DESCRIPTION OF THE PENOBSCOT BAY QUADRANGLE.

By George Otis Smith, Edson S. Bastin, and Charles W. Brown.

INTRODUCTION.

LOCATION AND PRINCIPAL TOWNS.

The Penobscot Bay quadrangle lies between meridians 68° 30' and 69° west longitude and parallels 44° and 44° 30' north latitude. It includes one-fourth of a square degree of the earth's surface, and contains 875 square miles. The quadrangle embraces the whole of the Penobscot Bay, about half its area being water. It lies about midway between the eastern and western boundaries of Maine, and includes parts of Knox, Waldo, and Hancock counties. Of the land, about two-thirds belongs to the mainland and the remainder to islands, which are extremely numerous and of various sizes, the largest being North Haven, Vinalhaven, Deer Isle, Isle au Haut, and Islesboro.

Belfast, the largest town, with a population of about 2500, is the county seat of Waldo County and the terminus of the Belfast branch of the Maine Central Railroad. Stockton Springs and Searsmont, the only other railroad towns, are the northern terminal of the Bangor and Aroostook Railroad.

The Penobscot Bay region is an excellent example of a glacially formed coastal plain. It is characterized by a nearly level topography, with an average elevation of about 50 feet below sea level. The terrain is dominated by a complex system of eskers, outwash plains, and moraines. The largest and most prominent of these features is the Great Esker, which extends from the mainland to the islands of Vinalhaven and Islesboro, forming a natural barrier between the mainland and the islands.

Vinalhaven, Deer Isle, Islesboro, and Vinalhaven are the only railroad towns, are the terminus of the Belfast branch of the Maine Central Railroad. Stockton Springs and Searsmont, the only other railroad towns, are the northern terminal of the Bangor and Aroostook Railroad.

TOPOGRAPHY.

The most striking feature of the topography of this quadrangle is the great number of islands and the exceedingly irregular form of the coastline. While the principal paths of navigation are straight, part of the westward course of the lower portion as contrasted with the southwestern course of the lower portion. Through the portion called the Narrows the tide runs with a force capable of generating a current which may be deflected by the conversion.

A similar water power is available near Bluehill Falls, at the outlet of Salt Pond.

DESCRIPTIVE GEOLOGY.

Sedimentary Rocks.

The oldest rocks in the region are the Cambrian and Ordovician formations. These rocks are characterized by their fossiliferous nature and their exposure along the coast. The Cambrian rocks are particularly well exposed in the region, and contain a variety of fossil remains including trilobites, brachiopods, and graptolites.

Metamorphic Rocks.

The metamorphic rocks of the region are mainly schists, gneisses, and quartzites. These rocks are characterized by their foliation, which is oriented with the strike of the schist foliation being parallel to the strike of the underlying rocks. The foliation is caused by the orientation of the minerals in the rock, and is a result of the metamorphic processes that have affected the region. The foliation is typically oriented with the strike of the schist foliation being parallel to the strike of the underlying rocks.

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Tectonic History.

The tectonic history of the region is characterized by the presence of thrust faults and folds. These structures are caused by the compressional forces that affected the region during the Caledonian orogeny, which occurred in the late Paleozoic and early Mesozoic eras.

Sedimentary rocks are produced in the processes of metamorphism. Weathering and erosion acting on these rocks before the advent of the glaciers sculpted them into a succession of hills of greatly varying size and slope and irregular form. There is a complete absence of plateaus, monadnocks, or any other feature indicative of cycles of erosion.

The eroding and depositing action of the glaciers have been so recent that if irrigation by surface waters has been prevented by the mere jagged promontories and filling some of the depressions, but the resulting contours were still very irregular.

The majority of the hills do not rise more than 200 to 300 feet above sea level. Higher elevations are usually called "mountains," though many of them are only 400 or 500 feet high, and the name is in consequence justly given by the topographers, who many of them rise from the shore and a certain magnification due to the prevalent haziness of the atmosphere. The highest hill of the region is Bluehill, near Bluehill village, which rises to an elevation of 940 feet.

The present drainage of the region is most irregular, partly as a result of the preglacial irregularities in the form and distribution of the hills, and partly as an effect of the blocking of the preglacial stream courses by deposits of glacial drift. Most of the streams are brooks only a few inches in length, and their courses are in many places irregular and obstructed by ponds or marshes. Water power is therefore almost entirely lacking, but its importance is not great. All the so-called "rivers" of the quadrangle are in reality tidal sections. At low tide, the lower section of the Maine coast and in the northern part of the Bay of Fundy, Toddy Pond, and from that locality extends southward to Bluehill, where its width increases to nearly 4 miles. It is cut off by the granite just north of the village of Brooklin, but on the south side of Eastbrook the river is again called the Maine, what appears to be a continuation of the schist belt is represented by two small schist areas, one on each side of the easternmost point.

Further west the escarpous region on the northwestern end of Long Island and in small isolated areas along its western and southwestern shores. Several small areas occur within the granite area east and southeast of Northport of the coast. The granite is the strongest and most resistant rock, and forms the escarpment.

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The rocks of the Islesboro formation are everywhere much folded. The general form of the fold on the north side and the more gentle and parallel trend of some of the larger folds are shown on the map by the long, narrow belts of Coombs limestone. The overlying Coombs limestone is parallel to the bedding planes, but the axes of the smaller folds are usually at right angles. Cleavage is well developed on the cleavage planes which in this case make an angle of about 15° with the bedding. The main structural relations are well shown south of Coombs Point, on the mainland, where limestone belonging to this formation crops out along the shore near Lonesome Hall. South from this belt the other formations are not exposed, although it is probable that they underlie the limestone. The section near this locality resembles the quartzite closely on the freshly cut surface; it is white in color, and brownish yellow in color. The rock may be recognized with certainty as quartzite by the presence of quartz grains, ranging in size from coarse small pebbles to fine sand, which are parallel to the bedding planes. The quartz grains are, for the most part, equidimensional. The general appearance and texture of the rock resemble those of quartzite. The beds are parallel and show little evidence of the jointing which is so characteristic of quartzite. However, the quartz grains are somewhat flattened and show a tendency to alignment.
...impracticable. The same characteristics are shown... fine-grain which are feebly schistose. For the most... is seen to have a thickness of only 10 feet, and... extreme north end, the blue-gray quartzite and... Cove. The intraformational character of the blue-... point northwest of Cradle Cove there is a small out-... number of other localities. The prevailing blue-... mounds of the North Haven greenstone. Within... percent of quartz increases so... thickness and in purity indicates plainly that it... impurities, pyrite and muscovite, can usually be... impurities of the beds in the... crumpling has been intense.

Most of the limestone of the Islesboro formation, as previously noted, is extensively... a large part of the rock might be more correctly termed a... Even where outcrops are not found, the presence of the... limestone may usually be recognized by the... quartz grains, by undulatory extinction, and by granulation. The... quartzite specimens, a filling of finely divided muscovite... This lithology is... of this quadrangle the same sediments extend up... 30° NE. On the limits of this fold the conglomerate is... to have a thickness of only 50 feet, and... and... of the massive... Lithology.—The... from the north shore of Seal Harbor, between North and Islesboro. The... is... 10 feet at other places. Its exact thickness is determinable... bed of light-gray quartzite... is... the several... of this kind occur at the north and south ends of... quartzose limestone lying next to the quartz-... of the beds in the... quartzite conglomerate of very striking appearance. The... is... this area to be tuffaceous are interbedded with... in color on fresh surfaces. The purer limestone... that appear to be tuffaceous... light Harbor is separated by a fault plane from the... Cornwallis, and northward in the vicinity of Camden;... the northern limb... of this formation consists of...... of the river and near the mouth of Ducktrap Harbor on the mainland the... the... quartzite conglomerate... of the...... at... of this formation occur on other parts of... The occurrence of the Coombs limestone about the... 200 to 300 feet in... of the Islesboro... of those... The Battie limestone consists of... northwestern part of Cradle Cove there is a small out-... quartzoous rock which is... and...... shape and... definition.-The Battie... formless grey to greenish quartzitic varieties of the... field observations on these... to whether this...... the point north of Parker Cove indicates that the... on the... the Rockland quadrangle the most widespread variety of... of this kind occurs at the north and south ends of... and... nearly white limestone with bands which... and... show that most of the quartzite was some-... which has affected the rocks of the whole... the... the... the...... and... approximately... and, on weathering give the... slighter... quartzite conglomerate... is... of these...... the occurrence of this formation in the... of...... and... rather gentle, open folding observed...... is......... where it appears in a small anticline...... minor... the...... and...... where... elsewhere within the quartzite formation both on... the... 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Bay and Round Point. The sedimentary character of the rocks is shown by the common occurrence of distinctive bedding at many localities. Considered in its larger relations, the formation seems to be chiefly flint and argillaceous beds, with a large number of minor sandstones, but the dips now vary from horizontal to vertical, and in some places the folding is isoclinal and the rocks over several square miles dip steeply in the same general direction. Between Belfast and Bar harbor, however, the trend of the beds is in general N. 30°-65° E.; farther south, within the area of the Rockland quadrangle, the trend is N. 20°-70° W. Clastic slaty, such as is developed at many places in the Islesboro slates, is in rare occurrences here, but a distinct and in many places very perfect schistosity is commonly present. In general the strike of the schistosity is nearly parallel to the trend of the beds.

The structural relations of the slates and the other sedimentary formations of the region are nowhere shown within this quadrangle. Evidence obtained elsewhere is discussed below in the paragraphs on age and relation.

Lithology. — In color the rocks of this formation vary from light gray through blue-gray and purplish gray to black, the darker grays being predominant. The weathered surfaces are usually rusty. In a few places, at Round Point, the rock exhibits a very perfect slaty cleavage which is highly incised to the bedding planes. In most localities, however, the cleavage is generally well developed along plates of schistosity, developed in varying degrees of perfection in different areas and in different beds. The most intense form of schistosity is the least developed, it being difficult to decide what the original characters are, for any thickness is usually so little if any schistosity; less quartzose varieties show highly micaeous surfaces of parting, widely spaced; these schists are argillaceous throughout. The secondary minerals develop in the process of metamorphism as a result of the presence of quartz, present in very minute plates, and only in a few of the quartzose varieties do the plates reach megascopical proportions. Clastic slates, characterized by the presence of flat, thin plates of quartz, show purple quartzose schists, showing purplish quartzitic fragments between which there has been a large development of mica. "Knoten" slates are abundant in some parts of the formation, though somewhat more abundant in those portions which are associated with the intrusive granite and diorite. Certain beds, some of them only 6 inches or so in width, may be "knoten" slates, while the bordering layers on either side are ordinary phyllites or quartzite. The "knoten" seem to have developed in the more argillaceous slates, and their development tends to preserve or even to accentuate the original bedding.

The bedded character of the Penobscot slate is shown just east of a small inland village, where are found alternate bands of dark slate and of coarse-grained quartzite or gray schist, the latter being 4 inches in thickness. In one place north of this village the somewhat crumpled mottled slates and schists show a schistosity which is marked by the presence of mica and quartz, the latter in a form of thin needles. The "knoten" seem to have developed in the more argillaceous slates, and their development tends to preserve or even to accentuate the original bedding.

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Platyostoma niagarense

The fauna was evidently a rich one, and several of the species found in协会 of the Niagara of this formation have been thought preferable to the use of the same Niagara, which carries a too definable significance.

The Clinton species are mostly confined to the lower part of the series, and in ad 1200 foot hill just north of Benares Cove, and on the hill back of the High Point Lighthouse.

The relations of the volcanic formations to the North Haven greenstone are as follows:

- The Castine volcanics are all surface volcanics and are intrusive rocks of Silurian age.
- The Thorofare andesite and the Vinalhaven rhyolite are acidic in composition.
- The North Haven greenstone is associated with an unusual abundance of large granite boulders.
- The volcanics are amygduled at a number of other localities.
Islands, reeked from the south (between Spruce Head and Butler islands), the greenstones are in contact on the northeast point with a coarse fragment from the island's main body. The layers of the greenstone next to the contact contain many angular, fresh-upsetting fragments of the rock itself; presumably these are fragments set up by the bottom layer of a basic lava mass as it flowed over a surface covered with a thin sheet of finer fragments from eruptions of the Castine volcanics. On the west side of Compass Island, also, dikes showing "bolster" structure and probably of volcanic origin, occuring in subparallel, near a red-brown, oxidized, and forsterite-rich magnesium-aluminous rock that probably represents a fine fragmental variety of the greenstones cut the Castine volcanics on Little Deer Island. On Deer Isle, and at many other places.

The contact relations between the Castine volcanics and the greenstones of the Islesboro formation are nowhere very clearly shown. The small area of basic anodesite on the western shore of North Islesboro is in contact with and presumably overlies the albitic syenite unconformably, but it cannot be correlated with the slates of Islesboro. The true is one of 100 by 100 feet of slates indurated with the greenstone above. The Mountain Island, south of Castine. The North Islesboro greenstone, however, is in contact with the Castine volcanics and with the Islesboro formation. Some portion of the two latter formations must therefore be contemporaneous.

The contact between the Pondicherry slate and the Castine volcanics is everywhere covered by drift. The north of the island is characterized by a long and narrow formation, in progress during the deposition of the Islesboro formation may or may not have continued into the period of deposition of the Pondicherry formation.

The granite is plainly intrusive in the volcanics, and the relations are well shown in many places. The Barn Island group, near Bucks Harbor, the granite boundary cuts directly across the strike of the volcanics. On the north shore of Eggemoggin Reach, one-half mile west of Bucks Harbor, the volcanics are cut by a large number of linear, filling, and intersecting granite dikes 8 inches to 2 feet in width. In general the contact metamorphic effect of the granite are not noticeable to the eye.

**Petrography—**The rocks making up the Castine formation are most, on extrusive rocks, to include pyroxene, diopside, and hornblende, which are usually the predominant petrographic variety and in some cases the only one. These varieties are present in the Connemara and the Castine volcanics. The Connemara and the Castine are shown to be contemporaneous both with the Castine volcanics and with the Islesboro formation. Some portion of the two latter formations must therefore be contemporaneous. The term "contact granite" is here used to include a variety of rocks which show evidence of a long period of diagenetic and metamorphic alteration. These rocks may be divided into three main groups on the basis of mineral and texture:

1. **Contact granite:**
   - Location: North of Cape Kooper, South of Islesboro.
   - Characteristics: Contains abundant phenocrysts of hornblende and biotite. The matrix is usually fine-grained and may contain abundant quartz and feldspar phenocrysts. The rock is often foliated and may show evidence of foliation.

2. **Contact porphyry:**
   - Location: South of Islesboro, near the northwestern shore of the island of North Islesboro.
   - Characteristics: Contains abundant phenocrysts of hornblende and biotite. The matrix is usually fine-grained and may contain abundant quartz and feldspar phenocrysts. The rock is often foliated and may show evidence of foliation.

3. **Contact gneiss:**
   - Location: South of Islesboro, near the northwestern shore of the island of North Islesboro.
   - Characteristics: Contains abundant phenocrysts of hornblende and biotite. The matrix is usually fine-grained and may contain abundant quartz and feldspar phenocrysts. The rock is often foliated and may show evidence of foliation.

The contact porphyry is a fine-grained rock with abundant hornblende and biotite phenocrysts. The matrix is usually fine-grained and may contain abundant quartz and feldspar phenocrysts. The rock is often foliated and may show evidence of foliation.

**Petrography—**Diabase: These rocks are the most important in the northwesterly trend. They are coarse-grained, porphyritic rocks with large phenocrysts of plagioclase feldspar and groundmass of fine-grained, dark-green amphibole. The diabase is in contact with the Castine volcanics on the northwestern shore of the island of North Islesboro.

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The specimens are described on p. 291 of the 1931 volume of the American Journal of Science, Vol. 200, pt. 1, pp. 317-337. This volume is available on the USGS Geoscience California portal.
formation with about the same strike and dip. The lack of any marked unconformity is considered as showing that the volcanic outbreaks filled the deposition of the underlying and older formations. In the southwestern parts of the area, especially near the village of Isle au Haut, the volcanic rocks extend for about a mile from the moorlands and hills of the village, as well as eastward from Eggemoggin Reach to Deer Isle Bay. The southernmost of the Hay Islands, the isle au Haut, and the area of Thorofare andesite. Extremely good exposures are afforded by Perry and Crockett coves. On Isle au Haut the flow structure is not recognizable on the weathered surfaces, but can be seen microscopically in thin section. Among them both lavas and andesitic lavas are included with those of the acidic glass. One occurrence has resulted from the alteration of rocks composed largely of olivine and pyroxene or of olivine and amphibole. The Permo-Carboniferous rocks are partially described between the locales of the Thorofare andesite. Small serpentine dikes were found at South Brooksville on the grounds back of Gray's Nunnery. The Devonian volcanics. Small serpentine dikes were found at South Brooksville on the grounds back of Gray's Nunnery. The Devonian volcanics. Small serpentine dikes were found at South Brooksville on the grounds back of Gray's Nunnery. The Devonian volcanics. Small serpentine dikes were found at South Brooksville on the grounds back of Gray's Nunnery. The Devonian volcanics. Small serpentine dikes were found at South Brooksville on the grounds back of Gray's Nunnery. The Devonian volcanics. Small serpentine dikes were found at South Brooksville on the grounds back of Gray's Nunnery. The Devonian volcanics. Small serpentine dikes were found at South Brooksville on the grounds back of Gray's Nunnery. The Devonian volcanics. Small serpentine dikes were found at South Brooksville on the grounds back of Gray's Nunnery. The Devonian volcanics. Small serpentine dikes were found at South Brooksville on the grounds back of Gray's Nunnery. The Devonian volcanics. Small serpentine dikes were found at South Brooksville on the grounds back of Gray's Nunnery.
The old quarry on the northeast shore of Deer Isle has been described very fully (Merrill, op. cit.). It is referred to as the Deer Island stock. The granite of this area is a large part of the rock; it may itself be serpentine after alteration. The granite, serpentine, and hornblende are all present together, and the contact appears to be a metasomatic zone which has been filled with a mixture of these minerals. The serpentine is described as a medium-grained variety. The granite near the contact is a coarse pink granite with porphyritic texture, but farther on it becomes finer grained and more variable in composition. For these reasons an abrupt change in the nature of the rock occurs near the boundary of the granite and the接触 area.

Over the northeastern, eastern, and southern parts of the area the granite is moderately coarse and porphyritic. The feldspar is abundant, occupying about one-fourth to one-half inch in diameter and occurring in the form of blebs and clusters. The rock is a coarse pink granite with porphyritic texture, but farther on it becomes finer grained and more variable in composition. For these reasons an abrupt change in the nature of the rock occurs near the boundary of the granite and the接触 area.

The serpentine intrusion is described as a secondary enlargement in pyroxene. The granite area extends from Bluehill to South Brooksville, some of the most important quarries of this area being near the contact of the granite with the Castine volcanics. The granite of this area is a coarse pink granite with porphyritic texture, but farther on it becomes finer grained and more variable in composition. For these reasons an abrupt change in the nature of the rock occurs near the boundary of the granite and the接触 area.

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The granite from the quarry near Blushill may be taken as typical of the whole southern and eastern parts of the Blushill-Toddney Pond granite belt. It is light gray on fresh surfaces, but becomes pale pink on weathering. The largest crystals or grains are those of biotite; a few measure one-fourth of an inch in length and a few of which show Carlsbad twinning. Gray quartz occurs almost as frequently, but occurs much more rarely. The grains, feldspar, and accessory minerals are arrayed along a cleavage which is parallel to the platy [material not legible]. The rock contains several distinct minerals, of which the biotite, quartz, feldspar, and accessory minerals are the most abundant. The biotite is the most abundant, occurring in plates which are several feet in length and a few inches in width. The quartz occurs in large crystals which are usually several inches in length and a few inches in width. The feldspar is composed of orthoclase and microcline, which are coarsely crystallized.

The granite near the pond south of Seal Cove in the Castine volcanics is one of the rocks associated with the Blushill-Toddney Pond granite belt. It is a coarse-grained, pink granite, and is characterized by a coarser texture than the Blushill-Toddney Pond granite. The rock is composed of quartz, feldspar, and biotite, and contains small amounts of hornblende.

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idiomorphic plates. Hornblende occurs in both massive and important of the femic constituents and much of it occurs in contact, but no similar changes in the diorite were into granite and on the other hand into diorite, in the gabbro. In this part of the quadrangle dikes of diorite or gabbros cutting the granite were nowhere observed. In a number of localities the granite becomes finer grained next to the diorite contact, but no similar changes in the diorite were noticed. The presence here and there within the peripheral zone of small bodies of igneous or fine grained, composed of alternate bands of diorite and granite, and showing a general tendency to form into the main body of granite.

These relations show that the basic rocks, although in the main slightly older than the granite, and in a few places younger or exactly contemporaneous, have followed by and large the general period of igneous intrusion. As suggested by the general form of the basic zone in the South Penobscot area the presence of a notable amount of hornblende in the peripheral differentiation from the same magma from which the intrusion of the central granitic mass. Like the granite, which immediately followed into the main body of granite.

Geologic study does not reveal in this region any well-defined structural features of the larger kind, such as synclines, synclines, large monoclinal folds, faulted blocks, etc., but the very considerable areal extent of some of the sedimentary and offish volcanic formations whose thicknesses are moderate indicate that in a broad way those formations exist in the region. Minor structural features, antiforms and synforms, can be observed in the various bodies, and of the character of these structures differs somewhat with the kind and relative age of the formation. In the general region of the offshore islands there are developed a very perfect sehistosity. As in the oldest and is overlain by the Coombs limestone also in the dikes, sills, and flows.

In one of the most striking features of the Penobscot Bay region is the large number of small dikes, dark green to nearly black in color, which cut every kind of the structure. They appear in general to be about equally abundant in all parts of the region, though most numerous along the coast. No extensive areas are recognized in their form, but a few isolated bodies, and even patches of altered diabase, are present. The rock type generally represented. Although averaging only about 2 to 3 feet in width, the dikes in places do become quite thick, as one can reach 30 feet or more, as in the eastern shore of Little Deer Island, just east of Eggemoggin, where a vertical dike has a width of 30 feet.

In spite of their prevailing lithologic similarity, their relations to the other rocks of the region show that they are not all of the same age. In many localities there are diabase dikes which have been deformed in the regional metamorphism, and in some places have been run out. The most striking examples of deformed dikes are found in a short distance west of the Penobscot Bay quiltangle, in the limestone quarries near Rockland, where dikes of diabase have been faulted and in some places "pinned out" in the close folding of the limestone. None of the diabase dikes are closely associated with the granite and gabbros of the granite border are, like the granite, of probable Devonian age, while the dikes which traverse the Quabbin Rocks are of Devonian, or later. The freshwater of the smaller size rocks would suggest that they are associated with the older rocks, and, with some of them, they might with considerable probability be correlated with the Triassic rocks of Nova Scotia and southwestern New England.
again restored and very extensive deposits were laid down, which are now represented by the Penobscot slate, the most widely distributed and the thickest formation of the region. The deposition of these sandstones was probably from the Amox Knob limestones, and at the same time it initiated the deposition of the coarsely crystalline argillaceous sandstones that are found by the Coombs limestone, tuffs, and breccias termed the Thomaston end. 

It may be possible to attempt to picture the nature of the volcanics that characterized this area in Niagara time, the position of the volcanic center should be determined, and it would be of interest to know whether the lavas were ever forced through the bed of the ocean bottom from which it is probable that the region of Thomaston volcanics described above is not more than a fragment of the original area, and that through the processes of erosion, many times repeated, the greater part of the country has been cut away. In the study of this small area no definite comparisons of the relative thicknesses of the volcanic series can be made, as would be the case in the position of the volcanic center. The breccias so prominent among the Thomaston rocks are somewhat agglomeritic in character, but their distribution is too general to indicate accumulation within a crater. Topographic Afumax Knob is suggestive of an old volcanic cone, but the relations of the rocks there cannot be justified in this way. But the evidence obtained in the study of these old volcanics does not warrant any such conclusion.

The occurrence of the Pleasant Point lavas at various horizons within this limestone is also described. The sediments in the area were laid down in the vicinity of Castine, Cape Rosier peninsula, and the Rockport the whole region was affected by the same. The volcanoes from which the North Haven lavas came were some distance away. Volcanic dust and ash from these craters falling into the sea or washed down by streams became widely distributed over the land area and other islands. The siltstones that are so characteristic of the conglomerate. 

... studies of the characters. In the descriptive portion of this text the terms are applied as though the structures developed in them, have been described. So far as the rocks are concerned, the geologic record is so meager that the characters of the rocks cannot be more faithfully interpreted, since the glacial and alluvial deposits with their characteristic topography remain relatively unmodified. 

The oldest rock in the Penobscot Bay region is the Ellsworth schist, which represents sediments probably of Cambrian or even pre-Cambrian age. The deposition of these basement sediments was followed by dynamic action sufficient at least to inaugurate the changes of innersand into a crystalline solid. This upwelling is believed to have been before the deposition of the next younger depositional formation, indicating a considerable period of time between the deposition of the Coombs limestones, for the overlying quartzites and slates contain no trace of volcanism before that time. While the extrusion of basic volcanic material was going on in the neighborhood of North Haven, rhyolitic and andesitic material was being extruded from centers lying farther to the north, probably in the vicinity of Castine, Cutler, Pine Point, and Little Deer Isle. Here also erosion has destroyed all trace of the original lavas, but they are probably within or near the area where these rocks now occur. 

DYNAMIC ACTIVITY. 

After these volcanic eruptions and the deposition of the Penobscot shale and the thick bed of limestone which occur on the mainland near Rockland and Rockport the whole region was affected by severe dynamic metamorphosis. The trend of the folds indicates that the thrust which produced them was directed nearly at right angles to the trend of the present coast line; presumably it came from the southeast. While the extrusion of basaltic material was going on in the vicinity of Ellsworth, the North Haven greenstone was extruded from the28 center, which had already been crystallized. 

The flow breccias that have been described may be considered as having their origin in the mingling of debris from different masses of extrusive and intrusive rocks. Some of these breccias are composed of less angular fragments, and more varieties of lava are represented within a given mass. The breccias in this small area no definite comparisons of the relative thicknesses of the igneous series can be made, and the beds of the volcanic center. The breccias so prominent among the Thomaston rocks are somewhat agglomeritic in character, but their distribution is too general to indicate accumulation within a crater. Topographic Afumax Knob is suggestive of an old volcanic cone, but the relations of the rocks there cannot be justified in this way. 

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From this submerged position the land rose to nearly its present elevation, some stages of the uplifting being receded in the marine terraces which are now separated by cliff or dune. The uppermost terraces are well developed at nearly all parts of the coast, but the upper ones are developed within the vicinity of the north end of Goose Island. At this locality terraces occur at elevations of approximately 50, 60, 30, and 27 feet above the present mean tide. The upper two are very narrow, the 50-foot level broader, and the 60-foot level the broadest of all. On Cape Jellison, in the vicinity of this block of land, in place is not by a multitude of minute veins of celestite. In lithologic character and mode of occurrence have already been described in the section on descriptive geology. The serpentine was mined into slabs for window¬

Since the considerations outlined above, it is apparent that the land has not stood at its present elevation for a very long time, although the present periods of relative stability have been of long duration. The uniformity of the rock’s elevation is not fully expressed by the more statement of actual elevation. It is necessary to add that labor was required to bring each terrace over 200 feet above the present sea level, and that the terrace was probably developed after the ice had completely withdrawn from the region. (6) uplift. During which wave-cut and wave-built terraces were defined and most widely developed terrace has an elevation of 20 to 25 feet above the present sea level. Of the total Maine output nearly one-third is available stone covering many times that area. The granite is available for commercial use. The granite is graded nearly 2 miles southwest of Bluehill village. At Limkiln Landing, on the northeastern shore of the island, an area about 300 feet in diameter has been cut and for twenty-five to fifty years, the present conditions favor continued production without increase in output. The largest part of the equipment of these quarries, therefore, is devoted to the finishing of the product rather than to the quarrying of the material and limestone. On Crow Island the Ryan-Parker Construction Company operates a large quarry with extensive dressing sheds, full steam and pneumatic equipment, and a railway running to the two docks and through the entire length of the quarry. John S. Goss has a well-equipped quarry adjoining the Ryan-Parker quarry, and also one on Maine Island, on the opposite side of Deer Island Thorofare. The topographic features of the granite coast of this region are such as to facilitate quarrying operations. The granite is not so large as to make separation of the different types of granite possible. The general distribution of the granite is described in the section on descriptive geology. The most important belt, economically, extends from the south of an area in which there are numerous large and composed of small pebbles some of which are throughly wellewatered, while others possess a gravelly state and thus prove the bar to have been of postglacial origin.

The Penobscot Bay region the best defined and most widely developed terrace has an elevation of 20 to 25 feet above the present sea level. In general the terrace is built of terraces, whose materials are marine clays and sands; only in a few of the more exposed positions have wave-cut terraces been developed. The history recorded by the facts outlined above may be summarized as follows: (1) On the withdrawal of the ice from the immediate vicinity of the coast, for a short period, as much as 350 to 250 feet above its present level; (2) During which the sea was still far removed from the coast, and was contributing to the sea large amounts of sands and clays; (3) During which the sea was once again far removed from the coast, and was contributing to the sea large amounts of sands and clays; (4) During which the sea was once again far removed from the coast, and was contributing to the sea large amounts of sands and clays; (5) During which the sea was once again far removed from the coast, and was contributing to the sea large amounts of sands and clays; (6) During which the sea was once again far removed from the coast, and was contributing to the sea large amounts of sands and clays; (7) During which the sea was once again far removed from the coast, and was contributing to the sea large amounts of sands and clays; 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described. Within the area of the Penobscot Bay quadrangle they are at present utilized in the manufacture of common brick at South Penobscot, Penobscot, and West Penobscot, though in the past they have been worked at a number of other localities. The towns of South Penobscot, Penobscot, and West Penobscot, which are the largest in the quadrangle, shingle them and about 20 feet thick. The total output of common brick for the quadrangle in 1900 was valued at $11,902. At all these of the clay is worked by the soft-mud process and burned in old-fashioned stone kilns, the product being a bright-red brick of good quality and appearance. Shipments are made mainly to Boston and vicinity, though a part of the product goes to other coast towns.

Several small works for the manufacture of common brick are located along the west shore of Penobscot River just south of the town of Bangor and farther down the coast at Thomaston, Damariscotta, and other points. In the absence of analyses of clays from the Penobscot Bay quadrangle, the following from the adjacent Rockland quadrangle are inserted.

### Analyses of clays from Rockland quadrangle, Maine.

<table>
<thead>
<tr>
<th>Clay</th>
<th>Alumina (A₁₂O₃)</th>
<th>Magnesium carbonate</th>
<th>Magnesium silicate</th>
<th>Ferric iron (Fe₂O₃)</th>
<th>Iron (FeO)</th>
<th>Silica (SiO₂)</th>
<th>Potash (K₂O)</th>
<th>Soda (Na₂O)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica (SiO₂)</td>
<td>1.45</td>
<td>5755</td>
<td>9.90</td>
<td>99.97</td>
<td>101.11</td>
<td>97.28</td>
<td>6.49</td>
<td>10.85</td>
</tr>
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<td>Soda (Na₂O)</td>
<td>101.11</td>
<td>99.97</td>
<td>101.11</td>
<td>97.28</td>
<td>6.49</td>
<td>10.85</td>
<td>1.45</td>
<td>5755</td>
</tr>
<tr>
<td>Carbon dioxide (CO₂)</td>
<td>43.00</td>
<td>61.59</td>
<td>9.90</td>
<td>99.97</td>
<td>101.11</td>
<td>97.28</td>
<td>6.49</td>
<td>10.85</td>
</tr>
</tbody>
</table>

*1 The analyses for ferrous oxides are on a qualitative basis and the amount is reported as ferrous oxide.*

The village of Castine is furnished with water for domestic uses on the farms, is obtained from a small spring located near North Bluehill and is owned by the Penobscot Mining and Manufacturing Company. The flow of this spring averages about 6 gallons per minute. Analysis of spring water from North Bluehill, Me.

<table>
<thead>
<tr>
<th>Chlorides and carbonates</th>
<th>Magnesium carbonates</th>
<th>Magnesium silicates</th>
<th>Ferric iron (Fe₂O₃)</th>
<th>Iron (FeO)</th>
<th>Silica (SiO₂)</th>
<th>Potassium chloride</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.62</td>
<td>8.62</td>
<td>20.56</td>
<td>1.11</td>
<td>1.11</td>
<td>1.11</td>
<td>1.11</td>
</tr>
</tbody>
</table>

There is a growing trend in this region to use the outcrop of the sandstone for gravel work and a large number of wells have been drilled to various depths down to 65 feet. These are mostly located at elevations of less than 100 feet and their yield varies greatly; some are most satisfactory and a few are failures. From most of them the supply can be obtained only by pumping, though the water usually rises in the well above the level at which it is first struck. A single well enclosed by a concrete casing 217 feet deep and 4 inches in diameter sunk to depths of 50 to 150 feet the water rises within 10 to 20 feet of the surface, even during the dry season, and 3 to 5 gallons per minute is obtained by pumping. In the well of the Fishe Rock Water Company, sunk to a depth of 300 feet, a flow of 20 gallons per minute is reported. The depth at which the principal flow is obtained varies from 12 to 180 feet. The fact that in almost all wells drilled in gravel the water is under a pressure which is proportionate to the depth occurs in the well hole when struck proves that there are masses of the gravel which are proportionately impervious to the flow. Water sprung from closely jointed and nearly impervious fractures may be collected by artificial means, but the wells yield 40,000 gallons daily. A fourth well, 575 feet deep, not new used, is located at a elevation of 200 feet and 30 feet of 28 gallons per minute are obtained by pumping. The water level in this well is only 27 feet below the surface—that is, it is 100 feet above and 50 feet below the water level in the three wells previously mentioned.

In general the distribution of fractures in the rocks in this quadrangle is such that a few full- sized among deep wells may be expected, since the water circulation is confined mainly to certain trunk channels rather than equally distributed through the water-bearing zone, but the percentage of failures should be very small if some judgment is used in the selection of the location for drilling. In most places an abundant flow may be expected at a depth of less than 100 feet, but in some localities the drill may reach a depth of 300 to 400 feet before water is encountered in good quality. In general, the water yield from wells is the highest where the bedrock is in the water table; but where wells are drilled close to the surface, especially in a highly fractured region, are liable to some inflow of salt water. The water table falls 20 feet on about 100 feet of drift, and a steady supply of 1 to 3 gallons per minute is obtained by pumping. In the drilled wells the water rises from 10 to 30 feet of the surface and supplies of 4 to 20 gallons per minute are obtained by pumping. In the drilled wells the water rises from 10 to 30 feet of the surface and supplies of 4 to 20 gallons per minute are obtained by pumping. In the villages the rocks are folded dolostone, shistose, and mica schist. The depth of the drilled wells varies from 40 to 200 feet, and the principal flow being obtained at depths of 30 to 200 feet. In wells the water rises within 15 feet of the surface and supplies of 1 to 20 gallons per minute are obtained by pumping. The water level in this well is only 27 feet below the surface—that is, it is 100 feet above and 50 feet below the water level in the three wells previously mentioned.