangle and one month was devoted to reconnaissance in the nearby Cherryfield, Machias and Eastport quadrangles. The work was carried out under the supervision of Prof. E. S. Larsen, of Harvard University, and the writer wishes to take this opportunity of making grateful acknowledgment of his constant helpfulness and of the stimulating suggestions which he made throughout the course of the study.

### SCHIST OF COLUMBIA FALLS

Although the schist of the area may be a correlative of the presumably pre-Cambrian Ellsworth schist which outcrops farther west, it will be referred to herein as the schist of Columbia Falls. The formation is somewhat variable in appearance but its weathered surface is generally characterized by the presence of narrow ridges a millimeter or two in height, representing the more resistant bands. The schist of most exposures is strongly contorted, so that individual observations of the dip and strike of the schistosity on small outcrops are of little value in interpreting the structure. The largest outcrops are those along the river at Columbia Falls where the strike is  $N40^{\circ}E$ . The dip of the schistosity is generally very steep.

Three distinct metamorphic facies are represented in the schists of the Columbia Falls region: a sericite-chlorite schist, a biotite schist, and a hypersthene hornfels. The last has been found only within the Cherryfield quadrangle to the west.

The sericitic variety occurs in the village of Columbia Falls on the banks of the Pleasant River, where the schistosity is well developed. The rock consists of bands of quartz alternating with bands composed of albite, orthoclase, sericite, chlorite, epidote, and quartz. The quartz in the bands consisting solely of this mineral is relatively coarse, and the grains are conspicuously elongated or flattened parallel to the schistosity. Boundaries between quartz grains are extremely irregular. In the bands consisting of several minerals, only the sericite and chlorite are consistently parallel to the schistosity; the (010) plane of many of the feldspar individuals is roughly parallel to the schistosity. This rock may be referred to the green schist facies of Eskola (1920, 1939).

The biotite facies outcrops near Centerville and in the area to the northwest of this village. The hand specimen shows black and pale pink bands a few millimeters in width. Under the

microscope, three types of band or layer may be distinguished: (1) chiefly fine flakes of slightly chloritized biotite approximately 0.05 mm. in diameter, and magnetite, with a small percentage of quartz and feldspar; (2) quartz, perthite, and albite, with a small percentage of chlorite; (3) coarse-grained quartz. Although this schist shows unmistakable evidence of having been subjected to a non-hydrostatic state of stress, the effects of such stress are not as marked as in the sericite-chlorite schist. About 80 per cent of the biotite individuals have their *c*-axes perpendicular to the schistosity; the (010) planes of the albite show no readily perceptible relation to the schistosity; the quartz grains are not elongated nor are the boundaries between quartz grains as irregular as in the sericite-chlorite schist. The biotite schist belongs to the amphibolite facies of Eskola. If the northeast strike observed at Columbia Falls persists, the biotite schist outcropping near Centerville must lie between the schist outcropping at Columbia Falls and that outcropping at Tibbettstown, described below.

The hypersthene hornfels which outcrops near Tibbettstown, Cherryfield quadrangle<sup>1</sup>, is fine-grained and compact, showing little tendency to break parallel to the banding. A fresh surface is black, streaked with the comparatively coarse yellowish-gray bands which form the ridges on the weathered surfaces. Under the microscope, the coarser light-colored bands are seen to consist chiefly of perthite, with about 25 per cent of hypersthene and a few grains of oligoclase. Most of the hypersthene is distributed along planes parallel to the banding, but an ordinary microscopic examination does not reveal any preferred crystallographic orientation of individual grains. The grain size in these bands averages about 0.3 mm. The bands vary in width from 0.3 mm. to 4 mm. The main mass of the rock consists of fine-grained quartz, oligoclase, magnetite and biotite all having an average diameter of approximately 0.05 mm. When seen under the microscope, the boundaries between the two types of material appear sharp, and there are practically no gradations between the two, either with respect to grain-size or mineral constituents. The minerals present are those characteristic of Eskola's hornfels facies.

Within the schist, a few small bodies of metamorphosed gabbro-diorite have been observed. In general, these consist of remnants of pyroxene having a frayed appearance, zoisite, epidote, and sphene in a fine granular groundmass of albite. A small injection of a two-mica albite granite was found in a boulder of schist which probably belongs to the Columbia Falls series.

It will be noted that metamorphic facies corresponding to higher and higher temperatures are encountered as one proceeds

<sup>1</sup>Not to be confused with a village of the same name in the Columbia Falls quadrangle.

across the probable strike from Columbia Falls to the north and northwest. In the same direction, there is also a progressive change in texture; the schist on the southeast border of the area of metamorphic rocks shows marked effects of a non-hydrostatic state of stress, whereas the hornfels on the northwest appears to have been developed under a more nearly hydrostatic state of stress.

## SILURIAN VOLCANIC AND SEDIMENTARY ROCKS

### General Statement

The Silurian rocks of the quadrangle consist of a series of flows, and possibly sills, of rhyolite, quartz latite and andesite, with tuffs and interbedded shales. These are tentatively correlated with rocks in the Eastport quadrangle (Bastin and Williams, 1914) on the basis of lithological similarities.

The only extensive outcrops of these rocks within the Columbia Falls quadrangle are in the southeastern part. These represent the western end of a northeastward plunging syncline whose eastnortheast to northeasterly strike is well marked in the structure and topography of the western part of the Machias quadrangle to the east. At the western end of the syncline the dips are in general moderate, ranging from a few degrees on the mainland west of Chandler Bay to about  $15^\circ$  on Roque Island. Farther north, on the north side of the neck connecting Looks Head with the mainland andesite flows with intercalated tuff strike  $N70^\circ E$ . In places in this locality, dips are steep to the south and in others, vertical. Near the contact with the Jonesport gabbro-diorite, which may be observed near Natts Point and at several other places farther south on the shore of Chandler Bay, the stratified Silurian rocks are vertical or dip steeply southward, and the strike varies from northwest through east-west to southwest. In the southern part of the Machias quadrangle the dips vary greatly; inclinations of  $30^\circ$  and of  $90^\circ$  have been observed within a few hundred yards. The strike in this locality is most commonly approximately northeast. Thus the oldest Silurian rocks represented in this syncline lie on the mainland west of Chandler Bay, and the youngest farther east in the district north of the Point of Main, Machias quadrangle.

### Petrography

A short traverse across the Eastport quadrangle was made in 1929 in order to gain familiarity with the field appearance of the rocks of that area. It was found that certain types of sedimentary and volcanic rocks occur in several of the stratigraphic units of the Eastport quadrangle. However, a few types seem to have a sufficiently characteristic appearance and limited oc-

currence to serve as horizon markers. On the basis of these, a tentative correlation has been made between the rocks of the Columbia Falls-Machias region and those of the Eastport quadrangle.

The compact dark gray shale weathering to light brown which outcrops at the north end of Sand River Beach and along the road immediately to the north is probably the oldest of the Silurian rocks of the Columbia Falls quadrangle.

The gray shale is overlain by glossy gray quartz latite and quartz latite tuff which outcrop along the shore north of Sand River Beach as far as the Lower Bay School, at Natts Point farther south, and at the base of Ikes and Gay hills. A similar rock occurs near Machias. Both latite and latite tuff have been so extensively silicified that it is not possible to determine their original composition and texture. A few of these rocks contain phenocrysts of oligoclase, in some specimens extensively altered to epidote. Embedded in some of the altered phenocrysts are small fine-grained aggregates of quartz. Oligoclase also occurs in irregular, poorly developed laths in the groundmass. Orthoclase is present in smaller amounts. Quartz may constitute as much as 50 per cent of the groundmass in which aggregates of quartz grains somewhat coarser than adjacent individuals are common. In hand specimen this rock is strikingly similar to the glossy gray rhyolite which is, according to Bastin and Williams (1914), the commonest type of rhyolite in the Dennys formation. Its stratigraphic position is in accord with the hypothesis that it is of Dennys age.

An andesite tuff overlies the quartz latite on Ikes and Gay hills. A similar rock outcrops on the slopes of Milton Mountain in the northwest corner of the quadrangle. In hand specimen this rock is dark green and in most specimens one may readily observe angular fragments up to several centimeters in diameter. The individual fragments consist of plagioclase laths less than 0.1 mm. in length and very fine-grained chlorite in a cryptocrystalline groundmass. Where a determination could be made, it was found that the plagioclase contains approximately 30 per cent anorthite.

Relatively fresh, highly amygdaloidal andesite flows are closely associated with the tuff. In these, the feldspar is a fresh sodic andesine in well-developed laths. The original dark mineral is completely altered to hornblende or chlorite. The vesicles are filled with calcite and epidote; the latter is confined to the peripheral portions of each vesicle. The slightly amygdaloidal andesite on the shore north of Sand River Beach appears to be at approximately the same horizon as the tuff of Ikes and Gay hills. It consists of fine-grained, secondary hornblende and altered plagioclase. The vesicular andesite and volcanic breccia on the



series of ridges and islands extending in a gently curving arc from the north shore of Pond Cove through Looks Head and the western arm of Roque Island may be somewhat younger. A specimen from this flow taken near the contact with the granite on Looks Head consists of altered sodic andesine with about 35 per cent of secondary hornblende.

Overlying this andesite is a dull gray rhyolite, which is exposed on the hill top at the northeast end of Pond Cove. Two varieties of this rock are represented: a spherulitic rhyolite and a tuff. In the first type the spherulites average about 5 mm. in diameter and are closely packed. In places, the interstitial material is very fine-grained and contains much quartz. Elsewhere, the space between the spherulites is entirely filled with coarse-grained quartz, apparently of secondary origin. Alteration products include zoisite, chlorite and a colorless micaceous mineral, probably sericite. The tuff in hand specimen is a compact fine-grained rock indistinguishable from a rhyolite, but under the microscope it is characterized by an irregularly distributed pumiceous texture.

A buff to greenish buff shale outcrops on the eastern arm of Roque Island. The rather fine bedding is marked by slight color variations, but there is little tendency to part along bedding planes, so that the shale as a whole is unusually massive and resistant to weathering. Although this rock closely resembles no member of the Edmunds formation seen by the writer, it is more nearly similar to the shales of that formation than to any others which were observed in the Eastport quadrangle. Moreover, the location of the outcrop suggests that the shale represents approximately the same age as do the beds strongly resembling various members of the Edmunds which are exposed on Foster and Ram Islands, in the adjoining Machias quadrangle.

Silurian rocks also underlie a part of the area east of Whitneyville and north of the Maine Central Railroad. No outcrops were observed, but fragments of purple rhyolite tuff from a well dug in 1929 were found near the easternmost house (shown on the 1921 edition of the topographic map) on the Machias Road. This material resembled the Edmunds tuff outcropping north of Dennysville, Eastport quadrangle.

Members of the Silurian volcanic series younger than the Edmunds have not been found within the Columbia Falls quadrangle, but in the stratigraphically highest part of the syncline in adjacent parts of the Machias quadrangle, between Buck's Harbor and the Point of Main, there are red, brown, and more rarely black rhyolites strikingly like those of the Eastport formation which overlies the Edmunds in the Eastport quadrangle. The red and green shales associated with limestone on the Point of Main are similar to the red and green Eastport shales outcropping northwest of Kendall Head, Eastport quadrangle.

## GRANITE OF JONESBORO

### Occurrence and Field Relations

The pink granite outcropping in the hills north of Jonesboro and Mason Bay, and on the islands south and southeast of Jonesport will be referred to as the granite of Jonesboro. The same granite outcrops north of Whitneyville at the edge of the quadrangle, in the hills a few miles north of Machias (Machias quadrangle), and at Marshfield, northeast of the Columbia Falls quadrangle. Some of the granite at Yoho Head, in the Machias quadrangle, probably belongs to the same body. The rapakivi of Head Harbor Island is very similar to the granite of Jonesboro and is doubtless a facies of it. It has been described elsewhere by the writer (1940).

No incontrovertible evidence of the age of the granite of Jonesboro relative to that of the Silurian rocks was found. In hand specimen the granite is practically identical with, although of a somewhat deeper pink than that of the Fox Islands, about 75 miles to the westward, which Geo. O. Smith (1896) has shown to be intrusive into the Silurian volcanic rocks of that area. The granite of Jonesboro is, on the other hand, distinctly different in appearance from the reddish granite, probably of pre-Upper Devonian age, which outcrops along the St. Croix River a few miles northwest of the Eastport quadrangle.

The only contact of the granite with presumably older rocks, which can be located within a few tens of feet, is that at the eastern end and south side of the neck connecting Looks Head with the mainland. Here the granite maintains its characteristic grain size to within a few tens of feet of the nearest outcrop of andesite. The contact is covered by soil and beach deposits. The andesite shows no conspicuous results of contact metamorphism.

### Petrography

The granite of Jonesboro is in general pink or pink and white, although locally, as at Calton Point, the rock is pale reddish violet, the color of the perthite. The dark mineral is invariably biotite, partially altered in some specimens to chlorite. The plagioclase is rarely idiomorphic; in some hand specimens a few large white individuals having irregular outlines stand out from the somewhat finer pink groundmass. Perthite commonly shows idiomorphism as well as large size; these two features attain an extreme development in the rapakivi type. The rarity of idiomorphic plagioclase and the presence of idiomorphic relatively large orthoclase individuals commonly serves to distinguish the granite of Jonesboro from the light-colored differentiates of the younger Jonesport series. Another diagnostic character commonly present in the granite of Jonesboro but never observed in

members of the series of Jonesport is the overgrowth of oligoclase on perthite. This feature, present to a limited extent in most of the granite of Jonesboro, is conspicuous in the rapakivi of Head Harbor Island. Quartz is abundant, generally comprising from 30 to 35 per cent of the rock. The grain-size of the normal granite varies from 1 mm. to about 4 mm.; the rapakivi contains individuals as large as 2 cm. in length.

With few exceptions the granite preserves a uniform character over wide areas. As far as can be determined by inspection of outcrops and ordinary microscopic examination of thin sections, the rock as a whole is structurally isotropic. Although typically pegmatitic or aplitic facies are not abundant, a few small dikes and veins of such material occur in the quarries north of Jonesboro and elsewhere. Mirolitic cavities a few inches in diameter are also found locally.

The orthoclase is highly perthitic. Under the microscope, the quartz commonly shows lines of extremely small dark bodies, possibly inclusions. Under the highest power, many of these lines may be seen to grade into minute cracks. Within a single thin section, these cracks are generally parallel, or occur in two intersecting sets. The biotite, or chlorite after biotite, is commonly in large clear flakes, in contrast to the biotite of the light-colored differentiates of the series of Jonesport, which is generally in fine aggregates. In a few specimens, the biotite shows evidence of slight crushing.

An analysis of the granite from Booth Brothers' Jonesboro quarry, published by T. N. Dale (1907), is given in Table 1.

Table 1  
Granite of Jonesboro (Booth Bros. Quarry, Jonesboro, Me.)

Analysts Ricketts and Banks

SiO <sub>2</sub>	72.97		
Al <sub>2</sub> O <sub>3</sub>	14.63		Norm
FeO	1.73	Q	29.08
CaO	1.48	or	30.69
MgO	0.27	ab	27.75
MnO	0.10	an	7.33
Na <sub>2</sub> O	3.28	C	0.80
K <sub>2</sub> O	5.18	hy	3.85
S	0.03		
CO <sub>2</sub>	none		
	99.67		99.50

A specimen from the same quarry, collected by the writer, consists of the following essential minerals: quartz 35 per cent, perthite 40 per cent, albite-oligoclase ( $Ab_9An_1$ ) 20 per cent, biotite and chlorite 5 per cent.

## INTRUSIVE SERIES OF JONESPORT

### Occurrence and Field Relations

In the southern and southwestern part of the quadrangle is a series of intrusive rocks varying from one containing approximately 15 per cent olivine, 35 per cent augite and 50 per cent of a zoned plagioclase having the approximate average composition  $Ab_{40}An_{60}$ , to quartz diorite, granodiorite, granite and pegmatite. Wherever the contact between a darker and a lighter-colored member of the series is exposed, the lighter-colored member is invariably clearly intrusive into the darker colored one. As indicated on the map, Pl. 1, the areal extent of the gabbrodiorite is much greater than that of the lighter-colored rocks of the series. These rocks will be referred to as the intrusive series of Jonesport. The quartz diorite outcropping in the vicinity of Whitneyville is similar to some of these rocks and is probably related. The granite of Seward Ridge may also be a member of the series. Although of somewhat different appearance and mineralogical composition, the microgranite outcropping west of Popplestone Beach may also belong to the series.

Small areas of gabbro-diorite near Tibbetstown in the northwestern corner of the Columbia Falls quadrangle and in adjacent parts of the Cherryfield quadrangle possibly belong to the series. The gabbros of the Yoho Head locality and of Miller Mountain in the Machias quadrangle as well as some of the dikes of that district probably belong to the same intrusive epoch. In the unmapped area northeast of the Columbia Falls quadrangle is a group of plutonic rocks whose field appearance is similar to that of some members of the series.

A significant although small outcrop of rocks presumably belonging to the series is near the Maine Central Railway tracks, midway between Jonesboro station and Whitneyville. Here a quartz diorite and a light-colored differentiate intrude and are chilled against the granite of Jonesboro.

The contact zone between the Silurian rocks and the gabbrodiorite may be observed at several places west of Chandler Bay, south of Natts Point. Here the Silurian rocks contain numerous irregular dikes of the gabbro-diorite and its light-colored differentiates. The Silurian rocks dip more steeply than elsewhere and in places they are contorted.

### General Description

Pyroxene is the chief primary dark mineral contained in most of the rocks of the series. It is generally partially altered to

amphibole, biotite, and/or chlorite. Primary amphibole is found in some microgranite and pegmatite. The composition of the pyroxenes and amphiboles will be discussed in detail in another publication.

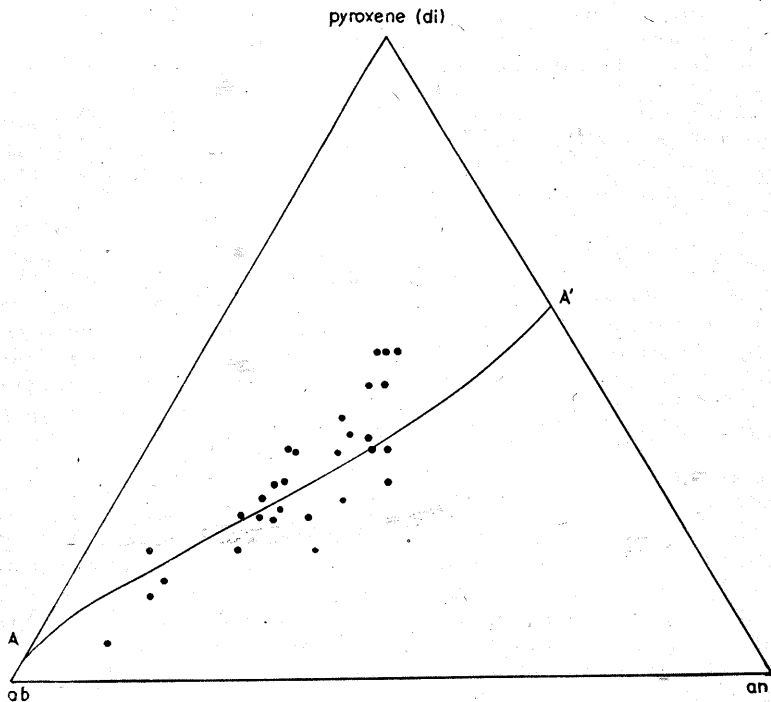


Fig. 2—Modal plagioclase and pyroxene content, reduced to 100, of some rocks of the series of Jonesport. The line A-A' is the field boundary of the system diopside-plagioclase.

Except in the pegmatites, the composition of the plagioclase varies systematically with the quantity of dark mineral present. Figure 2 shows the relationship between plagioclase composition and pyroxene content of some typical rocks of the series which consist essentially of plagioclase and pyroxene. The estimates for pyroxene are correct within  $\pm 5$  per cent. To the usual error of  $\pm 5$  per cent in the determination of the plagioclase is added the error in estimating the average composition of zoned plagioclase; the two may combine to produce an error of approximately  $\pm 10$  per cent An in the plagioclase. It will be noted that the location of points representing rock composition corresponds roughly to the field boundary of the plagioclase-diopside equilibrium diagram shown in the same figure (Bowen 1915).

The darker rocks of the series are typically diabasic whereas in many of the lighter-colored members, the pyroxene or amphibole is idiomorphic.

The late end-members of the series are of two types. The first includes relatively large masses of quartz diorite and granodiorite, as well as small injections into these, of granite and of microgranite. The second type includes a varied group of pegmatitic dikes, pockets and veins mainly of granitic or dioritic composition. These will be discussed in another section.

The term *light-colored differentiate* is arbitrarily applied to all those non-pegmatitic rocks of the series containing less than 5 per cent of dark minerals. The plagioclase in these rocks generally contains between 10 and 15 per cent anorthite. The quartz content ranges between a few per cent and 45 per cent, and perthite may constitute from a few per cent to about 60 per cent of the rock. Although it is possible that intrusions of more than one age and origin have been referred to this group, there seems to be no basis upon which reasonable subdivisions can be made. Of the various properties which characterize the group in general, each outcrop may show a slightly different combination from that exhibited by others, but nearly all have some of the essential features of rocks which clearly belong to the series.

Their commonly white to gray color generally distinguishes the members of the series from the older pink granite of Jonesboro, but their contact facies may be pink to dull red. Most of the light-colored end-members of the series are characterized by laths of white or pale gray plagioclase which can be seen in hand specimen. Another feature which commonly distinguishes them from the granite of Jonesboro is the character of the dark minerals. Whereas primary biotite occurring in large homogeneous flakes, locally altered to chlorite, is the only dark mineral contained in the granite of Jonesboro, the members of the series of Jonesport contain pyroxene, amphibole, biotite and/or chlorite. The biotite occurs most commonly in fine-grained aggregates, but in a few specimens there are large clear homogeneous plates which appear to be primary. In some thin sections all textural gradations between these two types may be observed. The color of the biotite varies from golden brown through pale dull brown to dull green. Like the biotite, chlorite occurs in fine-grained aggregates. Many of the aggregates of biotite and of chlorite have sharp angular boundaries which suggest that the aggregates are secondary after intergranular pyroxene or amphibole.

The largest outcrop of light-colored differentiate closely associated in the field with darker members of the series is that of the pink granodiorite in The Highlands region near Addison. Particularly in the western part of this district, the granodiorite occurs chiefly in large and small dikes of irregular shape in the darker rocks of the series. A typical specimen of the granodio-

rite contains 45 per cent quartz, 30 per cent perthite, 22 per cent plagioclase containing 13 per cent anorthite, and 3 per cent pyroxene and amphibole, the latter probably secondary after pyroxene, together with small amounts of chlorite and epidote. In some specimens of this area there is a partially chloritized biotite instead of pyroxene or amphibole. The quartz and the perthite individuals have a diameter of about 2 mm., the oligoclase grains a diameter of approximately 1 mm.

The quartz diorite of Whitneyville, not associated with dark-colored rocks, is referred to the series on the basis of its appearance in hand specimen and in thin section. A typical specimen contains 10 per cent quartz, 4 per cent perthite, 80 per cent plagioclase ( $Ab_{87}An_{13}$ ) and 6 per cent biotite, chlorite and pistacite; the dark minerals occur in angular, sharply bounded aggregates of very small individuals.

Although no contacts between the quartz diorite of Whitneyville and other rocks are exposed, fine-grained rocks which are probably contact facies of the quartz diorite occur at a number of places. Among these are the pink quartz porphyries exposed northeast of Whitneyville and on the Middle River Road, and a fine-grained pinkish albite porphyry which outcrops where the Whitneyville-Jonesboro road crosses Dan Hill Brook.

The pyroxene granite outcropping at the top of Seward Ridge, in the northern section of the area, doubtless represents a rather large mass which is almost entirely covered by Pleistocene deposits and forest. In hand specimen it resembles some members of the series.

The microgranite outcropping immediately west of Popplestone Beach may belong to the series, although its appearance is different from that of a typical member of this group. In hand specimen the rock is gray or pinkish gray. Microscopic examination shows that the rock contains a few altered feldspar phenocrysts. The groundmass consists of feldspar, chiefly albite, with about 10 per cent quartz and 5 per cent dark mineral. A specimen collected near the road at the north end of Popplestone Beach contains approximately 5 per cent biotite and less than 1 per cent muscovite. Another specimen from a point about one-half mile west of the road contains approximately 5 per cent hornblende. The rock has a distinct flow structure which appears to be related to a closely spaced system of joints striking  $N40^{\circ}E$  to  $N50^{\circ}E$  and dipping approximately  $75^{\circ}SE$ . This structure is not parallel to that of the adjacent sediments which dip gently to the east.

The location of a few of the more prominent of the small masses of light-colored differentiates is indicated on the map, Pl. 1. In some localities the texture of the smaller apophyses contrasts with the grain size of the immediately adjacent older

rock, the fine-grained apophyses occurring in coarse-grained rock, and coarse-grained apophyses in fine-grained rock. A good example of this may be observed on the road which follows the shore of the Pleasant River estuary, just west of the northern end of The Highlands. This phenomenon appears to indicate a greater permeability to steam and other vapors in the coarser rock. The greater permeability of the coarser rock is not surprising, since thermal contraction, in so far as it produces intergranular spaces, should be expected to result in wider and hence on the average more continuous cracks in coarse than in fine-grained rock.

The light-colored porphyry which is intruded into the diorite-gabbro outcropping in the hills north of Tibbetsstown, Cherryfield quadrangle, probably belongs to the series.

### Pegmatitic and Hydrothermal Facies

Some of the pegmatites associated with the Jonesport series are very similar to pegmatites derived from granites, inasmuch as they consist largely of quartz, orthoclase and sodic plagioclase. Where it is possible to determine the sequence, it is found that the deposition of quartz and orthoclase followed a period in which plagioclase and a subordinate quantity of quartz and orthoclase were deposited. Other pegmatitic dikes and "pockets" contain a striking concentration of hornblende, accompanied by biotite, which is generally more or less segregated from the normal pegmatitic or aplitic material. In some dikes and "pockets" hornblende occupies the outer portion and appears to be earlier than the light-colored constituents of the interior, and in others hornblende occupies the interior and clearly later portions. In many of these the feldspar appears to be replaced by hornblende. A similar relationship between plagioclase and hornblende is found in irregular masses of very coarse-grained rock in the diorite-gabbro of Yoho Head (Machias quadrangle). The plagioclase in these masses has a lower refractive index than elsewhere in a zone which follows closely the irregularities of the neighboring hornblende, to which the plagioclase has apparently lost lime.

### Structure

Several members of the series of Jonesport exhibit a conspicuous alignment of some minerals. This is particularly striking in a diorite outcropping on The Split Road,  $\frac{1}{4}$  mile northeast of the eastern end of Nash Harbor. In this rock, the feldspar laths are vertical. In the Popplestone microgranite described above, a flow structure strikes N50°E and dips 75°SE. Petrofabric analyses would doubtless reveal many other cases of marked anisotropy in the rocks of the series.

The jointing in these rocks is uniformly and well developed over large areas. Wherever they outcrop in the southern half



of the quadrangle, an east-west system is conspicuously developed. In places the joints are closely spaced, as in The Highlands and at South Addison. Various topographic features of the southern part of the area, such as Carryingplace Cove, the submarine channel of Moosabec Reach and the Ports Harbor-Hicks Creek depression north of the village of South Addison probably owe their origin to this system of jointing. South and southeast of The Highlands a north-south system of joints is as conspicuous in some places as the one striking east-west. The course of the submarine channels to the east and to the west of Moose Island are doubtless attributable to the presence of these joints. Along the Jonesport shore, a horizontal system is conspicuous in addition to the two vertical ones. All three sets are also developed to some extent in the older granite of Jonesboro outcropping on the islands south and southeast of Jonesport.

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