1930

# First Annual Report on the Geology of the State of Maine

Lucius H. Merrill

Edward H. Perkins

# FIRST ANNUAL REPORT

on the

# GEOLOGY

of the

# STATE OF MAINE

*By*

LUCIUS H. MERRILL
State Geologist

and

EDWARD H. PERKINS
Assistant Geologist

AUGUSTA
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STATE OF MAINE
IN THE YEAR OF OUR LORD ONE THOUSAND
NINE HUNDRED AND TWENTY-NINE

An ACT Relating to a State Geologist

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Be it enacted by the People of the State of Maine, as follows:

Sec. 1. The governor shall appoint a state geologist to serve for a term of two years.

Sec. 2. The duties of the state geologist shall be to investigate the mineral resources of the State of Maine, developed and undeveloped; to promote and direct research in the possibilities for the commercial development of mineral deposits; to collect and compile data on Maine geology, including mineral specimens; to assist any department of the state which shall request his assistance; to recommend legislation suitable for stimulating the business of mining; and to do such other things as may be necessary in the proper performance of the foregoing duties.

Sec. 3. All data and information secured by the state geologist in examination of any mineral deposit or geological formation shall be disclosed forthwith to the owner of the land examined, together with information and recommendations regarding the possibilities for commercial development, with special reference to Maine persons and enterprises interested, and such information shall not be given by the state gqelogist to any other person during one week following the disclosure to the owner of the land.

Sec. 4. The state geologist shall report annually to the governor and council regarding his activities for the preceding year. The report shall contain a description of all lands and properties examined, with particular reference to the possibilities for proper development and the problems of operation, including the name and address of the owner, distance from improved roads, distance from railroad shipping points; also specific recommendations for action by the legislature to encourage search for and development of, mineral deposits; and such other data as may appear to have practical value. The report shall be printed and sent free to owners of lands described therein, to all known operators of mines and quarries within the state, to all departments of state, and to members of the legislature; also to all public libraries and to high schools, academies and colleges within the state; and to any other persons upon payment of a reasonable charge covering the cost of the report.

Sec. 5. The state geologist may establish his headquarters at the University of Maine. The trustees of the University of Maine may employ the state geologist as a member of the faculty and assign to him duties connected with teaching and educational research in geology and kindred subjects.

Sec. 6. For the purposes of this act there is hereby appropriated the sum of two thousand dollars for the fiscal year ending June thirty, nineteen hundred and thirty, and the sum of two thousand dollars for the fiscal year ending June thirty, nineteen hundred and thirty-one. This money shall be held in the state treasury at the disposal of the state geologist for such purposes as the governor and council may approve.

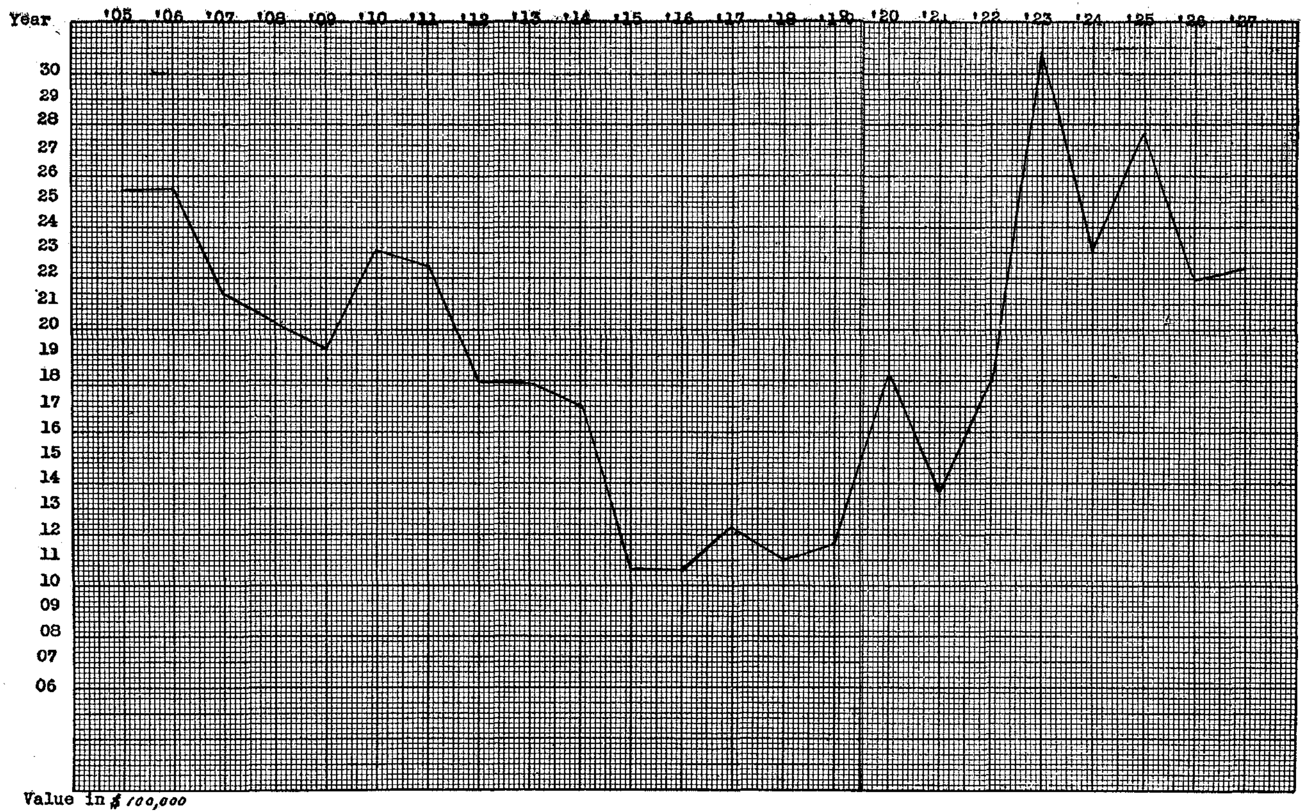
# INTRODUCTION

*To the Governor and Council:*

In accordance with the provisions of the act relating to a state geologist and following the appointment of a geologist by the Governor, work was begun as soon as conditions permitted. Samples of rocks and minerals were received for analysis and identification. The number rapidly increased and it quickly became evident that the unaided geologist would soon be unable to comply with the requests received with desirable promptness. To expedite matters, permission was obtained to secure an assistant, with the understanding that the expense to the State would not be increased thereby. The services of Dr. Edward H. Perkins of Colby College were secured, and with his assistance much was accomplished that otherwise would have been seriously delayed.

Respectfully submitted,

LUCIUS H. MERRILL




Curve showing value of granite produced from 1905 to 1927 inclusive

## MAINE GRANITES

The granites of Maine are widely known for their strength, durability and color, the latter varying from very light to dark gray and from pink to red. It is found in inexhaustible amounts, especially in the southern half of the State. Many quarries have been opened along the coast, thus permitting shipment by water. The importance of the granite quarrying industry to the State may be seen by a study of the figures published each year by the United States Geological Survey.

Value of the granite and related igneous rocks produced in Maine in the years 1905 to 1927 inclusive, including those used for building and ornamental purposes, rough and dressed, those employed in paving, and for curbing and flagging.

| *Year* | *Value* |
|---|---|
| 1905 | 2,555,400 |
| 1906 | 2,560,021 |
| 1907 | 2,146,420 |
| 1908 | 2,027,508 |
| 1909 | 1,939,524 |
| 1910 | 2,315,730 |
| 1911 | 2,257,034 |
| 1912 | 1,803,679 |
| 1913 | 1,790,279 |
| 1914 | 1,717,110 |
| 1915 | 1,062,283 |
| 1916 | 1,068,485 |
| 1917 | 1,237,647 |
| 1918 | 1,211,743 |
| 1919 | 1,274,474 |
| 1920 | 1,824,651 |
| 1921 | 1,386,660 |
| 1922 | 1,805,473 |
| 1923 | 3,059,608 |
| 1924 | 2,311,686 |
| 1925 | 2,774,707 |
| 1926 | 2,204,030 |
| 1927 | 2,242,262 |

The variations in value are more strikingly shown by the diagram facing page 5. They may be due to changes in the price of the stone per ton, or to the amount of the stone sold. The marked reduction in value for the period of 1912 to 1922 may perhaps be attributed in part to one or more of the following causes:

1. The increasing use of Portland cement in place of stone.
2. The discovery of granite near the localities where it is to be used, thus reducing the expense of transportation.
3. The substitution of Indiana oolite for granite. This is especially noticeable in the government buildings at Washington.
4. The depression in building during and following the recent war.
5. The possible overproduction of Maine granite, and a consequent reduction in price. There were 92 granite quarries in operation in Maine in 1905. The number is probably much smaller today.

## LITHGOW HILL GRANITE QUARRIES. HALLOWELL, MAINE

**Location**

Upper part of Lithgow Hill, 2½ miles northwest of Hallowell.

**Owners**

Hallowell Granite Works, Hallowell, Maine. Information was obtained from the Superintendent, Mr. L. E. Longfellow.

**Quarries**

a. Tayntor Quarry. Abandoned for years.

b. Longfellow Quarry. Now connected with the Stinchfield Quarry. It is not being used at the present time, but is filled with water which is used for cooling.

c. Stinchfield Quarry. This quarry is kept pumped out and is worked as contracts warrant. All these quarries are described in Bulletin 738, U. S. G. S. pages 233-236.

**Present Conditions**

None of these quarries have been working in 1929. The cutters expected a very good season, but it did not develop. A contract for the Arlington Memorial Bridge in Washington, D. C., was finished in the spring of 1929. At the present time only crushed granite is being taken out for use in Augusta and Gardiner. At times finishing work is done on stone brought in from other quarries. Granite from Vinal Haven, Stonington, and Jonesboro was piled around the finishing shed.

The reason for the lack of contracts was said to be the use of reinforced cement and the fact that the granite business was moving south. No contracts were in view.

**Geological Relations**

The rock, which is a muscovite-biotite granite, is described in Bulletin 738, pages 235-236. The chief imperfections are segregations of biotite which occur as irregular masses or in bands drawn out during flowage.

Sheet structure is well developed and as in most granite bodies the partings get farther apart as one goes down into the rock mass. A study of the quarries and the outcrops about Lithgow Hill show that the sheeting dips away from the center of the hill on all sides of the granite body. This would indicate that the hill is composed of a stock of granite whose form resembled that of the present surface. A similar but larger body of the small granite, which is not shown on any published map, occurs east of the Kennebec River. The valley of this river in which Augusta and Hallowell are located follows a band of biotite schist between the two stocks of granite.

There is some evidence of multiple intrusion associated with the Lithgow Hill body. A coarse muscovite granite cuts the finer biotite-muscovite granite in places and a tourmaline granite is found along the southern margin in Farmingdale. All of these bodies are cut by small dikes of pegmatite.

Unlike most of the Maine granites, the Hallowell granite shows an indistinct foliation parallel to the major structure of the region; i. e., northeast-southwest. This may be due to flowage at time of intrusion or to compression after intrusion. The presence of well developed slickensides in the quarry indicates some compression.

The age of the intrusion is very uncertain. It cuts gneisses and schists which may be of Precambrian age. Probably it should be placed in the period of Devonian intrusion when so many of our New England granites were formed.

Visited August 13, 1929

By Edward H. Perkins

## OAK HILL QUARRY. SWANVILLE, MAINE

**Location**

South side of Oak Hill, Swanville, six miles northwest of Belfast.

**Owners**

Oak Hill Granite Company, Belfast, Maine.

Information was obtained from the manager, Edwin Mollison.

**History and Present Condition**

The quarry was opened about 1872 and was worked more or less until about 1899 when it was closed. It was used for paving blocks and monumental stone.

The present owners started work in 1926 to obtain paving blocks for New York City. About $300,000 worth of business has been done since opening. The amount of business rises and falls with the amount of paving in New York. In 1928 about 100 men were employed, but this summer only about 40 are at work. If more paving is done the number will be increased.

The blocks are cut at the quarry in the open air and are shipped by truck to Belfast and by boat to New York. The blocks are set in a base of sand and concrete and the joints filled with asphalt.

The equipment at the quarry consists of two derricks, a cable way, and two compressors.

In the near future it is expected that some large blocks will be taken out for monumental work.

**Geological Relations**

The rock is an extremely uniform fine-grained biotite granite. It has been described in U. S. G. S. Bulletin 738, page 261. Aside from the "sap" along some of the joints the rock is remarkably free from imperfections. The fine even grain makes possible the splitting into even close-fitting blocks.

The sheet structure is well developed. The sheets range in thickness from less than a foot at the surface to 8½ feet at the bottom of the quarry. The monumental stone is to be taken from these large sheets while the paving blocks come from the thinner material at the top. Like most of our granite hills the sheets dip out on all sides parallel to the surface.

The rock in the bottom of the quarry appears to be under considerable pressure and the removal of the upper sheets has resulted in thrust faulting on a small scale. These faults with their accompanying slice faults are miniature copies of the great thrust faults of the west.

The Oak Hill granite is intruded into the metamorphic Cambrian and Precambrian Penobscot formation. It is probably one of the numerous Devonian intrusions of New England.

Visited August 10, 1929
By EDWARD H. PERKINS

## DODLIN HILL QUARRIES. NORRIDGEWOCK, MAINE

### Location

Dodlin Hill. About 2½ miles south of Norridgewock village.

### Quarries

a. **Dodlin Quarry.** East side of hill near the base. Disused for many years. For description see U. S. G. S. Bulletin 738, pages 255-256.

b. **Marble Quarry.** This is the "Lawton Quarry" of Bulletin 738, pages 256-257.

Owned by B. C. Marble, Skowhegan, Maine, who would probably give information as to the history and business conditions. The foreman seems to have very little information.

The quarry has been operated for the last few years for monumental and building stone. It was not opened, however, in the spring of 1929 on account of lack of contracts. About six men are working in the cutting shed at Norridgewock village on stone for a school building in Old Town, Maine. According to the foreman business is very dull.

### Geological Relations

The rock is a light gray granite which may be classed as a quartz monzonite. Nothing can be added to the description in Bulletin 738.

The hill is part of a mass of granite which underlies most of the region between Norridgewock and the Belgrade Lakes. This mass in turn seems to be an offshoot of a still larger batholith between the Belgrade Lakes and Farmington; the

Vienna Batholith. The sheet structure in the quarries and in the outcrops about Dodlin Hill is roughly parallel to the present surface. As sheet structure appears to form parallel to the original surface of the granite it is probable that the surface of the intrusion and the present surface roughly coincide and Dodlin Hill and the similar hills about it represent upward projecting bosses from the main mass below.

The granite of Dodlin Hill shows at least three periods of intrusion. The first intrusion cooled rapidly and is a moderately fine grained rock. The second intrusion probably arrived when the first rock was still warm and so cooled more slowly, forming the coarser grained rock which makes up the mass of the hill. A final minor stage gave aplite and pegmatite dikes which filled cracks in the older rocks. These dikes are chiefly quartz and feldspar, but contain small amounts of pyrite, chalcopyrite, and bornite. Small particles of molybdenite have been found in the granite of the lower or Dodlin Quarry.

The granites of this region cut Silurian strata and are therefore of post-Silurian age. Most of the similar granites in New England appear to have been intruded in Devonian times and the Dodlin Hill granites are probably of this age. It is possible, however, that they may have been intruded in late Carboniferous time.

Visited August 13, 1929.
By Edward H. Perkins

## HOULTON GRANITE AND MARBLE WORKS

**Owner**

W. H. Watts, Houlton, Maine.

**Sheds**

Houlton, Maine.

**Quarry**

On west side of Drews Lake, New Limerick. Granite is cut during the summer and hauled over the ice of the lake during the winter.

The rock is a medium grained biotite granite. Joints run east and west, and north and south.

The rock becomes darker and of finer grain as one goes deeper.

Composition of granite compared with that of Barre, Vermont, granite. Figures furnished by W. H. Watts. Analysis was said to have been made at Colby College.

| | *Houlton* *"True Blue"* | *Barre* *"Rock Of Ages"* |
|---|---|---|
| Quartz | 24.4% | 26.4% |
| Feldspar | 69.1 | 65.5 |
| Mica | 6.2 | 7.9 |
| Foreign (?) | 0.3 | 0.2 |

Other quarries of pink and gray granite are owned in Smyrna but are not being operated.

**Present Conditions**

About $20,000 worth of business is being done each year and is said to be increasing about 10% a year. The work is entirely monumental. All the county work is done here and granite is shipped south. At the time of my visit granite was being shipped to Qunicy, Mass.

Visited August 17, 1929
By EDWARD H. PERKINS

## MOUNT WALDO GRANITE QUARRY. FRANKFORT, MAINE

This quarry is in the town of Frankfort, on the north spur of Mount Waldo, one-third of a mile southwest of Frankfort Village, and 660 feet above sea level. It is said to have been opened as long ago as 1837. Work was suspended in 1914 and no stone has been quarried there since that date.

The quality of the stone seems to vary somewhat in different parts of the quarry. It has been described as a biotite granite of medium gray shade and fine, even-grained texture. In places, however, the stone is coarsely porphyritic, the feldspar crystals attaining a diameter of from one-half to one and one-half inches. The ultimate compressive strength varies from 29,183 to 32,635 pounds per square inch. In 1905 the quarry measured 800 feet from north to south, 400 feet from east to west, and from 10 to 30 feet in depth. The rift is horizontal and the grain vertical. The sheets are from one to eight feet in thickness. The granite is under a compressive strain, causing vertical fissures the entire length of the quarry. This fissuring has occurred in the summer time and has been accompanied by an explosive sound. Such fissures are believed by many geologists to be due to the expansion of the granite when exposed to the heated rays of the summer sun.

The granite of this quarry has been widely used for building purposes, especially for government buildings. It was used in the post offices of Milwaukee, Indianapolis, Cleveland and Jersey City. It was used also in the Philadelphia Mint, and the Public Library of St. Louis.

The quarry has recently passed into the hands of the firm of Grenci & Ellis, Inc., of New York City. A railroad is now under construction for the transportation of the stone down the mountain and it is expected that quarrying will begin in the near future.

## ANGELL AND HAGGERTY QUARRY. MOUNT DESERT, MAINE

Operators, Angell and Haggerty Co. 41 Park Row, New York. Pres., H. Haggerty.

The quarry is located in the town of Mount Desert, north of Acadia Mountain, on the west shore of Somes Sound. The stone is of fine grain and of excellent quality. The product is used exclusively for paving stone. An order for over 1,000,000 blocks is being filled, the stone to be delivered by Sept. 1. The proximity of the quarry to the water greatly facilitates shipping.

## FELDSPAR

Feldspar is one of the most important minerals produced in Maine today. The term includes no less than seven or eight varieties, all of which consist of silicates of alumina combined with one or more of the bases potash, soda, or lime. The potash and soda feldspars are the most valuable and are the only ones that require farther mention here.

The importance of feldspar is due to the fact that when the finely ground material is mixed with the proper proportions of pulverized quartz and clay or kaolin and the mixture is subjected to a high temperature, the feldspar, having a lower melting point than the other minerals, assumes a semi-fused condition. On cooling it hardens to a glassy state and the fine particles of quartz and clay or kaolin are firmly cemented together. These qualities admirably adapt it to the manufacture of pottery, an industry now carried on in at least thirty states, but most extensively at East Liverpool, Ohio, and Trenton, N. J.

The potash feldspar, or orthoclase, (or spar, as it is often called) is the most important of the feldspars and fortunately the most abundant. It is a constituent of our common granite, where it is associated with quartz and usually one of the micas, either muscovite or white mica, or with black mica or biotite.

The granites employed for building purposes are usually fine-grained and the mineral components so small that it is practically impossible to effect their separation. Granites, however, are sometimes found with a very coarse grain, allowing an easy and more complete separation of the minerals. Such granites are called pegmatites, and it is from these that the feldspars of Maine are obtained.

In 1926 feldspar was quarried in 17 states. Of these North Carolina was the largest producer, her output making up nearly 44 per cent of the total quantity and 37 per cent of the total value for that year. Maine ranked second, producing about one-third as much as North Carolina, or 16 per cent of the total output of the United States. The annual production for this state is now about 25,000 tons, by far the larger part of which is from the counties of Androscoggin, Cumberland, Oxford, and Sagadahoc. The most productive quarry now in operation in the state is at Topsham, where the spar is mined and prepared for shipment. The quarry and the mill are the property of the Consolidated Feldspar Corporation, N. G. Smith, Vice President. The product, which is of very high grade, is shipped to the large potteries of New Jersey and Ohio. The quarry at Mt. Apatite, Auburn, is under the same management. At present it is not in operation, although it is not abandoned.

## REPORT ON THE FELDSPAR AND TRAP DEPOSITS ON THE LAND OF MISS FLORENCE PUTNAM, HIRAM, MAINE

The locality examined is on the east slope of Mount Cutler at Hiram Station. The examination was made on November 30, 1929, at which time there was considerable ice and snow on the ground. Most of the surface was also covered by a glacial boulder till. For these reasons the exact determination of the structure was impossible.

## Nature of the Rocks

1. **Mica Schist.** The oldest formation is a mica schist which occurs as inclusions in the granite gneiss which makes up most of the mountain. These schist fragments probably represent the old sediments into which the granite was forced.

2. **Granite Gneiss.** The main mass of Mount Cutler seems to be a fine grained muscovite (colorless mica) granite. This has been altered by earth movements until a banded structure has developed. A granite with such a structure is called a gneiss. This structure may have been of importance in determining the location of the pegmatite masses.

3. **Pegmatite.** This is a very coarse-grained rock composed of feldspar, quartz, and muscovite mica. The feldspar is the only mineral of economic importance. It occurs mingled with the quartz and muscovite and also in quartz and mica, free masses ranging from a few inches to several feet in thickness. Several places where blasting has been done were examined. These localities are indicated by numbers on the diagram. (Fig. 1) At locality 1 the feldspar is overlaid by the granite gneiss. Near the contact there is considerable mica and quartz, but downward and away from the granite the feldspar becomes quartz and mica free. At localities 2, 3, and 4 pegmatite is exposed containing large blocks of feldspar but also considerable graphic granite—a mixture of quartz and feldspar. Locality 5 was ice covered so that no close examination could be made. It was said, however, to contain more good feldspar than Locality 1, and from what could be seen through the ice this statement might well be true.

The feldspar appears to be a good grade of potash feldspar (orthoclase or microcline) and to be iron free. There is considerable iron stain on the joint surfaces but this is probably due to the weathering of the mica.

4. **Trap.** The youngest rock exposed is a trap dike running N25E and appearing to have a vertical dip. Its greatest width is about 70 feet. The rock varies from a fine-grained basalt to a coarser diabase. In places the two types of rock

are so mixed as to indicate two periods of intrusion. Under the microscope the trap is a mixture of plagioclase feldspar and hornblende. This should make very good road metal. The dike extends up the mountain as far as examined and is said to continue well to the top.

### Structure

The structure of the granite is indicated by the banding which runs N45W and dips steeply into the mountain (SW). This structure may be of importance in determining the position of the pegmatite. Where the older rock has a distinct structure as at Mount Cutler the pegmatite as it rises from below tends to follow this structure. If this holds true on Mount Cutler the pegmatite should extend in bands parallel to the gneiss (N45W) and dip with it into the mountain. This possible structure is indicated in Fig. 2. Should this be the case the pegmatite should continue to a depth below the surface of the mountain. It should be understood, however, that this inferred structure may not prove to be correct for the following reasons; (a) insufficient observations on the ice and till covered surface, and (b) because of the tendency of pegmatites to be irregular and to depart from the controlling structure.

The structure of the trap is very simple. A major dike runs N25E through the mountain. At the surface it appears as several small dikes separated by slivers of pegmatite. These smaller dikes probably unite into a large dike below as is indicated in Fig. 3.

## CONCLUSIONS

### Feldspar

A large amount of pegmatite is exposed on the east slope of Mount Cutler, containing much high grade potash feldspar. The rock probably occurs in bands parallel to the structure of the surrounding rock (N45E) and dipping to a depth beneath the mountain. Pegmatites are extremely irregular in content. Masses of good feldspar will give place both vertically and horizontally to poor grade mixtures and vice versa. For this reason it is impossible to predict the amount of good feldspar from a surface examination alone. For Mount Cutler it may be said that the surface examination indicates an exceptional amount of good grade feldspar. Whether this increases or decreases in amount below the surface can only be determined by development work. If the deposit should be worked, the ease of transportation is a strong economic point in its favor.

## Trap

Unlike pegmatite trap is uniform in structure and the amount of good material may be estimated by the surface exposures. At Mount Cutler the dike contains a large amount of good road material close to the railway, which will cut down the expense of transportation.

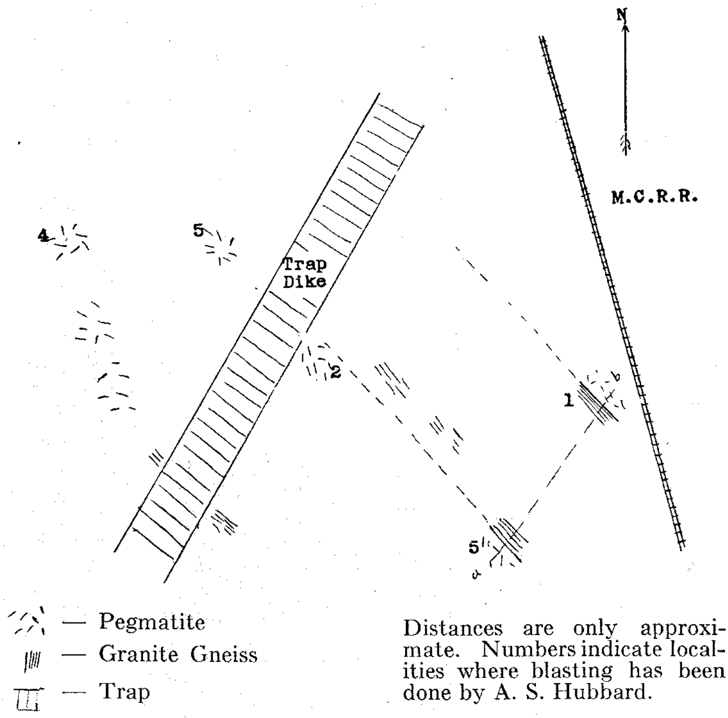
The following quotation from a letter (Dec. 5, 1929) by Professor James W. Goldthwait, Geologist of the New Hampshire Highway Department, has a bearing on the question of the economic value of the trap. "We have rapidly come to the point, in New Hampshire, where we cannot meet the demand for gravel for our own roads, and see no prospect of doing so. . . . . . The solution of our trouble as I see it lies in Maine, where larger supplies are to be expected. The condition as regards trap rock and other suitable stone for construction is almost as bad, and probably to be relieved by commercial developments in Maine."

In this connection it might be pointed out that the Hiram trap dike is on a railway only a short distance from the New Hampshire line.

If a market could be found for the trap it might be well to develop that rock and use part of the income from this to pay for development work on the feldspar. If this is possible the value of the feldspar might be determined at little or no cost to the owners.

Respectfully submitted,

By Edward H. Perkins




— Pegmatite
— Granite Gneiss
— Trap

Distances are only approximate. Numbers indicate localities where blasting has been done by A. S. Hubbard.

Fig. 1. Probable Geological Relations on Mount Cutler, Hiram, Maine.

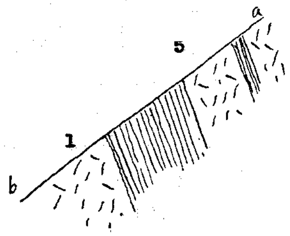



Fig. 2. Section showing possible structure along line a-b, Fig. 1.

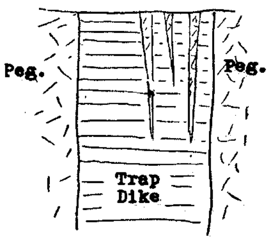



Fig. 3. Probable structure of Trap Dike

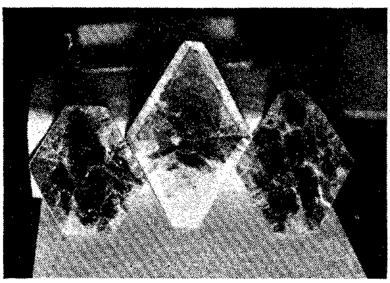
# REPORT ON FELDSPAR QUARRIES VISITED AUG. 21-24, 1929

## NEWRY TOURMALINE MINE

Land owned by International Paper Company.
Mine leased by General Electric Company.
Operated by W. D. Nevell, Andover, Maine.

The mine is in the woods on the top of a hill in the north east corner of Newry. A truck road leaves highway No. 219 about seven miles south of the village of Andover and climbs the 900 feet to the mine in about a mile.

The rock seems to be a replacement of orthoclase-quartz pegmatite in chlorite schist. A second and third replacement has brought in the rare minerals.



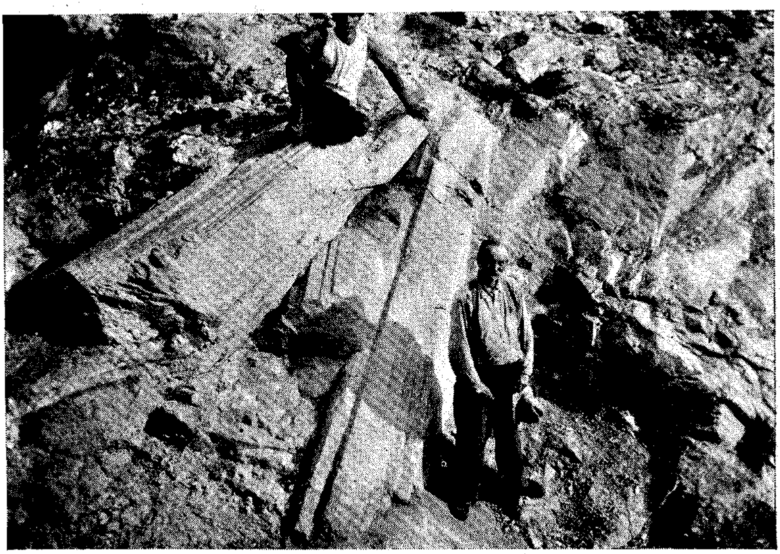
*Courtesy of* S. G. Perham

ZONE MICA
Muscovite with Lepidolite border. Nevel Quarry
Newry, Maine.

The mine was worked for pollucite and spodumene. Work was stopped in August, 1929, when the mineralized body was worked out. Mr. Nevell said that pollucite was obtained "in at least moderate amounts" and spodumene in rather large amounts. He was unwilling to give exact figures but said that the General Electric Company might be willing to do so. The pollucite was taken by the General Electric Company for radio tubes. The spodumene was taken by the Ward Leonard Company, Mount Vernon, N. Y., for the lithium. The mine produced quite a lot of Lepidolite but this was so mixed with Clevelandite that the lithium could not be extracted.

The feldspar in this mine is of good grade but the expense of shipping does not make it worth while to mine for this mineral alone.

A great many rare minerals, especially phosphates, have been found in the Newry Mine. Some of these are new to science and are to be described by the Harvard University Department of Mineralogy. A Mr. W. N. Bailey, of Andover, is to supply me with a complete list of minerals from this locality.



*Courtesy of* S. G. Perham

LARGEST KNOWN CRYSTALS OF BERYL
Bumpus Quarry, Albany, Maine

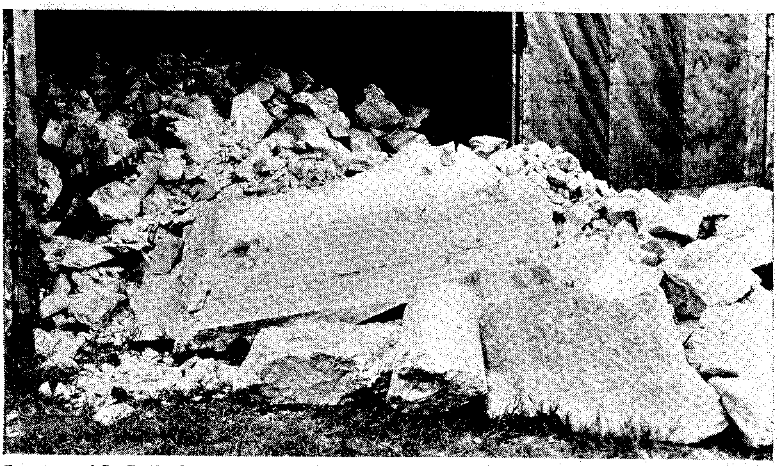
## BUMPUS QUARRY

**Owner.** H. E. Bumpus, Albany, Maine.

**Location.** On road about $1\frac{1}{2}$ miles southwest of Albany townhouse.

The quarry is worked for feldspar which is sold to Harold C. Perham, South Paris, Maine. The feldspar is orthoclase of very high grade. Free from mica and quartz. In fact there is *very* little quartz in quarry. A little scrap muscovite is produced and a small amount of clear quartz has been taken out.

This quarry is remarkable for the beryl crystals. Eight or ten very large crystals are exposed. The four largest measure: 18 ft. x $3\frac{1}{2}$ ft., 13 ft. x 3 ft., 12 ft. x 3 ft., and 10 ft. x $3\frac{1}{3}$ ft. The crystals are ordinary opaque bluish beryl. In addition a little aquamarine and golden beryl has been found. There is no evidence of cleavelandite or other indicators of rare minerals.



*Courtesy of* S. G. Perham

DETACHED CRYSTALS OF BERYL
Bumpus Quarry, Albany, Maine.

## PARIS. MOUNT MICA

This locality has been closed for some years. The old workings have now been leased by the Westernhouse Company. The mine is to be opened soon for pollucite.

## MAINE MINERAL STORE. WEST PARIS

**Owner.** Stanley J. Perham.

This store has been opened to handle the rare minerals from the feldspar quarries connected with the Perhams. The following information was obtained from Stanley J. Perham who runs the store.

The quarries controlled by Harold C. Perham, A. C. Perham, and S. J. Perham are connected with the Trenton Flint and Spar Company, Trenton, N. J. Up to the present time this company has obtained part of its spar from North Carolina but from now on intends to work entirely in Maine. The present price runs about $19 to $20 a ton. A crushed spar war is on but it is expected that this will soon be settled and the price will go up.

The Trenton people are to open a new mill in West Minot to crush rock from the Maine quarries. It is expected that Maine will go back to second place in feldspar production.

Mr. Perham had no exact figures as to the production of the various Maine quarries. He said that the Trenton Flint and Spar Company might be willing to give their Maine production if you wrote them.

## PERHAM FELDSPAR QUARRY. WEST PARIS

**Owner.** Harold C. Perham, South Paris.

**Location.** On high hill about 1½ miles west of West Paris.

This quarry is worked along on east-west dike. Two levels have been worked out and prospecting is going on at a lower level. No feldspar is being taken out at present.

This quarry showed no Cleavelandite or other evidence of the replacement bodies which carry the rare minerals. The feldspar visible was microcline of a low grade.

## BENNETT LEDGE. BUCKFIELD

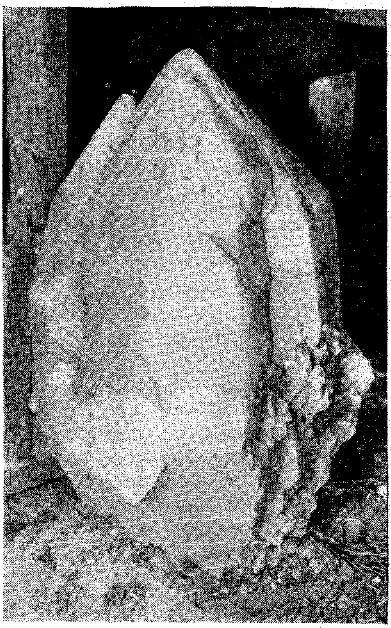
**Location.** About 2½ miles from Buckfield on the road from Buckfield to South Paris.

This mine is not working at the present time. It has in the past produced a great many rare minerals. I included a list as published in the American Mineralogist for July 1927.

A large amount of quartz is on hand. This is to be shipped to the Trenton Flint and Spar Company and the quarry is to be reopened for qaurtz and feldspar. A little caesium beryl has been produced. This is one of the quarries controlled by the Perhams.

## STINCHFIELD QUARRY. WEST MINOT

This quarry has not been operated for some years. It is to be opened soon by the Perham interests and will produce feldspar for the new mill of the Trenton Flint and Spar Company at West Minot.



*Courtesy of* S. G. Perham

GIANT CRYSTAL OF QUARTZ
Three feet high, two and one-half feet across. Bennett Quarry Buckfield, Maine.

## HIBBS LEDGE. HEBRON, MAINE

This quarry is controlled by the Perham interests. At the present time about fifteen men are working getting out feldspar and quartz for the Trenton Flint and Spar Company. The spar is being piled at the quarry and will be crushed at West Minot when the new mill is ready.

Considerable rose quartz has been found this season. A small amount of scrap mica was stored in one of the sheds.

Purple apatite crystals have been found in small amounts. These differ from those found at Mount Apatite in having pointed terminations.

## MAINE FELDSPAR COMPANY'S QUARRY. MOUNT APATITE

This is the largest quarry now working in Maine. Here as elsewhere business is dull and only a small force of men is working. What has been the most productive part of the quarry up till this spring is now flooded. Two new prospects are being developed.

Up till this spring the Maine Feldspar Company bought feldspar from other quarries but at the present time are not in the market for any spar.

The following clipping is from the Waterville Sentinel for September 3, 1929:

The Mr. Apatite mine of the Consolidated Feldspar Co. has been closed and the Feldspar mill here will be closed Oct. 1, it was learned today. The mine employs 23 men, and six at the mill. Reason for the discontinuance was not dis-disclosed nor was any date for resumption of operations.

## KEITH'S QUARRY. MOUNT APATITE

This quarry is now being worked for feldspar by Mr. Keith. About 150 to 200 tons are being quarried a month. Up till this spring the Maine Feldspar Company took the feldspar. After they ceased buying Mr. Keith found a market with the Trenton Flint and Spar Company. Mr. Keith intends to keep on working at about the present rate for some time.

The replacement body which carried the rare minerals was worked out a few years ago. However, a small body of cleve-landite is visible in one part of the quarry and with the coming of cool weather Mr. Keith intends to open this up in the hope of finding gem material or pollucite.

Mr. Keith said that at the present time the feldspar industry was on the decline and was uncertain about it coming back for some time. He said that in time Maine might return to second place but doubted if it would ever go ahead of North Carolina in the feldspar industry.

## DIATOMACEOUS EARTH DEPOSIT
## CORNISH, MAINE

**Location.** Hosac Pond, Cornish, Maine.

**Owners.** L. M. Watkins, Cornish, Maine.
J. H. Stone, Steep Falls, Maine.

Deposit is in a lake bed. The section consists of

| | |
|---|---|
| Peat | 6—8 inches |
| Diatomaceous Earth | 8 inches—1 foot |
| Peat | Depth unknown |

Material is used for polishing powders and heat insulation. Prepared by floating out organic matter.

**Analysis**

| | |
|---|---|
| Silica | 82% |
| Iron and Aluminum Oxides | 9% |
| Calcium Carbonate | 5% |
| Moisture and volatile matter | 4% |
| | 100% |

I understand that another diatomaceous earth deposit is being worked by Devenport and Briggs, Wilton, Maine. I have not visited this.

## COAL

Coal is found and mined in New Brunswick and to a much greater extent in Nova Scotia. These provinces are so closely adjacent to our eastern boundary that it is not strange that hope is occasionally inspired of finding coal beds in eastern Maine, especially in Washington County.

The question was negatively answered twenty-six years ago, but since a repetition of the inquiry is still heard at intervals, it may not be amiss to quote here the results of an examination of the area in question by George Otis Smith and David White of the United States Geological Survey. Their report was published in 1904 in the Professional Paper No. 35, entitled "Geology of the Perry Basin in Eastern Maine." The portion of their report relating to coal is summarized as follows:

1. The strata of the formation, which are exposed in exceptional completeness, bear no evidence of the presence either

of any seam of coal, of whatever thickness, or of any of the usual and more or less characteristic accompaniments of coal seams, such as old soils, Stigmaria clays, leached plant shales, etc., there being no traces of even carbonaceous or black-shale beds or partings. 2. The fossils show that the rocks are of upper Devonian age; i. e., that they were laid down in a period earlier than the deposition of any commercially workable coals yet discovered on any continent. There is, therefore, no basis whatever for the hope of finding usable coal in any of the concealed parts of the Perry formation.

## PETROLEUM AND NATURAL GAS IN MAINE

The belief in Maine petroleum and natural gas appears to be almost as persistent as faith in Maine coal. Inasmuch as the vain search for absent mineral treasure usually entails a loss of both time and money, it may be well to quote farther from Professional Paper No. 35 of the United State Geological Survey, "Geology of the Perry Basin." On page 89 of the publication appears the following assertion: "The assignment of a Devonian age to these rocks may suggest the possibility of finding oil or gas in the Perry area. On this point it need only be stated that the outlook is no more encouraging than that for coal. The occurrence of joints and faults, such as have been described in this report, as well as the presence of interbedded lava flows, are most unfavorable indications, since they preclude the conservation and storage of any liquid or volatile hydrocarbons, even had they originally been present."

## THE MINERALS OF MAINE

Maine seems to be lacking in extensive deposits of those metals which are most essential to man. On the other hand the number of mineral species found in the State is remarkably large. Some of these are without known value. Yet our knowledge of them is still so incomplete that it would be rash to assert that any one of them is useless. For example, the mineral pollucite, discovered in the Isle of Elba, and long believed to be confined to that locality, is now known to occur at several places in Maine. It is the richest known source of caesium, a metal now in such great demand that pollucite is widely sought. Beryl, not an uncommon mineral in the pegmatites, contains beryllium, a metal stronger and lighter than aluminum. These desirable qualities have greatly increased the value of beryl and but little now escapes the watchful eye of the quarryman. A list of the minerals found at any point is therefore of great value. The following list, compiled by Prof. Freeman F. Burr of St. Lawrence University, is in two parts, each arranged alphabetically, the first by the mineral names, and the second by the localities in which the minerals have been found. Such a list can never be complete, but each new discovery should go on record. Whenever the list of minerals found in a certain locality is of unusual length, or the associations are of an unusual character, a list of the minerals found there is sometimes compiled. Such lists have been made for Bennett's feldspar quarry at Buckfield, and for the Newry quarry. These follow the more complete index.

## MINERALS OF MAINE
## INDEX, BY MINERAL NAMES

(Numbers refer to Dana's System, Sixth Edition)

Acmite—326—Phippsburg
Actinolite (see Amphibole)
Adularia (see Orthoclase)
Aegerite (see Acmite)
Albite—316—Albany, Auburn, Buckfield, Greenwood, Hartford, Hebron, Litchfield, Newry, Paris, Rumford, Sanford
Allanite (Orthite)—409—Hurricane Island, Norway, Somerville, Stoneham, Topsham, Vinalhaven
Alum (see Kalinite)
Alunogen—775—Newry, Rumford
Amblygonite—559—Auburn, Buckfield, Greenwood, Hebron, Newry, Paris, Peru, Rumford
Amphibole—338—
- Hornblende—Bethel, Bristol, Brooksville, Deer Isle, Gray, Greene, Machias, Monmouth, Moultonborough, Raymond, St. George, Thomaston, Wayne, Winthrop, York
- Actinolite—Bethel, Brunswick, Freeport, Jay, Monmouth, Portland, Pownal, Rumford, Thomaston, Unity

Pargasite—Bethel, Parsonsfield, Phippsburg
Tremolite—Bethel, Bowdoinham, Raymond, Rockland, Thomaston

Analcite—450—Greenwood (quartz pseudomorphs after), Perry

Andalusite—398—Bangor, Belfast, Bingham, Bucksport, Camden, Carmel, Gorham, Greenville, Harpswell, Monmouth, Moscow, Mt. Abraham, North Berwick, Searsmont, South Berwick, Spaulding, Standish, Union, Washington

Anorthite—320—Phippsburg, Sanford

Apatite—549—Auburn, Bethel, Bluehill, Brunswick, Buckfield, Freeport, Greenwood, Hartford, Hebron, Jay, Litchfield, Livermore, Minot, Monmouth, Newry, Norway, Oxford, Paris, Peru, Pownal, Rumford, St. George, Topsham, Warren, Waterford

Apophyllite—435—Perry

Argentite—42—Sullivan

Arsenic—8—Greenwood

Arsenopyrite—98—Belfast, Bethel, Bluehill, Buckfield, Clinton, Concord, Corinna, Eastport, Eden, Fairfield, Farmington, Franklin, Greenwood, Hebron, Mount Desert, Newfield, Paris, Pembroke, Poland, Rumford, South Thomaston, Sullivan, Thomaston, Topsham, Verona, Winslow

Asbestus (Asbestos) (see Serpentine, Chrysotile)

Augite (see Pyroxene)

Autunite—661—Auburn, Newry, Rumford, Topsham

Axinite—410—Phippsburg, Wales

Azurite—289—Brooksville, Moxie Gore

Barite—719—Bethel, Brunswick, Deer Isle, Sanford, Sullivan, Woodstock

Basanite (see Quartz)

Bertrandite—422—Greenwood, Stoneham

Beryl—344—Albany, Andover, Auburn, Baldwin, Bethel, Bowdoin, Bowdoinham, Brunswick, Buckfield, Canton, East Livermore, Franklin Plantation, Freeport, Fryeburg, Georgetown, Greenwood, Hartford, Hebron, Lovell, Minot, Monmouth, Newry, North Yarmouth, Norway, Oxford, Paris, Peru, Poland, Stoneham, Topsham, Windham, Winslow, Winthrop, York

Beryllonite—546—Newry, Stoneham
Biotite—462—Auburn, Bath, Brunswick, Buckfield, Edgecomb, Hebron, Litchfield, Paris, St. George, Topsham
Bismuth—11—Cooper, Franklin, Hancock, Lubec (?), Sullivan, Topsham
Bornite—78—Bingham, Bluehill, Brooksville, Concord, Lubec, Pembroke
Brookite—253—Paris
Calcite—270—Bethel, Brunswick, Cherryfield, Chesuncook, Clinton, Cutler, Deer Isle, Dexter, Dover, Eastport, Freeport, Fort Fairfield, Foxcroft, Franklin, Harmony, Industry, Lubec, Marshfield, Norridgewock, Perry, Phippsburg, Portland, Rockland, Rockport, Sanford, Skowhegan, Strong, Thomaston, Trescott, Warren, Wilton, Woodstock, 5R7
Cancrinite—360—Gardiner, Litchfield, West Gardiner
Cassiterite—248—Andover, Auburn, Buckfield, Greenwood, Hebron, Newry, Norway, Paris, Peru, Rumford, Stoneham, Winslow
Cerargyrite—169—Sullivan
Chabazite—447—Phippsburg
Chalcocite—54—Bluehill
Chalcopyrite—83—Bluehill, Brooksville, Brunswick, Castine, Cherryfield, Concord, Cooper, Corinna, Deer Isle, Dexter, Eastport, Ellsworth, Franklin, Gardiner, Gouldsborough, Lubec, Moxie Gore, Parsonsfield, Pembroke, Penobscot, Rumford, Sedgwick, Sullivan, Trescott, Union, Winslow, Winterport, Winthrop
Childrenite—649—Hebron
Chlorite (see Prochlorite)
Chrysoberyl—242—Canton, Greenwood, Hartford, Hebron, Norway, Peru, Stoneham, Stowe, Sumner
Chrysocolla—504—Beddington (probably this)
Chrysolite (Olivine)—376—Addison, Bristol, St. George
Cimolite—495—Norway, Stoneham, Topsham
Cobalt (probably a sulphide)—Union
Columbite—525—Brunswick, Buckfield, Greenwood, Hartford, Newry, Paris, Poland, Standish, Stoneham
  Manganocolumbite—Newry, Rumford
Cookeite (see Lepidolite)

Copper—15—Camden, Carroll
Copperas (see Melanterite)
Corundum—231—Greenwood
Cyanite—400—Gorham, Standish, Windham
Dahllite—676—Buckfield
Damourite (see Muscovite)
Diallage (see Pyroxene)
Dioptase—383—Beddington (?) (see Chrysocolla)
Dolomite—271—Concord, Pembroke
Elaeolite (see Nephelite)
Eosphorite—650—Buckfield, Newry, Poland
Epidote—407—Bethel, Brunswick, Camden, Carmel, Eastport, Eden, Gouldsborough, Lubec, Machiasport, Marshfield, Pembroke, Phippsburg, Portland, Raymond, Sanford, Topsham, Woodstock, 5R7
Fairfieldite—592—Buckfield
Feldspar (see Albite, Anorthite, Labradorite, Microcline, Oligoclase, Orthoclase)
Fibrolite (see Sillimanite)
Fluorite—175—Bluehill, Cooper, Stoneham, Winslow
Gahnite—236—Greenwood
Galenite (Galena)—45—Aurora, Bingham, Bluehill, Brooksville, Camden, Cherryfield, Concord, Corinna, Deer Isle, Denmark, Dexter, Dixfield, Dover, Eastport, Exeter, Franklin, Gouldsboro, Hampton (?), Kezar Falls, Lubec, Marion, Milton Plantation, Mt. Glines, Parsonsfield, Pembroke, Rangeley, Robinson, Rumford, Scarborough, Sullivan, Thomaston, Topsham, Trescott, Union, Verona, Warren, Winslow
Garnet—370—Albany, Arrowsic, Auburn, Bath, Bethel, Boothbay, Bowdoinham, Brooksville, Brunswick, Buckfield, Carthage, Deer Isle, Farmington, Freeport, Friendship, Fryeburg, Greene, Greenwood, Hallowell, Harpswell, Hartford, Jackson, Lewiston, Minot, North Yarmouth, Norway, Orr's Island, Oxford, Paris, Parsonsfield, Peru, Phippsburg, Poland, Portland, Raymond, Rumford, Searsmont, Somerville, Southport, Standish, Strong, Topsham, Washington, Wayne, Windham, Winslow, Winthrop, Woodstock

Gold—13—Acton, Albion, Baileyville, Baring, Bluehill, Byron, Calais, Carrying Place, China, Columbia, Concord, Cutler, Dallas Plantation, Gardiner, Haynes Township, Jerusalem Plantation, Livermore, Madrid, Machiasport, Moscow, Mt. Vernon, Newfield, New Sharon, Orland, Orrington, Pembroke, Pittsfield, Pittston, Readfield, Sandy River Plantation, Skowhegan, Verona, Winthrop, Woodstock

Graphite—2—Albany, Augusta, Bangor, Bath, Belfast, Bethel, Bowdoinham, Brunswick, Buckfield, Camden, Canton, Cape Elizabeth, Charlotte, Dixfield, Dover, Farmington, Freeport, Georgetown, Greenwood, Hampden, Lebanon, Lewiston, Lincolnville, Madrid, Marion, Marshfield, Monmouth, Newry, Paris, Phillips, Phippsburg, Pittston, Raymond, Rockland, Rumford, Sandy River Plantation, Sangerville, Scarborough, Searsmont, Sebago, Thomaston, Windham, Woodstock, Yarmouth

Gummite—712—Newry

Gypsum—746—Saco, Skowhegan, Sullivan

Halloysite—493—Thomaston

Hamlinite—548—Greenwood, Stoneham

Hatchettolite—521—Newry

Hematite—232—Aroostook, Baldwin, Brunswick, Buckfield, Castle Hill, Cherryfield, Hodgdon, Katahdin Iron Works, Linneus, Lubec, Mapleton, New Sweden, Norridgewock, Perham, Phippsburg, Pleasant Ridge Plantation, Portland, Rockland, Saco, Southport, Wade, Waite, Washburn, Woodland, Woodstock

Herderite—547—Auburn, Buckfield, Greenwood, Hebron, Newry, Paris, Stoneham

Hornblende (see Amphibole)

Hydronephelite—457—Litchfield

Hypersthene—324—Wayne

Idocrase (see Vesuvianite)

Ilmenite (Menaccanite)—233—Greenwood, Newry

Iolite—353—Gardiner

Iron—25—Castine (Meteorite)

Kalinite (Alum)—764—Concord, Wales

Kaolinite—492—Buckfield, Woolwich

Kerolite (Kerolith, Cerolite) (see Serpentine)

Labradorite—319—Litchfield, Thomaston, Union
Laumontite—445—Machias, Machiasport, Phippsburg
Lepidolite—460—Auburn, Buckfield, Greenwood, Hebron, Newry, Norway, Oxford, Paris, Raymond, Rumford, Waterford
Cookeite—Auburn, Buckfield, Greenwood, Hebron, Paris
Lepidomelane—462B—Litchfield
Leucopyrite (see Löllingite)
Limonite—259—Abbott, Andover, Anson, Argyle, Atkinson, Augusta, Aurora, Barnard Plantation, Bath, Bluehill, Bristol, Brownville, Bucksport, Camden, Canton, China, Clinton, Dexter, Dixfield, Dover, Farmington, Foxcroft, Gardiner, Greenbush, Greenwood, Harmony, Harpswell, Harrington, Hodgton, Howland, Jay, Katahdin Iron Works, Lebanon, Liberty, Linneus, Moxie Gore, Newfield, New Limerick, New Portland, Orland, Oxbow Plantation, Paris, Pembroke, Phillips, Phippsburg, Pittston, Rangeley, Raymond, Rumford, Saco, Salem, Sebec, Shapleigh, Skowhegan, Somerville, Strong, The Forks Plantation, Thomaston, Troy, Turner, Union, Wade, Wales, Warren, Wells, West Forks Plantation, Whitefield, Williamsburg, Winslow, Winthrop, 3R7, 8R7
Lithiophilite—544—Buckfield, Newry, Norway
Löllingite—97—Paris
Magnetite—237—Albany, Andover, Augusta, Bath, Bethel, Bluehill, Brownfield, Buckfield, Camden, Deer Isle, Eden, Gardiner, Gouldsborough, Greenwood, Hodgdon, Isle au Haut, Katahdin Iron Works, Leeds, Mount Desert, Patten, Phillips, Raymond, Salem, Swan's Island (Marshall's Island), Thomaston, Union, Wayne, 5R7
Malachite—288—Bluehill, Brooksville, Brunswick, Castine, Litchfield, Lubec, Pembroke, Woolwich
Manganite—258—Buckfield, Newry, Rumford
Manganocolumbite (see Columbite)
Manganotantalite (see Tantalite)
Marcasite—96—Concord, New Portland (?)
Margarodite (see Muscovite)
Melanterite (Copperas)—751—Concord, Dixfield, Greenwood, Saco, Wales, Winthrop

Mica (see Biotite, Lepidolite, Lepidomelane, Muscovite, Phlogopite)
Microcline—315—Buckfield, St. George
  Amazonite—Southwest Harbor, Tremont
Microlite—522—Auburn, Newry, Rumford
Molybdenite—34—Auburn, Augusta, Belfast, Bluehill, Bowdoinham, Brunswick, Cooper, Franklin, Greenwood, Hebron, Machias, Norridgewock, Norway, Paris, Sanford, Topsham, Whiting, No. 10 (Hancock County)
Molybdite—219—Cooper, Franklin
Montmorillonite—496—Buckfield, Greenwood, Paris, Rumford
Muscovite—458—Albany, Andover, Auburn, Brunswick, Buckfield, Canton, Edgecomb, Freeport, Fryeburg, Gardiner, Gilead, Greenwood, Hartford, Hebron, Lewiston, Limington, Litchfield, Monmouth, Norway, Oxford, Paris, Peru, Phippsburg, Raymond, Rumford, Southport, St. George, Topsham, Unity, Waterford, Winslow, Woodstock, Woolwich
  Damourite—Newry, Norway, Rumford, Stoneham, Topsham
  Margarodite—Rumford
  Nacrite—Unity
  Pinite—Newry, Paris, Rumford
Nacrite (see Muscovite)
Nephelite (Elaeolite—357—Litchfield, Monmouth
Nickel (probably a sulphide)—Union
Oligoclase—317—Marshfield, Norway
Olivine (see Chrysolite)
Opal—212—Jonesport
Orthoclase—313—Albany, Auburn, Bath, Bethel, Boothbay, Bowdoin, Bowdoinham, Brunswick, Buckfield, Canton, East Livermore, Edgecomb, Freeport, Fryeburg, Georgetown, Gorham, Greene, Greenwood, Hallowell, Hebron, Leeds, Lewiston, Lisbon, Litchfield, Livermore, Marshfield, Minot, New Castle, Newry, Norway, Orland, Paris, Peru, Phippsburg, Poland, Pownal, Raymond, Rumford, Southport, Topsham, Waterford, Woolwich
  Adularia—Parsonsfield
Ottrelite (Phyllite)—467—South Portland

Pargasite (see Amphibole)
Petalite—310—Buckfield, China (?), Hartford, Peru
Phenacite—382—Stoneham
Phlogopite—462A—Gardiner, Lewiston
Phyllite (see Ottrelite)
Pinite (see Muscovite)
Platinum—20—Hermon
Pollucite—322—Buckfield, Hebron, Newry, Paris, Rumford
Prehnite—411—Newry, Perry, Portland, Woodstock
Prochlorite (Chlorite)—469—Cutler, Eastport, Marshfield, Monmouth, Newry, Raymond, St. George, Topsham

Psilomelane (Wad, Bog Manganese)—269—Bethel, Bluehill, Buckfield, Dover, Gardiner, Hodgdon, Linneus, Oxford, Paris, Perry, Pittston, Rockland, Skowhegan, South Berwick, Topsham, Troy, Waite, Winslow, Winthrop, 3R7, 8R7, 6R8

Purpurite—Dana, App'x II, p. 83—Newry, Peru, Rumford

Pyrite—85—Albion, Andover, Anson, Augusta, Baldwin, Benton, Bethel, Bingham, Bluehill, Brooksville, Brunswick, Buckfield, Calais, Camden, Carmel, Cherryfield, China, Clinton, Concord, Cooper, Corinna, Deer Isle, Dexter, Dover, Eastport, Eden, Farmington, Franklin, Gardiner, Gouldsborough, Hallowell, Hampden, Harmony, Harpswell, Hartford, Hodgdon, Industry, Jay, Jewell's Island, Katahdin Iron Works, Kennebunk, Kingfield, Lebanon, Lewiston, Lexington Plantation, Linneus, Litchfield, Lubec, Manchester, Marshfield, Milton Plantation, Minot, Mount Desert, Mt. Vernon, New Limerick, New Portland, Norridgewock, North Yarmouth, Pembroke, Peru, Phillips, Pittston, Pleasant Ridge Plantation, Poland, Pownal, Raymond, Rockland, Rumford, Saco, Sidney, Skowhegan, Smyrna, Stowe, Sullivan, Thomaston, Thorndike, Trescott, Troy, Turner, Unity, Verona, Vinalhaven, Wales, Waterville, Wayne, Winslow, Winthrop, York

Pyrochlore—520—Buckfield

Pyrolusite—254—Bluehill, Castle Hill, Greenwood, Lubec, Mapleton, New Sweden, Thomaston, Woodland, York

Pyromorphite—550—Lenox, Lubec

Pyroxene—325—
- Augite—Deer Isle, Newry, Phippsburg, Raymond
- Diallage—Bethel, Deer Isle
- Diopside—Raymond, Rumford
- Sahlite—Bethel, Rumford

Pyrrhotite—74—Andover, Bingham, Bluehill, Buckfield, Concord, Katahdin Iron Works, Litchfield, Rumford, Standish

Quartz—210—
- Colorless or White—Abbot, Auburn, Bethel, Bingham, Boothbay, Bowdoin, Bowdoinham, Brooklin, Brunswick, Buckfield, Castine, Concord, Denmark, Dover, East Livermore, Fairfield, Fort Kent, Freeport, Gardiner, Greenville, Greenwood, Hebron, Jay, Katahdin Iron Works, Lexington Plantation, Liberty, Livermore, Lubec, Moxie Gore, Newry, Paris, Perry, Peru, Phippsburg, Pittston, Portland, Presque Isle, Rockland, Skowhegan, Solon, Stoneham, The Forks Plantation, Thomaston, Topsham, Wayne, Winslow, Woolwich
- Amethyst—Albany, Denmark, Litchfield, Marshfield, Perry, Portland, Stoneham, Stowe, Windham, Wiscasset, Woolwich
- Basanite—Topsham
- Blue—Bucksport, Verona
- Chalcedony—Perry
- Rose—Albany, Auburn, Bowdoin, Brunswick, Freeport, Greenwood, Hebron, Kennebunk, Livermore, Norway, Paris, Pownal, Rumford, Skowhegan, Topsham, Wayne
- Smoky—Auburn, Freeport, Marshfield, Minot, Paris, Poland, Pownal, St. George, Topsham

Reddingite—594—Buckfield, Newry, Rumford

Rhodochrosite—274—Buckfield, Deer Isle, Franklin, Newry

Rhodonite—335—Bluehill

Rutile—250—Albany, Bethel, Brunswick, Kennebunk, Monmouth, St. George, Warren

Sahlite (see Pyroxene)

Scapolite (see Wernerite)

Serpentine—481—Brooksville, Deer Isle, Hampden, North Haven, Sidney, Spencer Township
- Fibrous (Chrysotile asbestus)—Deer Isle, Hampden, Harpswell, Spencer Township
- Kerolite—Rockland, Thomaston

Siderite—273—Newry, Pembroke, Winthrop

Sillimanite (Fibrolite)—399—Bethel, Brunswick, Litchfield, Winthrop

Silver—14—Sullivan

Silver ores (probably as more or less complex sulphides)—Bluehill, Concord, Corinna, Dallas Plantation, Deer Isle, Dexter, Gardiner, Gouldsborough, Lubec, Newfield, Pembroke, Woodstock

Silver ores (see Silver, Argentite, Cerargyrite, Stephanite)

Sodalite—362—Litchfield, West Gardiner

Sphalerite—58—Bingham, Bluehill, Cherryfield, Concord, Corinna, Cutler, Deer Isle, Dexter, Gouldsboro, Lincolnville, Lubec, Paris, Parsonsfield, Pembroke, Rumford, Sullivan, Thomaston, Topsham, Warren, Woodstock

Spodumene—327—Auburn, Buckfield, Gorham, Greenwood, Hartford, Litchfield, Newry, Paris, Peru, Rumford, Windham

Kunzite—Rumford

Staurolite—428—Andover, Brunswick, Byron, Camden, East Livermore, Farmington, Harpswell, Hebron, Jackson, Monmouth, Mt. Abraham, Oldtown, Sebago, Sidney, Standish, Strong, Temple, Windham, Winthrop

Stephanite—153—Sullivan

Stibnite—28—Bluehill, Carmel, Sullivan

Stilbite—443—Hallowell (?)

Talc—484—Bethel, Camden, Deer Isle, Dexter, Harpswell, Hope, Portland, Rockland, Sidney, Sullivan, Thomaston, Vassalboro, Warren

Tantalite—526—Standish

Manganotantalite—Auburn, Buckfield

Tetrahedrite—148—Bluehill, Carmel, Sullivan

Thomsonite—456—Thomaston

Titanite (Sphene)—510—Albany, Andover, Bethel, Brunswick, Kennebunk, Sanford, Thomaston, Thurston

Topaz—397—Albany, Buckfield, Stoneham

Torbernite—659—Newry, Peru, Rumford

Tourmaline—426—

Black—Albany, Auburn, Augusta, Brunswick, Buckfield, Camden, Cornish, Falmouth, Farmingdale, Freeport, Georgetown, Greenville, Greenwood, Hallowell, Hartford,

Hebron, Leeds, Limerick, Lisbon, Livermore, Minot, Mt. Vernon, Newry, Paris, Pownal, Sanford, Searsmont, Standish, St. George, Topsham, Wayne, Winslow
Colored—Albany, Auburn, Brunswick, Buckfield, Georgetown, Gray, Greenwood, Hebron, Newry, Norway, Oxford, Paris, Poland, Pownal, Rumford, Sanford, Windham
Triphylite—543—Buckfield, Hartford, Newry, Peru, Rumford
Triplite—555—Stoneham
Uraninite—711—Newry
Vesuvianite (Idocrase)—393—Bath, Hebron, Parsonsfield, Phippsburg, Poland, Raymond, Rumford, Sanford
Vivianite—597—Madawaska, Newfield (?), York
Wernerite—387—Freeport, Parsonsfield, Pownal, Raymond, Rumford
Wolframite—812—Bluehill, Bowdoinham, Topsham (?)
Yttrocerite—209—Auburn, Paris
Zircon—394—Farmington, Greenwood, Hebron, Hurricane Island, Litchfield, Monmouth, Newry, Oxford, Paris, Rumford, Somerville, St. George

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## MINERALS OF MAINE

### INDEX BY TOWNS

Abbot—Limonite, Quartz
Acton—Gold
Addison—Chrysolite
Albany—Albite, Beryl, Garnet, Graphite, Magnetite, Muscovite, Orthoclase, Amethyst and Rose Quartz, Rutile, Titanite, Topaz, Tourmaline
Albion—Gold, Pyrite
Andover—Beryl, Cassiterite, Limonite, Magnetite, Muscovite, Pyrite, Pyrrhotite, Staurolite, Titanite
Anson—Limonite, Pyrite
Argyle—Limonite
Arrowsic—Garnet
Atkinson—Limonite

Auburn—Albite, Amblygonite, Apatite, Autunite, Beryl, Biotite, Cassiterite, Garnet, Herderite, Lepidolite (incl. Cookeite), Microlite, Molybdenite, Muscovite, Orthoclase, Quartz (white, rose, smoky), Spodumene, Manganotantalite, Tourmaline, Yttrocerite

Augusta—Graphite, Limonite, Magnetite, Molybdenite, Pyrite, Tourmaline (black)

Aurora—Galenite, Limonite

Baileyville—Gold

Baldwin—Beryl, Hematite, Pyrite

Bangor—Andalusite, Graphite

Baring—Gold

Barnard Plantation—Limonite

Bath—Biotite, Garnet, Graphite, Limonite, Magnetite, Orthoclase, Vesuvianite

Beddington—Chrysocolla

Belfast—Andalusite, Arsenopyrite, Graphite, Molybdenite

Benton—Pyrite

Bethel—Amphibole (Hornblende, Actinolite, Pargasite, Tremolite), Apatite, Arsenopyrite, Barite, Beryl, Calcite, Epidote, Garnet, Graphite, Magnetite, Orthoclase, Psilomelane, Pyrite, Pyroxene (Diallage, Sahlite), Quartz, Rutile, Sillimanite, Talc, Titanite

Bingham—Andalusite, Bornite, Galenite, Pyrite, Pyrrhotite, Quartz, Sphalerite

Bluehill—Apatite, Arsenopyrite, Bornite, Chalcocite, Chalcopyrite, Fluorite, Galenite, Gold, Limonite, Magnetite, Malachite, Molybdenite, Psilomelane, Pyrite, Pyrolusite, Pyrrhotite, Rhodonite, Silver ores, Sphalerite, Stibnite, Tetrahedrite, Wolframite

Boothbay—Garnet, Orthoclase, Quartz

Bowdoin—Beryl, Orthoclase, Quartz (white, rose)

Bowdoinham—Amphibole (Tremolite), Beryl, Garnet, Graphite, Molybdenite, Orthoclase, Quartz, Wolframite

Bristol—Amphibole (Hornblende), Limonite, Chrysolite

Brooklin—Quartz

Brooksville—Amphibole (Hornblende), Azurite, Bornite, Chalcopyrite, Galenite, Garnet, Malachite, Pyrite, Serpentine

Brownfield—Magnetite

Brownville—Limonite

Brunswick—Amphibole (Actinolite), Apatite, Barite, Beryl, Biotite, Calcite, Chalcopyrite, Columbite, Epidote, Garnet, Graphite, Hematite, Malachite, Molybdenite, Muscovite, Pyrite, Quartz (white, rose), Rutile, Sillimanite, Staurolite, Titanite, Tourmaline, (black, colored)

Buckfield—Albite, Amblygonite, Apatite, Arsenopyrite, Beryl, Biotite, Cassiterite, Columbite, Dahllite, Eosphorite, Fairfieldite, Garnet, Graphite, Hematite, Herderite, Kaolinite, Lepidolite (also Cookeite), Lithiophilite, Magnetite, Manganite, Microcline, Montmorrilonite, Muscovite, Orthoclase, Petalite, Pollucite, Psilomelane, Pyrite, Pyrochlore, Pyrrhotite, Quartz, Reddingite, Rhodochrosite, Spodumene, Manganotantalite, Topaz, Tourmaline (black colored), Triphylite

Bucksport—Andalusite, Limonite, Quartz (blue)

Byron—Gold, Staurolite

Calais—Gold, Pyrite

Camden—Andalusite, Copper, Epidote, Galenite, Graphite, Limonite, Magnetite, Pyrite, Staurolite, Talc, Tourmaline (black)

Canton—Beryl, Chrysoberyl, Graphite, Limonite, Muscovite, Orthoclase

Cape Elizabeth—Graphite

Carmel—Andalusite, Epidote, Pyrite, Stibnite, Tetrahedrite

Carroll—Copper

Carrying Place—Gold

Carthage—Garnet

Castine—Chalcopyrite, Iron (Meteorite), Malachite, Quartz

Castle Hill—Hematite, Pyrolusite

Charlotte—Graphite

Cherryfield—Calcite, Chalcopyrite, Galenite, Hematite, Pyrite, Sphalerite

Chesuncook—Calcite

China—Gold, Limonite, Petalite (?), Pyrite

Clinton—Arsenopyrite, Calcite, Limonite, Pyrite

Columbia—Gold

Concord—Arsenopyrite, Bornite, Chalcopyrite, Dolomite, Galenite, Gold, Kalinite, Marcasite, Melanterite, Concord, Pyrrhotite, Quartz, Silver, Sphalerite

Cooper—Chalcopyrite, Fluorite, Molybdenite, Molybdite, Pyrite, Bismuth

Corinna—Arsenopyrite, Chalcopyrite, Galenite, Pyrite, Sphalerite

Cutler—Calcite, Gold, Prochlorite, Sphalerite

Dallas Plantation—Gold, Silver ores

Deer Isle—Amphibole (Hornblende), Barite, Calcite, Chalcopyrite, Galenite, Garnet, Magnetite, Pyrite, Pyroxene (Augite, Diallage), Rhodochrosite, Serpentine (incl. Chrysotile), Silver ores, Sphalerite, Talc

Denmark—Galenite, Quartz (white, amethyst)

Dexter—Calcite, Chalcopyrite, Galenite, Limonite, Pyrite, Silver ores, Sphalerite, Talc

Dixfield—Galenite, Graphite, Limonite, Melanterite

Dover—Calcite, Galenite, Graphite, Limonite, Psilomelane, Pyrite, Quartz

East Livermore—Beryl, Orthoclase, Quartz, Staurolite

Eastport—Arsenopyrite, Calcite, Chalcopyrite, Epidote, Galenite, Prochlorite, Pyrite

Eden—Arseopyrite, Epidote, Magnetite, Pyrite

Edgecomb—Biotite, Muscovite, Orthoclase

Ellsworth—Chalcopyrite

Exeter—Galenite

Fairfield—Arsenopyrite, Quartz

Falmouth—Tourmaline (black)

Farmingdale—Tourmaline (black)

Farmington—Arsenopyrite, Garnet, Graphite, Limonite, Pyrite, Staurolite, Zircon

Fort Fairfield—Calcite

Fort Kent—Quartz

Foxcroft—Calcite, Limonite

Franklin—Arsenopyrite, Bismuth, Calcite, Chalcopyrite, Galenite, Molybdenite, Molybdite, Pyrite, Rhodochrosite

Franklin Plantation—Beryl

Freeport—Amphibole (Actinolite, Apatite, Beryl, Calcite, Garnet, Graphite, Muscovite, Orthoclase, Quartz (white, rose, smoky). Tourmaline (black), Wernerite

Friendship—Garnet

Fryeburg—Beryl, Garnet, Muscovite, Orthoclase

Gardiner—Cancrinite, Chalcopyrite, Gold, Iolite, Limonite, Magnetite, Muscovite, Phlogopite, Psilomelane, Pyrite, Quartz, Silver ores

Georgetown—Beryl, Graphite, Orthoclase, Tourmaline (black, colored)

Gilead—Muscovite

Gorham—Andalusite, Cyanite, Orthoclase, Spodumene

Gouldsboro—Chalcopyrite, Epidote, Galenite, Magnetite, Pyrite, Silver ores, Sphalerite

Gray—Amphibole (Hornblende), Tourmaline (colored)

Greene—Amphibole (Hornblende), Garnet, Orthoclase

Greenbush—Limonite

Greenville—Andalusite, Quartz, Tourmaline (black)

Greenwood—Albite, Amblygonite, Analcite, Apatite, Arsenic, Arsenopyrite, Bertrandite, Beryl, Cassiterite, Chrysoberyl, Columbite, Corundum, Galenite, Garnet, Graphite, Hamlinite, Herderite, Ilmenite, Lepidolite (incl. Cookeite) Limonite, Magnetite, Melanterite, Molybdenite, Montmorillonite, Muscovite, Orthoclase, Pyrolusite, Quartz (white, rose), Spodumene, Tourmaline (black, colored), Zircon

Hallowell—Garnet, Orthoclase, Pyrite, Stilbite (?), Tourmaline (black)

Hampden—Graphite, Pyrite, Serpentine (incl. Chrysotile)

Hancock—Bismuth

Harmony—Calcite, Limonite, Pyrite

Harpswell—Andalusite, Garnet, Limonite, Pyrite, Serpentine (Chrysotile), Staurolite, Talc

Harrington—Limonite

Hartford—Albite, Apatite, Beryl, Chrysoberyl, Columbite, Garnet, Muscovite, Petalite, Pyrite, Spodumene, Tourmaline (black), Triphylite

Haynes Township—Gold

Hebron—Albite, Amblygonite, Apatite, Arsenopyrite, Beryl, Biotite, Cassiterite, Childrenite, Chrysoberyl, Herderite, Lepidolite (incl. Cookeite), Molybdenite, Muscovite, Orthoclase, Pollucite, Quartz (white, rose), Staurolite, Tourmaline (black, colored), Vesuvianite, Zircon

Hermon—Platinum

Hodgdon—Hematite, Limonite, Magnetite, Psilomelane, Pyrite

Hope—Talc
Howland—Limonite
Hurricane Island—Allanite, Zircon
Industry—Calcite, Pyrite
Isle au Haut—Magnetite
Jackson—Garnet, Staurolite
Jay—Amphibole (Actinolite), Apatite, Limonite, Pyrite, Quartz
Jerusalem Township—Gold
Jonesport—Opal
Katahdin Iron Works—Hematite, Limonite, Magnetite, Pyrite, Pyrrhotite, Quartz
Kennebunk—Quartz (rose), Rutile, Pyrite, Titanite
Kezar Falls—Galenite
Kingfield—Pyrite
Lebanon—Graphite, Limonite, Pyrite
Leeds—Magnetite, Orthoclase, Tourmaline (black)
Lewiston—Garnet, Graphite, Muscovite, Orthoclase, Phlogopite, Pyrite
Lexington Plantation—Pyrite, Quartz
Liberty—Limonite, Quartz
Limerick—Tourmaline (black)
Limington—Muscovite
Lincolnville—Graphite, Sphalerite
Linneus—Hematite, Limonite, Psilomelane, Pyrite
Lisbon—Orthoclase, Tourmaline (black)
Litchfield—Albite, Apatite, Biotite, Cancrinite, Hydronephelite, Labradorite, Lepidomelane, Malachite, Muscovite, Nephelite, Orthoclase, Pyrite, Pyrrhotite, Quartz (amethyst), Sillimanite, Sodalite, Spodemene, Zircon
Livermore—Apatite, Gold, Orthoclase, Quartz (white, rose), Tourmaline (black)
Lovell—Beryl
Lubec—Bismuth (?), Bornite, Calcite, Chalcopyrite, Epidote, Galenite, Hematite, Malachite, Pyrite, Pyrolusite, Pyromorphite, Quartz, Silver ores, Sphalerite
Machias—Amphibole (Hornblende), Laumontite, Molybdenite
Machiasport—Epidote, Gold, Laumontite
Madawaska—Vivianite

Madrid—Gold, Graphite
Manchester—Pyrite
Mapleton—Hematite, Pyrolusite
Marion—Galenite, Graphite
Marshfield—Calcite, Epidote, Graphite, Oligoclase, Orthoclase, Prochlorite, Pyrite, Quartz (amethyst, smoky)
Milton Plantation—Galenite, Pyrite
Minot—Apatite, Beryl, Garnet, Orthoclase, Pyrite, Quartz (smoky), Tourmaline (black)
Monmouth—Amphibole (Hornblende, Actinolite), Andalusite, Apatite, Beryl, Graphite, Muscovite, Nephelite, Prochlorite, Rutile, Staurolite, Zircon
Moscow—Andalusite, Gold
Moultonboro—Amphibole (Hornblende)
Moxie Gore—Azurite, Chalcopyrite, Limonite, Quartz
Mt. Abraham—Andalusite, Staurolite
Mt. Desert—Arsenopyrite, Magnetite, Pyrite
Mt. Glines—Galenite
Mt. Vernon—Gold, Pyrite, Tourmaline (black)
New Castle—Orthoclase
Newfield—Arsenopyrite, Gold, Limonite, Silver ores, Vivianite (?)
New Limerick—Limonite, Pyrite
New Portland—Limonite, Marcasite (?), Pyrite
Newry—Albite, Alunogen, Amblygonite, Apatite, Autunite, Beryl, Beryllonite, Cassiterite, Columbite (incl. Manganocolumbite), Eosphorite, Graphite, Gummite, Hatchettolite, Herderite, Ilmenite, Lepidolite, Lithiophilite, Manganite, Microlite, Muscovite (Damourite, Pinite), Orthoclase, Pollucite, Prehnite, Prochlorite, Purpurite, Pyroxene (Augite), Quartz, Reddingite, Rhodochrosite, Siderite, Spodumene, Torbernite, Tourmaline (black, colored), Triphylite, Uraninite, Zircon
New Sharon—Gold
New Sweden—Hematite, Pyrolusite
No. 10 (Hancock County)—Molybdenite
Norridgewock—Calcite, Hematite, Molybdenite, Pyrite
North Berwick—Andalusite
North Haven—Serpentine
North Yarmouth—Beryl, Garnet, Pyrite

Norway—Allanite, Apatite, Beryl, Cassiterite, Chrysoberyl, Cimolite, Garnet, Lepidolite, Lithiophilite, Molybdenite, Muscovite (incl. Damourite), Oligoclase, Orthoclase, Quartz (rose), Tourmaline (colored)

Oldtown—Staurolite

Orland—Gold, Limonite, Orthoclase

Orrington—Gold

Oxbow Plantation—Limonite

Oxford–Apatite, Beryl, Garnet, Lepidolite, Muscovite, Psilomelane, Tourmaline (colored), Zircon

Paris—Albite, Amblygonite, Apatite, Arsenopyrite, Beryl, Biotite, Brookite, Cassiterite, Columbite, Garnet, Graphite, Herderite, Lepidolite (incl. Cookeite), Limonite, Löllingite, Molybdenite, Montmorillonite, Muscovite (incl. Pinite), Orthoclase, Pollucite, Psilomelane, Quartz (white, rose, smoky), Sphalerite, Spodumene, Tourmaline (black, colored), Yttrocerite, Zircon

Parsonsfield—Amphibole (Pargasite), Chalcopyrite, Galenite, Garnet, Orthoclase (Adularia), Sphalerite, Vesuvianite, Wernerite

Patten—Magnetite

Pembroke—Arsenopyrite, Bornite, Chalcopyrite, Dolomite, Epidote, Galenite, Gold, Limonite, Malachite, Pyrite, Siderite, Silver ores, Sphalerite

Penobscot—Chalcopyrite

Perham—Hematite

Perry—Analcite, Apophyllite, Calcite, Prehnite, Psilomelane, Quartz (white, amethyst, Chalcedony)

Peru—Amblygonite, Apatite, Beryl, Cassiterite, Chrysoberyl, Garnet, Muscovite, Orthoclase, Petalite, Purpurite, Pyrite, Quartz, Spodumene, Torbernite, Triphylite

Phillips—Graphite, Limonite, Magnetite, Pyrite

Phippsburg—Acmite, Amphibole (Pargasite), Anorthite, Axinite, Calcite, Chabazite, Epidote, Garnet, Graphite, Hematite, Laumontite, Limonite, Muscovite, Orthoclase, Pyroxene (Augite), Quartz, Vesuvianite

Pittsfield—Gold

Pittston—Gold, Graphite, Limonite, Pyrite, Psilomelane Quartz

Pleasant Ridge Plantation—Hematite, Pyrite

Poland—Arsenopyrite, Beryl, Columbite, Eosphorite, Garnet, Orthoclase, Pyrite, Quartz (smoky), Tourmaline (colored), Vesuvianite

Portland—Amphibole (Actinolite), Calcite, Epidote, Garnet, Hematite, Prehnite, Quartz (white, amethyst), Talc

Pownal—Amphibole (Actinolite), Apatite, Orthoclase, Pyrite, Quartz (rose, smoky), Tourmaline (black, colored), Wernerite

Presque Isle—Quartz

Rangeley—Galenite, Limonite

Raymond—Amphibole (Hornblende, Tremolite), Epidote, Garnet, Graphite, Lepidolite, Limonite, Magnetite, Muscovite, Orthoclase, Prochlorite, Pyrite, Pyroxene (Augite, Diopside), Vesuvianite, Wernerite

Readfield—Gold

Robinson—Galenite

Rockland—Amphibole (Tremolite), Calcite, Graphite, Hematite, Psilomelane, Pyrite, Quartz, Serpentine (Kerolite), Talc

Rockport—Calcite

Rumford—Albite, Alunogen, Amblygonite, Amphibole (Actinolite), Apatite, Arsenopyrite, Autunite, Cassiterite, Chalcopyrite, Columbite (Manganocolumbite), Galenite, Garnet, Graphite, Lepidolite, Limonite, Manganite, Microlite, Montmorillonite, Muscovite (incl. Damourite, Margarodite, Pinite), Orthoclase, Pollucite, Purpurite, Pyrite, Pyroxene (Diopside, Sahlite), Pyrrhotite, Quartz (rose), Reddingite, Sphalerite, Spodumene (incl. Kunzite), Torbernite, Tourmaline (colored), Triphylite, Vesuvianite, Wernerite, Zircon

Saco—Gypsum, Hematite, Limonite, Melanterite, Pyrite

Salem—Limonite, Magnetite

Sandy River Plantation—Gold, Graphite

Sanford—Albite, Anorthite, Barite, Calcite, Epidote, Molybdenite, Titanite, Tourmaline (black, colored), Vesuvianite

Sangerville—Graphite

Scarborough—Galenite, Graphite

Searsmont—Andalusite, Garnet, Graphite, Tourmaline (black)

Sebago—Graphite, Staurolite

Sebec—Limonite

Sedgwick—Chalcopyrite
Shapleigh—Limonite
Sidney—Pyrite, Serpentine, Staurolite, Talc
Skowhegan—Calcite, Gold, Gypsum, Limonite, Psilomelane, Pyrite, Quartz (white, rose)
Smyrna—Pyrite
Solon—Quartz
Somerville—Allanite, Garnet, Limonite, Zircon
South Berwick—Andalusite, Psilomelane
Southport—Garnet, Southport, Muscovite, Orthoclase
South Portland—Ottrelite
South Thomaston—Arsenopyrite
Southwest Harbor—Microcline (Amazonite)
Spaulding—Andalusite
Spencer Township—Serpentine (incl. Chrysotile)
Standish—Andalusite, Columbite, Cyanite, Garnet, Pyrrhotite, Staurolite, Tantalite, Tourmaline (black)
St. George—Amphibole (Hornblende), Apatite, Biotite, Chrysolite, Microcline, Muscovite, Prochlorite, Quartz (smoky), Rutile, Tourmaline (black), Zircon
Stoneham—Allanite, Bertrandite, Beryl, Beryllonite, Cassiterite, Chrysoberyl, Cimolite, Columbite, Fluorite, Hamlinite, Herderite, Muscovite (Damourite), Phenacite, Quartz (white, amethyst), Topaz, Triplite
Stowe—Chrysoberyl, Pyrite, Quartz (amethyst)
Strong—Calcite, Garnet, Limonite, Staurolite
Sullivan—Argentite, Arsenopyrite, Barite, Bismuth, Cerargyrite, Chalcopyrite, Galenite, Gypsum, Pyrite, Sphalerite, Stephanite, Stibnite, Talc, Tetrahedrite
Sumner—Chrysoberyl
Swan's Island (Marshall's Island)—Magnetite
Temple—Staurolite
The Forks Plantation—Limonite, Quartz
Thomaston—Amphibole (Hornblende, Actinolite, Tremolite), Arsenopyrite, Calcite, Galenite, Graphite, Halloysite, Labradorite, Limonite, Magnetite, Pyrite, Pyrolusite, Quartz, Serpentine (Kerolite), Sphalerite, Talc, Thomsonite, Titanite
Thorndike—Pyrite

Topsham—Allanite, Apatite, Arsenopyrite, Autunite, Beryl, Biotite, Bismuth, Cimolite, Epidote, Galenite, Garnet, Molybdenite, Muscovite (incl. Damourite), Orthoclase, Prochlorite, Psilomelane, Quartz (white, Basanite, rose, smoky), Sphalerite, Tourmaline (black), Wolframite (?)
Tremont—Microcline (Amazonite)
Trescott—Calcite, Chalcopyrite, Galenite, Pyrite
Troy—Limonite, Psilomelane, Pyrite
Turner—Limonite, Pyrite
Union—Andalusite, Chalcopyrite, Cobalt ore, Galenite, Labradorite, Limonite, Magnetite, Nickel ore
Unity—Amphibole (Actinolite), Muscovite (incl. Nacrite), Pyrite
Vassalboro—Talc
Verona—Arsenopyrite, Galenite, Gold, Pyrite, Quartz (blue)
Vinalhaven—Allanite, Pyrite
Wade—Hematite, Limonite
Waite—Hematite, Psilomelane
Wales—Axinite, Kalinite, Limonite, Melanterite, Pyrite
Warren—Apatite, Calcite, Galenite, Limonite, Rutile, Sphalerite, Talc
Washburn—Hematite
Washington—Andalusite, Garnet
Waterford—Apatite, Lepidolite, Muscovite, Orthoclase
Waterville—Pyrite
Wayne—Amphibole (Hornblende), Garnet, Hypersthene, Magnetite, Pyrite, Quartz (white, rose), Tourmaline (black)
Wells—Limonite
West Forks Plantation—Limonite
West Gardiner—Cancrinite, Sodalite
Whitefield—Limonite
Whiting—Molybdenite
Williamsburg—Limonite
Wilton—Calcite
Windham—Beryl, Cyanite, Garnet, Graphite, Quartz (amethyst), Spodumene, Staurolite, Tourmaline (colored)
Winslow—Arsenopyrite, Beryl, Cassiterite, Chalcopyrite, Fluorite, Galenite, Garnet, Limonite, Muscovite, Psilomelane, Pyrite, Quartz (white), Tourmaline (black)
Winterport—Chalcopyrite

Winthrop—Amphibole (Hornblende), Beryl, Chalcopyrite, Garnet, Gold, Limonite, Melanterite, Psilomelane, Pyrite, Siderite, Sillimanite, Staurolite

Wiscasset—Quartz (amethyst)

Woodland—Hematite, Pyrolusite

Woodstock—Barite, Calcite, Epidote, Garnet, Gold, Graphite, Hematite, Muscovite, Prehnite, Silver ores, Sphalerite

Woolwich—Kaolinite, Malachite, Muscovite, Orthoclase, Quartz (white, amethyst)

Yarmouth—Graphite

York—Amphibole (Hornblende), Beryl, Pyrite, Pyrolusite, Vivianite

3R7—Limonite, Psilomelane

5R7—Calcite, Epidote, Magnetite

8R7—Limonite, Psilomelane

6R8—Psilomelane

By FREEMAN F. BURR

## MINERALS FOUND AT BENNETT'S QUARRY BUCKFIELD, MAINE

I. Original Pegmatite Intrusion. Igneous origin.

1. Microcline. (Perthitic with Albite)
2. Quartz. (Anhedral. Gray)
3. Apatite. (Noncrystalline. Green)
4. Beryl. (Good crystals. Green or blue)
5. Tourmaline. (Black)
6. Lepidolite. (Silvery white)
7. Biotite. (Probably from wall rock)
8. Spessartite.
9. Arsenopyrite.
10. Amblygonite.

II. Second Intrusion. Replacement deposit formed by sodium-lithium solutions below 575° C.

1. Quartz. (Milky and smoky. Good cyrstals. One crystal measured by E. H. Perkins was 3 ft. x 2 ft.)
2. Lepidolite. (Lilac colored)
3. Cleavelandite.

4. Beryl. (Green, white, and pink)
5. Tourmaline. (Green and pink)
6. Spodumene.
7. Apatite. (Green crystals)
8. Herderite.
9. Columbite.
10. Manganotantalite.
11. Cassiterite.
12. Pollucite.
13. Topaz.

III. Third Intrusion. Replacement by low temperature lithium, manganese, and phosphate waters.

1. Amblygonite.
2. Lithiophilite.
3. Triphylite.
4. Rhodochrosite.
5. Eosphorite.
6. Fairfieldite.
7. Reddingite.

IV. Fourth Intrusion. Lithium-silicate waters forming veins and replacements.

1. Lepidolite. (Lilac colored)
2. Quartz. (Small colorless masses)
3. Cookite.
4. Rhodochrosite.
5. Apatite. (Colorless crystals)
6. Herderite.

V. Minerals formed by ground water. These are still forming.

1. Kaolin.
2. Montmorillonite.
3. Psilomelane.
4. Manganite.
5. Rhodochrosite.
6. Dahllite.

## LIST OF MINERALS FOUND AT NEWRY, MAINE

Compiled by E. M. Bailey, Andover, Maine. Mr. Bailey says that Palache and Forshug are the authorities for most of the minerals.

| | |
|---|---|
| Albite | Nevel Mine, Halls Ridge |
| Amblygonite | Nevel Mine, Halls Ridge |
| Apatite | Nevel Mine, Halls Ridge |
| Alunogen | Near Nevel Mine, a short distance N.W. |
| Autunite | Nevel Mine, Halls Ridge |
| Beryl | Plumbago Mt. Also Puzzel Mt. |
| Beryllonite | Nevel Mine |
| Cassiterite | Nevel Mine |
| Cleavelandite | Nevel Mine |
| Columbite | Nevel Mine |
| Cookeite | Nevel Mine |
| Chlorite | Nevel Mine. As a chlorite schist country rock at the mine. In micaceous flakes at Plumbago Mt. |
| Cymatolite | Nevel Mine |
| Damourite | Nevel Mine |
| Eosphorite | Nevel Mine |
| Ferromanganite | North of mine, but little noticed |
| Gummite | Nevel Mine |
| Herderite | Nevel Mine |
| Manganiferous Herderite | Nevel Mine |
| Graphite | Plumbago Mt. |
| Ilmenite | Plumbago Mt. Scattered grains in rock |
| Killingite | Nevel Mine |
| Lepidolite | Nevel Mine |
| Lithiophilite | Nevel Mine |
| Manganite | Nevel Mine |
| Muscovite | Nevel Mine |
| Microlite | Nevel Mine |
| Manganoapatite | Nevel Mine |
| Manganocolumbite | Nevel Mine |
| Pollucite | Nevel Mine |
| Purpurite | Nevel Mine |

| | |
|---|---|
| Prehnite | Plumbago Mt. |
| Pyrite | Plumbago Mt. |
| Pyroxene | Plumbago Mt. |
| Pyrolusite | Nevel Mine |
| Orthoclase | In many places |
| Pinite | Nevel Mine |
| Quartz | Nevel Mine. Also in many places |
| Rose Crystals | Nevel Mine |
| White Crystals | Nevel Mine |
| Smoky crystals | Nevel Mine |
| Opal coated crystals | Nevel Mine |
| Reddingite | Nevel Mine |
| Rhodochrosite | Nevel Mine |
| Spodumene | Nevel Mine |
| Siderite | Nevel Mine |
| Spessartite | Nevel Mine |
| Stewartite | Nevel Mine |
| Torbernite | Nevel Mine |
| Triphylite | Nevel Mine |
| Uraophyllite | Nevel Mine |
| Caesium Beryl | Nevel Mine |
| Crytolite | Nevel Mine |
| Tourmaline | Nevel Mine. Black, red, pink, green, blue, granular, etc. |
| Zircon | Nevel Mine. Small brown crystals |

Palache has material from the Nevel Mine with minerals which have not been named as yet.

## LIST OF MINERALS FOUND IN RUMFORD, MAINE

Compiled by E. M. Bailey, Andover, Maine

| | |
|---|---|
| Albite | Black Mt. |
| Alunogen | Nickel Mine |
| Almandite | Black Mt. and other places |
| Amblygonite | Black Mt. |
| Apatite | Black Mt. Small white crystals and gray nodules |
| Autunite | Black Mt. |
| Arsenopyrite | White Cap |

| | |
|---|---|
| Beryl<br>Aquamarine<br>Massive white | Black Mt. Also Ellis River mica mine |
| Biotite | In many places |
| Cassiterite | Black Mt. |
| Chalcopyrite | Near the Falls. In quartz. Not abundant |
| Cleavelandite | In several places on Black Mt. |
| Columbite | Black Mt. |
| Cookeite | Black Mt. |
| Copperas. Iron sulphate | Several places |
| Cymatolite | North Rumford |
| Damourite | Black Mt. |
| Essonite | At the falls |
| Ferromanganite | North Rumford |
| Graphite | Near Rumford Point |
| Indicolite | Black Mt. |
| Kunzite | Black Mt. A few very good specimens |
| Lepidolite | Black Mt. Abundant |
| Limonite (Bog ore and ochre) | North Rumford. Silver Farm. At the so called Paint Mine |
| Manganite (Pseudomorph after some carbonate) | Black Mt. |
| Manganoapatite | Black Mt. |
| Manganocolumbite | Black Mt. |
| Margarodite | Black Mt. |
| Microlite | Black Mt. Some small but fine crystals |
| Montmorillonite | Black Mt. |
| Orthoclase | Many places |
| Muscovite | Black Mt. Ellis River Mica Mine. Abundant |
| Muscovite-Plumose | White Cap |
| Pinite | Black Mt. |
| Pollucite | Black Mt. Sparingly |
| Pyrite | In many places |
| Pyrolusite | Nickel Mine |
| Pyroxene | Rumford Falls |
| Pyrrhotite | Black Mt. and Nickel Mine |

| | |
|---|---|
| Purpurite | Black Mt. |
| Rubellite | Black Mt. |
| Quartz. (Milky, Rose, Smoky) | Goddard Ledge and various places |
| Scapolite | Rumford Falls |
| Spessartite | Black Mt. |
| Sphalerite | Goddard Ledge |
| Spodumene | Black Mt., North Rumford, Abbott Farm. Abundant |
| Torbenite | Black Mt. Rarely |
| Tourmaline (black and other colors) | Black Mt. Abundant but little gem material |
| Triphylite | Black Mt. and North Rumford |
| Uranophilite | Black Mt. |
| Zircon | Black Mt. Small brown crystals |

This is a considerable list for one town but probably does not include all that might be found there. I believe that I can vouch for all listed though one might search a long time for some of them. Vesuvianite has been reported in Rumford but I never have found it there though it does occur in Roxbury and Woodstock.

(Signed) E. M. Bailey

# THE NATURAL HISTORY OF MAINE MINERALS

By Edward H. Perkins

Minerals may be studied in two ways; they may be collected as rare and beautiful specimens, or they may be looked upon as records of the past and studied for the light they throw upon the processes that go on in the great chemical laboratory of the earth's crust. It is to this latter method of study that the term Natural History may be applied.

Minerals may be classified into groups based on their methods of origin. Primary minerals are those which occur in their unaltered form as they crystallized from the parent rock solutions. The quartz and feldspar of our granite masses are good examples of primary minerals. The molten rock solutions, loaded with gases and fluids, were intruded into the crust from below and upon cooling the crystals of the quartz and feldspar took form throughout the mass until what was once a fluid became a mass of interlocking crystals.

Secondary minerals are those which have been altered from their primary form. The feldspar of the granite under the action of the moisture and gases of the atmosphere alters to the secondary mineral Kaoline, a white earthy substance very different from the hard crystalline feldspar. Other good examples of secondary minerals are serpentine, or soapstone, from primary hornblende and pyroxene and the red iron oxide, hematite, from the yellow iron sulfide, pyrite. In fact all soils are made up of secondary minerals formed by the decomposition of the primary species.

Both primary and secondary minerals may be formed in a variety of ways. Several of these methods of mineral formation will be considered with especial reference to their occurrence in Maine.

Over large areas in the State the bed rock consists of numerous foliated rocks known as gneisses and schists. These represent igneous and sedimentary rocks which have been altered into their present form by the action of heat and pressure beneath the earth's crust. These agents have caused a distinction of the former minerals and the development of new forms, namely white mica, or muscovite, black mica or biotite, and hornblende. These new minerals arrange themselves at right angles to the pressure which caused them, and parallel to each other, thus forming the characteristic banded or foliated structure.

Other metamorphic minerals are developed by the action of the intruded granite magmas upon the surrounding rock. Great pressure and heat may be developed by the intrusion which will form a foliated structure similar to that described above. In this case the foliation will tend to surround the intruding granite. Such contact metamorphism seems to be rare in Maine.

Much more common is the metamorphic effect of the vapors and liquids of the intruding rock upon the intruded rock. These substances along with the heat and pressure may exert a very great effect on the surrounding rock, the exact nature of the change being dependent upon the nature of the contact rock. In the neighborhood of Rockland are bodies of impure limestone which were once organic or inorganic precipitates in a precambrian sea. Later they were folded into tightly compressed folds and intruded by granites and diorites. The action of these agents has been to recrystallize the limestone into an impure marble with veins and pockets of secondary calcite, while the sandy impurities of the original limestone have formed needles of tremolite whose cleavage surface sparkle on a fresh broken surface. If the limerock is still more impure a lime schist is formed in which great masses of dark brown Vesuvianite crystalize. Such rocks have been found in Maine at Sanford and Raymond. Large garnet crystals are formed by the same processes in shales and fine-grained sandstones. Sometimes it may be clearly seen that these garnets developed at the expense of the surrounding rock. At Freeport for example, there is an igneous gneiss rich in dark garnets. Each crystal is surrounded by a zone of light colored rock from which all dark material has been removed to form the garnet. Under certain conditions other minerals may be developed by contact metamorphism. At the south end of China Lake and along the road between Phillips and Rangeley, staurolite is found in well-developed crystals, often taking the form of crosses. Pleasant Pond Mountain, to the east of Carratunk, seems to be a mass of andalusite schist with a core of granite. On the western slope of the mountain, ledges occur which are full of the variety of andalusite known as chiastolite, showing well-developed crosses in cross-section. Another closely related mineral is cyanite which has been found about Windham. All these minerals seem to have developed subsequent to the active work of heat and pressure as they are not crushed or foliated but cut the earlier developed foliation at various angles. The period of crystal formation seems therefore, to represent the last stages of the metamorphic processes.

The most variable and interesting minerals in Maine are those associated with the belt of pegmatite which extends from Topsham northwestward to Newry. A pegmatite may be defined as a rock having the compostion of a granite but with gigantic crystals and associated rare minerals not contained in a normal granite. Such rocks probably represent the end phase of the formation of a granite mass. A magma of granitic composition is intruded into the upper parts of the earth's crust and crystallization sets in. A spongy mass of crystals is formed similar to the pulp in a cider mill. Compressions force the last juices into the surrounding rock as cider is forced from apple pulp. The rock juice is rich in vapors of water, fluorine and boron which render it very fluid and give it great penetrating power. The material is forced up into cracks which it enlarges by dissolving and replacing the surrounding rock.

The effect of this absorption is well shown by comparing the pegmatites of Topsham and Auburn. In the former locality the pegmatite juices have absorbed amounts of biotite schist which is recrystallized with pegmatite as sheets of black mica. At Auburn where the surrounding rock contains little biotite that mineral is very rare in the pegmatite. Once the pegmatite has formed its chamber and come to rest crystallization sets in and through slow crystallization the great masses of feldspar and quartz are formed along with rarer minerals. Below the surface, however, intrusive processes are still active and new juices and vapors pass up into the solid pegmatite. These have great solvent power and dissolve the pegmatite just as the pegmatite dissolved the surrounding rock.

In these solution cavities thus formed are crystallized the rare minerals and gem stones such as beryl, tourmaline, apatite, lepidolite and cookite. Other solutions may follow each depositing its minerals until the resultant pegmatite deposit is a composite of all the various solutions which have come from the parent magma deep beneath the surface. With the final cooling of the magma the intrusive processes cease but surface and ground waters continue active in the decomposition of the primary minerals forming such secondary minerals as kaolin, montmorillonite, psilomelane, maganite, and rhodochrosite. These processes are still active and bring to a close the long series of chemical reactions associated with pegmatite formation.

# OUR MAINE EARTHQUAKES

By Edward H. Perkins

New England is not usually considered as part of an active earthquake belt and indeed it is not to be compared to such regions as the west coast of the United States and the islands of Japan. However, with a record of about 350 earthquakes between 1627 and 1928 or an average of about 1 1-6 shocks a year it is clear that New England cannot be considered an area of perfect crustal stability. These shocks have been by no means evenly distributed in time but seem to group themselves into periods of activity and quiescence. For example, 65 earthquakes are recorded between 1727 and 1737, 56 between 1843 and 1855, while the series which started in September 1924, has already exceeded the past groups in number. This excess in numbers for the present series may be in part due to better observation of the weaker shocks while in the earlier series only the more severe shocks have been recorded.

The earthquakes which have shaken New England have varied greatly in intensity from slight shocks hardly felt in a small localized area up to the great shock of February 28, 1925, which jarred 2,000,000 square miles. Earthquakes are classified according to a standard scale of intensity known as the Rossi-Forel Scale. This Scale is given in Table 1, from which it will be seen that earthquakes are divided into ten groups ranging from the hardly appreciable tremors of Group I up to the great earth-shakers of Group X. Table 2 gives the recorded earthquakes of intensity VII or over which have been recorded in Maine.

## TABLE 1

## ROSSI-FOREL SCALE OF EARTHQUAKE INTENSITIES

I. Microseismic shock: recorded by a single seismograph or by seismographs of the same model, but not by several seismographs of different kinds; the shock felt by an experienced observer.

II. Extremely feeble shock: recorded by several seismographs of different kinds; felt by a small number of persons at rest.

III. Very feeble shock: felt by several persons at rest; strong enough for the direction and duration to be appreciable.
IV. Feeble shock: felt by persons in motion; disturbances of movable object, doors, windows; creaking of ceilings.
V. Shock of moderate intensity; felt generally by everyone; disturbance of furniture, beds, etc.; ringing of swinging bells.
VI. Fairly strong shock: general awakening of those asleep; general ringing of swinging bells; oscillation of chandeliers; stopping of pendulum clocks; visible agitation of trees and shrubs; some startled persons leave their dwellings.
VII. Strong shock: overthrow of movable objects; fall of plaster; ringing of church bells; general panic, without damage to buildings.
VIII. Very strong shock: fall of chimneys; cracks in walls of buildings.
IX. Extremely strong shock: partial or total destruction of some buildings.
X. Shock of extreme intensity: great disaster, buildings ruined; disturbance of strata, fissures in the ground, rock-falls from mountains.

In general an earthquake decreases in intensity from the epicenter, or the point on the surface over the focus, toward the margin of the disturbed area. This distribution of intensity, however, may be very irregular, areas of slight intensity being surrounded by areas of greater intensity and *vice versa.* Damage tends to be much greater on loose unconsolidated deposits than on solid bed rock. During the earthquake of February 28, 1925, serious damage was done along the water front of the city of Quebec while the inhabitants of the upper town on solid rock hardly noticed the tremors. This relation between the nature of the rock and the intensity of the shock was also indicated in the same quake on a much broader scale. An investigation of this earthquake by Doctor Arthur Keith of the United States Geological Survey showed that the areas of greatest intensity were those of the weaker rocks such as the Triassic sandstones and shales of the lower Connecticut valley, the Paleozoic slates of the upper Connecticut valley, central and northeastern Maine, and northwestern Vermont; and the Carboniferous slates and sandstones of the Boston and Narragansett Basins. On the Precambrian and Paleozoic crystalline rocks separating these areas the intensity was much less.

Certain localities seem to be especially susceptible to shocks. Such an area is found in the town of Haddam, a short distance

TABLE II
LIST OF EARTHQUAKES OF EPICENTRAL INTENSITY OF VII OR MORE WHICH HAVE BEEN FELT IN MAINE

| Year | Day | Hour and Minute | Location of Epicenter | Intensity | | Approximate area shaken |
|---|---|---|---|---|---|---|
| | | | | At Epicenter | In Maine | |
| 1638 | June 11[1] | 2.00–4.00 P.M. | Off Cape Ann | VIII | VII | All New England |
| 1663 | Feb. 5[2] | 5.00–6.00 P.M. | St. Lawrence Valley | X | VII | Eastern part of North America |
| 1665 | Mar. 6[3] | | Quebec | VIII | IV | Northeastern North America |
| 1727 | Nov. 8[4] | 11.00<br>11.40<br>11.45 P.M. | Off Cape Ann | IX | VII | Maine, Virginia, Pennsylvania |
| 1732 | Sept. 16[5] | 11.00 A.M. | Quebec | IX | III | New England and Eastern Canada |
| 1755 | Nov. 8 | 4.11 A.M. | Off shore east of Boston | IX | VII | Halifax to South Carolina to Great Lakes |
| 1857 | Dec. 23 | 1.30 P.M. | Near Lewiston, Me. | VII | VII | Southern Maine |
| 1860 | Oct. 17 | 6.00 A.M. | St. Lawrence Valley | VIII | III | Quebec to New Jersey |
| 1869 | Oct. 22 | 6.00 A.M. | Bay of Fundy | VIII | III | New England and Maritime Provinces |
| 1870 | Oct. 20 | 11.25 A.M. | St. Lawrence Valley | IX | IV | New Brunswick to Iowa and Virginia |
| 1893 | Nov. 27 | 11.50 A.M. | St. Lawrence Valley | VII | III | Quebec, New England, New York |
| 1904 | Mar. 21 | 1.04 A.M. | Near Eastport, Me.[6] | VII | VII | New England and Maritime Provinces |
| 1918 | Aug. 20 | 11.20 P.M. | Near Norway, Me. | VII | VII | Southwestern Maine |
| 1924 | Sept. 30 | 3.50 A.M. | Western N. Brunswick | VII | III | Quebec, New Brunswick, No. Maine |
| 1925 | Feb. 28 | 9.19 P.M. | Murray Bay & Three Rivers, Quebec | IX | VI | Eastern No. America |
| 1926 | Aug. 28 | 2.00 P.M. | Near Rangeley Lakes | VII | VII | Western Maine east to Monson |

[1]June 1, Old Style. [2]Jan. 26, Old Style [3]Feb. 24, Old Style.
[4]Oct. 28, Old Style. [5]Sept. 5, Old Style.
[6]The slight earthquake of November 19, 1928, was probably near this epicenter.

east of the Connecticut River in central Connecticut, where quakes have occurred since colonial times. Another similar locality may have developed at Monson, Maine. The Rangeley earthquake of August 28, 1926, was centered about the Rangeley Lakes but a belt of fair intensity extended northeastward to Monson. During the early part of 1928 Monson was the center of a series of tremors which, while maintaining about the same intensity at the epicenter, rapidly diminished in areal extent. The areal effect of an earthquake is dependent upon the depth of the focus; the greater the depth the greater the area affected, but the less the intensity above the focus. The great earthquake of 1925 which was felt from the Atlantic to the Mississippi and from central Ontario to South Carolina must have had a deep seated focus, while the local Monson quakes may have been located at relative shallow depths. The decrease in the area affected with a constant intensity may indicate an upward movement of the Monson focus.

In addition to areas of earthquake susceptibility there are linear belts of weakness which are especially liable to earthquakes. One of the most famous of these belts is the San Andreas rift which may be traced for several hundred miles along the coast of California. A horizontal movement of from five to twenty feet along this rift was the cause of the San Francisco earthquake. This is a good example of a "live" fault line. Along the Atlantic coast several of these rifts have been recognized but have been supposed to be "dead." The best known is "Logan's Line," named from the Canadian geologist who first mapped it, which extends down the St. Lawrence Valley from Montreal to the sea. As one sails down the great river toward the gulf to the north one sees the ancient crystalline hills of the Laurentian plateau while to the south the shores are lined with fossiliferous sediments which have been thrust northward against the crystallines from their place of origin an unknown distance to the south. The zone of weakness due to the breaking and shattering of the rocks along this belt has determined the location of the St. Lawrence Valley. This rift is very ancient as in the city of Quebec occur beds of conglomerate with gigantic boulders which some geologists consider as slides due to earthquakes along Logan's Line during the Ordovician period hundreds of millions of years ago.

As many of the recent earthquakes seem to have their foci on or near Logan's Line this rift may still be active.

The study of the 1925 earthquake has indicated other lines of intensity in New England. One belt follows the St. Johns valley in northern Maine and crosses Logan's Line near Murray Bay, which place was one of the foci of the great quake. A second belt crosses central Maine and disappears in the wilderness area to the northwest. As the second focus of the 1925 quake was near Three Rivers an extension of the central Maine belt may cross Logan's Line at this place. The third and chief belt of high intensity in New England extends from northwestern Vermont into Cape Cod. The fourth belt follows the Connecticut Valley northward from Long Island Sound. Like Logan's Line this is very ancient, as faulting along this line certainly occurred in the Triassic Period and possibly much earlier. A fifth belt follows the western border of New England. The spots of greatest intensity come where these lines intersect. Off the coast in the Gulf of Maine is a submerged cliff which falls into line with an ancient rift in the Bay of Fundy. It is possible that this may be a "live" earthquake line as some of the shocks which have shaken New England in the past appear to have their origin off the coast. This Fundian Fault, as it is called, if active, is the danger point for our coastal cities. There is, however, the possibility that the escarpment may be a submerged cliff formed by marine erosion when the land stood at a higher level.

The origin of earthquakes has always attracted the attention of scientists. The views held during colonial times are well expressed in the following quotation from a "Lecture on Earthquakes" given on November 26, 1755, by John Winthrop, professor of mathematics and philosophy in Harvard College.

He conceived a heterogeneous earth containing within it "many large holes, pits and caverns. There are very probably long, crooked passages, which run winding through a great extent of earth and form a communication between very distant regions. Some of these cavities are dry, and contain nothing but air, or the fumes of fermenting minerals; in others are currents of water.

"You have seen that there are in the bowels of the earth inflammable materials of various kinds and in large quantities;

some in the form of solid or liquid bodies and others in that of exhalations and vapors; that there are also powerful principles constantly at work which are capable of inkindling these materials into an actual flame; and that the vapor generated from such flame will endeavor to expand itself on all sides with immense force. If now these inflammable vapors be pent up in close caverns, so as to find no vent till they take fire in any part, the same will spread itself, wherever it meets with materils to convey it, with as great rapidity, perhaps, as it does in a train of gunpowder, and the vapors produced from thence will rush along through the subterranean grottoes as they are able to find or force themselves a passage; and by heaving up the earth that lies over them, will make that kind of progressive swell, or *undulation,* in which we have supposed earthquakes commonly to consist; and will at length burst the caverns with a great shaking of the earth, as in springing a mine; and so discharge themselves into the open air."

Modern geologists classify earthquakes into two groups: volcanic earthquakes due to movements of lava in the upper crust, and tectonic earthquakes due to movements of the crust itself. It is very clear that vulcanism plays no part in causing the modern New England earthquakes, which therefore must be placed in the tectonic class. This type of earthquake is especially abundant in youthful mountain regions where compression of the earth's crust is forcing folded and faulted masses of rock upward. These processes are very active about the Pacific Ocean but a moment's consideration will lead one to reject active mountain making movements as the cause of Maine earthquakes. Some other cause must therefore be sought for the present movements. New England, like the rest of the northeastern North America, has recently recovered from a great glacial period during which even the highest mountain tops were under the ice. The great weight of the glacier depressed the country beneath; most where the ice was thick, to a less extent where the ice was thin. During the thousands of years of glaciation slow rock flowage from under the overloaded section caused an elevation of the surface in front of the glacier, just as putty pressed under a board will flow out and bulge up about the edges. With the retreat of the ice the crust slowly readjusted itself; the frontal bulge sank, while the depressed portions rose, the elevation being greatest where the depression was greatest. This upward movement is recorded in Maine by shorelines which are found at elevations of 240 feet on Mount Desert Island, 270 feet near Rockland, 310 feet near Bucksport, 350 feet near Belgrade, 460 feet near Bingham, while uplift of over 600 feet are recorded in the St. Lawrence valley.

That New England has not as yet reached its preglacial elevation is indicated by the submerged coastline of Maine where the many islands and bays show that a hilly topography is drowned beneath the sea. The uplift in response to the melting of the glacier caused stresses in the rocks which accumulated until the elastic limit was reached, the rocks then giving way with a snap, causing the vibrations we call earthquakes. The stresses may be relieved by a few large movements or a series of small movements. Once the stress is relieved a period of quiescence follows, during which renewed stresses accumulate to be relieved by another series of shocks. The yield to the stresses comes chiefly along the zones of weakness which have been described.

We do not know whether the present series of quakes which started on September 30, 1924, has relieved the accumulated stress or not. If so, the shocks will decrease in number and intensity, but if considerable stress is still unrelieved we may look for a continuation of shocks of varying degrees of intensity. The other two periods of activity lasted for ten and twelve years and if the present period is to be of the same length we may expect a continuation of earthquakes until about 1934 or 1936. The earthquake of February 28, 1925, was one of the really great earthquakes, which if located beneath a large city would have done tremendous damage. It is doubtful if any of the future shocks will be of equal intensity. It is fortunate that none of our belts of great intensity, with the exception of Logan's Line in Quebec, pass very near large cities. The evidence, therefore, seems to indicate the recurrence of many slight earthquakes, but the chance for a very destructive tremor seems to be slight.

# THE IGNEOUS ROCK OF MT. KINEO AND VICINITY

By Edward S. C. Smith

## INTRODUCTION

Moosehead Lake lies wholly within the limits of Piscataquis County, Maine, and is the largest lake in that State. It is forty miles in its greatest length and twelve in its greatest width, although where widest, numerous islands reduce the distance across actual water surface. No detailed study of the lake as a physiographic feature has yet been undertaken, but it is evidently the result of the damming of connecting valleys by glacial debris, and is much smaller than it was just after the ice sheet disappeared, at which time it was doubtless united with Brassua Lake on the west and Spencer Lake on the east. At approximately its mid-point the width of Moosehead Lake is reduced to three-fourths of a mile, and here on the east side of the lake, like a miniature Rock of Gibraltar, abruptly rises Mount Kineo.

It is a typical glaciated mountain with a gentle northwest slope well banked with till, whose east and southeast sides are precipitous cliffs developed by glacial plucking and scouring and at present maintained chiefly by frost action. The most spectacular side of the mountain is on the east where vertical walls are to be seen rising eight hundred feet from the water's edge. It is reported that the cliffs extend below the water for nearly one hundred feet, and while it was impossible to secure exact figures it is certain that the rock walls must continue to a considerable depth. The summit of the mountain is eighteen hundred six feet above tide or about eight hundred feet above the lake level.

The prominent position of Kineo together with its bold outline and sheer precipices usually prevents the casual observer from noting that it is but one of a series of similar prominences at least two of which are larger in bulk and somewhat higher. These two are Blue Ridge to the southwest and Little Kineo (unfortunately so named) to the northeast; other hills or small mountains in this series are Shaw Mountain and Table or Eagle Mountain. These mountains are in exact alignment or a northeast bearing and are all composed of the same material, rhyolite. It is the purpose of this paper to present the results of a field study of these rhyolite hills whose aim was to determine the nature, the origin and if possible the age of this igneous rock which is exposed as a nearly continuous mass sixteen miles in length and nearly half a mile in width, and outcropping as the above-mentioned series of mountains.

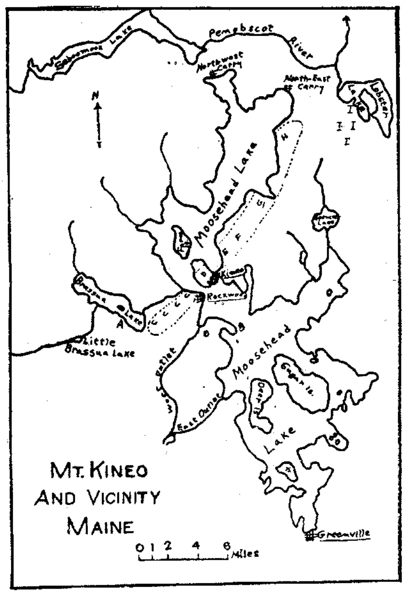



Fig. 1.—A, Rhyolite on west side of Brassau Lake; B, Rhyolite on south side of west outlet of Moosehead Lake; C, Blue Ridge; D, Mount Kineo; E, Shaw Mountain; F, "Little" Kineo; G, Eagle or Table Mountain; H, Norcross Mountain; I, Lobster Mountains. Dotted lines indicate probable limits of main body of rhyolite. Blank areas chiefly sediments.

The entire region which was examined in the course of this field study lies upon the Moosehead Plateau, described in a previous part of this paper, a generally flat to gently rolling upland averaging twelve-hundred feet above sea level. This plateau is composed of sedimentary rocks of about middle Paleozoic age intermixed with great masses of crystalline rocks, igneous and metamorphic, many of which form residual mountains.

While the immediate vicinity of Mount Kineo is readily accessible the rest of the area is not and although old lumber roads may be used to some extent much of the traversing is done in rather a wilderness. Two recent and well-executed sheets of the U. S. G. S. Topographic Atlas were used for the vicinity of Mount Kineo and Brassua Lake. For the rest of the area, maps furnished by the Maine Forestry Department and commercial County maps were used.

## HISTORICAL REVIEW

The first geological description of Mount Kineo seems to have been from the pen of Dr. Charles T. Jackson,[1] first State Geologist of Maine. Jackson describes the mountain as "composed entirely of a bluish hornstone, like flint, exceedingly hard and compact. After long exposure the surface of the stone becomes white." Farther on he states that "Hornstone which will answer for flints occurs in various parts of the State, where trap rocks have acted upon siliceous slate. The largest mass of this stone known in the world is Mount Kineo upon Moosehead Lake which appears to be entirely composed of it* * *" It is evident that Jackson believed Kineo to be made up of a rock which was once a sediment since altered by igneous activity. If Jackson recognized any part of the exposed rock as igneous he did not state it in his report.

Henry David Thoreau visited Kineo in 1857 and while he contents himself with quoting Jackson as to the kind of rock composing the mountain, he was apparently the first person to recognize a definite series of similar hills. After describing Kineo he mentions "two other allied mountains ranging with it northeasterly, presenting a very strong family likeness, as if cast in one mould."[2]

The second survey of the State was commenced in 1860 under the direction of Charles H. Hitchcock and in the preliminary report issued in 1861[3] John C. Houghton, the assistant

[1] Second Annual Report on the Geology of The Public Lands Belonging to the two States of Maine and Massachusetts, by C. T. Jackson, Augusta, 1838, page 60. This report was also published in Boston by Dutton and Wentworth and appeared as a document of the Massachusetts General Court.

[2] The Maine Woods, in the Manuscript edition of the writings of Henry David Thoreau, Houghton Mifflin Co.

[3] Preliminary Report upon the Natural History and Geology of the State of Maine, in the Sixth Annual Report of the Secretary of the Maine Board of Agriculture, 1861, page 432.

geologist, described Kineo as did Jackson, as a mass composed of "blue hornstone or flint," also stating that just opposite Kineo was a lower hill made up of the same rock. Houghton, however, did not observe the others. The next field season Prof. Hitchcock himself visited the mountain. He called it siliceous slate but adds "hornstone and flint are other common names for this rock."[1] Thus it appears that Hitchcock was under the impression that the rock was of sedimentary origin, in fact it is now referred to as "flint" locally.

Prof. Herbert E. Gregory made a reconnaissance about Kineo and the Allegash River[2] in connection with his work on the Aroostook County volcanics.[3]

The Kineo rhyolite breaks with a rather good conchoidal fracture and was especially desired by the aborigines, for it can be easily chipped; and they utilized this material for making tools and weapons as the numerous artifacts that have been recovered nearby mutely attest.

The archeologists have been very active in the vicinity of Kineo and papers are available for reference from Willoughby,[4] McGuire[5] and Moorhead.[6]

## GENERAL GEOLOGY

There are but two distinctly separate formations that need be here considered, namely, the Kineo rhyolite and the Moose River sandstone, which latter formation is penetrated by the former. The Moose River sandstone occupies a large area in the State of Maine extending through Somerset, Piscataquis and Penobscot counties. As this has been described in Part One of this paper little will be said other than that it is typically a rather thick-bedded, fine-grained argillaceous

[1] Second Annual Report upon the Natural History and Geology of the State of Maine, in the Seventh Annual Report of the Secretary of the Maine Board of Agriculture, 1862, page 331.

[2] Personal communication.

[3] Contributions to the Geology of Maine, by Henry S. Williams and Herbert E. Gregory, U. S. G. S. Bulletin 165, 1900, Part II, Geology of the Aroostook Volcanic Area.

[4] Prehistoric Burial Places in Maine, by Charles C. Willoughby, in Archeological and Ethnological papers of the Peabody Museum, Harvard University, vol. I, No. 6.
Prehistoric Workshops at Mt. Kineo, Maine, by Charles C. Willoughby, The American Naturalist, Vol. XXV, No. 411, March, 1901.

[5] Ethnological and Archeological Notes on Moosehead Lake, Maine, by Joseph D. McGuire, American Anthropologist, New Series, Vol. 10, page 549.

[6] Archeology of Maine, by Warren K. Moorhead, Andover Press, 1922. The chief geological interest in these relics rests in the utilization of the natural fracture of the rock for the development of artificial forms and in the study of the weathering effects on the rhyolite. This will be discussed on another page.

sandstone of dark greenish or bluish gray color, which locally may become either shaley or quite siliceous. Its structure seems to be that on an asymmetric syncline whose axis is north-east south-west. The steeply dipping beds appear on the south-east side of the anticline and the rhyolite seems to come in a little north-east of the axis. Except in a few places where the sandstone has been well soaked with quartz, evidences of any sort of contact metamorphism were lacking. This mass of igneous rock can be traced with only slight interruptions for sixteen miles, and by means of a fortunately placed railway cut, it is possible to follow the sedimentary rocks completely around the south-west end, thus definitely bounding it there.

In the wilderness on the north-east it is not as easily traced. It was, however, possible to work around the end of the last ridge, Norcross Mountain, and to observe for some miles around the lowland which must indicate an extensive area of some easily eroded rock. Some six or seven miles north-east of Norcross Mountain is an irregular group known as the Lobster Mountains. These the writer visited. The rock making up the bulk of the mass is a rather coarse quartz-feldspar-porphyry which is associated with a rudely stratified tuff or breccia. Whether these rocks bear any definite relation to the Kineo rhyolite cannot at present be shown. There are, however, two small areas of rhyolite of the Kineo type appearing as little stocks at short distances from the main body as shown on the map (Fig 1). The connection of these bodies with the principal mass is not to be observed at the surface. They are probably apophyses which have followed very localized lines of weakness. There is no direct evidence that any of this igneous rock ever reached the surface, but such a consideration is strongly suggested.

## PETROGRAPHY

In the hand specimen the fresh rhyolite is a dense grayish green rock whose only visible mineral constituent is quartz which appears as minute but usually distinguishable phenocrysts. Flow structure in a vertical direction if often to be observed. Splendid outcrops near the Mt. Kineo Hotel show great curving joint faces, the system being: N.40 E, dipping

15 N; N.55 W, dipping 80 S; N.105 W, dipping 70 W. There is reason to believe that there is considerable variation from these observed figures.

On being subjected to long-continued weathering the rhyolite becomes light buff or whitish, and the decay of the feldspathic material surrounding the quartzes permit them to drop out, forming a pitted surface. A point worthy of note is that in so far as the color change is concerned it seems to be in the nature of a photo-chemical effect. Artifacts secured from old beaches in the vicinity of Rockwood which have been submerged since the construction of dams at the east and west outlets show bleaching on the upper surface only. The lower or under side usually is the familiar greenish tinge. This effect was noted by McGuire.[1] Arrow points, knives and certain objects which the writer secured showed both these effects of weathering. One arrow point in particular had lost so many quartzes that it had begun to assume a rather porous appearance.

In thin section the rhyolite is seen to have a homogenous groundmass which under the highest power is revealed as chiefly quartz and feldspar. Scattered phenocrysts of quartz and feldspar occur sparingly in the matrix. The quartz shows undulatory extinction clearly showing that they are true phenocrysts. Occasionally the feldspars give evidence of strain and some are typically corroded. The feldspar is mostly orthoclase, often carsbad twins. Plagioclase is also present but in the sections studied did not give completely satisfactory results owing to unfavorably placed minerals. Positive identification has not been possible but they are probably albite or sodic oligoclase. Small amounts of magnetite are present as well as sericite and chlorite. The chlorite seems in part the alteration of biotite and has developed penninite. Thin sections from Blue Ridge and Norcross mountain show essentially the same mineral detail. The analysis of the Kineo rhyolite was made in the Geophysical Laboratory and is given in Table I together with that of the Haystack rhyolite described by Gregory.[2] For the sake of comparison an analysis of a rhyolite from Butte, Montana, described by Weed[3] is also included.

[1] McGuire, op. cit.
[2] Gregory, op. cit.
[3] Geology and Ore Deposits of the Butte district, Montana, by W. H. Weed. U. S. G. S. Professional Paper No. 74, 1912.

## AGE RELATIONS

As determined by Hitchcock[1] and Williams[2] the age of the Moose River Sandstone is Oriskany, and Clarke's later careful work[3] has shown this to be correct. The rhyolite made its appearence not earlier than Lower Devonian; it must be post-Oriskany. Doubtless a considerable period elapsed between the deposition of the sands and the advent of the igneous rock. It is not unlikely that the rhyolite appeared concomitant with the folding which affected the stratified rocks. The same uncertainty exists in regard to the previously mentioned rocks in Aroostook County. These rocks cut the Lower Devonian, but whether or not they are much younger is still unknown. Considerable areas of igneous rock yet remain to be studied in north Central Maine. At least one other extensive area of extrusive rock is known to exist, and there are probably others. The investigation of these other areas may lead to placing them all in their proper time relation, and may lead to definite conclusions concerning their areal distribution.

## SUMMARY

Moosehead Lake, Piscataquis County, Maine, is crossed at its mid-point by a dike-like mass of alkaline igneous rock which, because of its physical characters, chemical composition and field occurrence is assigned to the rhyolites. It is suggested that this rhyolite may be related to and of about the same age as the volcanics in Aroostook County. It is post-Oriskany in age.

## ACKNOWLEDGMENTS

The investigation of this area was carried on with the kind coöperation of Professor Edward H. Perkins, who undertook the details of the sedimentary formations, while the writer turned his attention to the igneous rocks. To Miss Mary G. Keyes of the Geophysical Laboratory is due the thanks of the author for undertaking the chemical analysis of the Kineo rhyolite, and for aid in securing aboriginal implements made

[1] Hitchcock, op. cit.
[2] Williams, op. cit.
[3] Early Devonic History of New York and Eastern North America, by John M. Clarke, Memoir 9, New York State Museum, 1909.

of the rhyolite he is under obligations to Miss Kathlyn Hilton of Rockwood. Mr. Neil Violette, Forest Commissioner of Maine, kindly furnished maps which were invaluable, and various officials of the Great Northern Paper Company materially assisted the writer in the field.

## TABLE I

Analyses of rhyolites

| | I | II | III |
|---|---|---|---|
| $SiO_2$ | 75.41 | 75.98 | 75.34 |
| $Al_3O_2$ | 12.89 | 12.34 | 12.97 |
| $Fe_2O_3$ | 0.08 | 0.85 | 0.75 |
| FeO | 1.79 | 0.93 | 0.54 |
| MgO | 0.01 | 0.15 | 0.86 |
| CaO | 1.09 | 0.13 | 0.85 |
| $Na_2O$ | 2.87 | 4.02 | 2.49 |
| $K_2O$ | 4.63 | 4.44 | 4.72 |
| $H_2O$ (plus) | 0.56 | 0.64 | 1.11 |
| $H_2O$ (minus) | 0.06 | 0.24 | 1.03 |
| $TiO_2$ | 0.10 | 0.17 | 0.18 |
| $ZrO_2$ | | 0.03 | 0.05 |
| $P_2O_5$ | 0.12 | 0.03 | 0.07 |
| MnO | 0.06 | trace | $SO_3$—0.03 |
| BaO | | 0.07 | 0.07 |
| | 99.67 | 100.02 | 100.06 |

I. Rhyolite, Mt. Kineo, Maine. Analysis by M. G. Keyes, Geophysical Laboratory.
II. Rhyolite, Haystack Mountain, Maine. Analysis by W. F. Hillebrand, U. S. Geological Survey.
III. Rhyolite, Hyde Park Dike, Butte district, Montana. Analysis by H. N. Stokes.

# A NEW RHYOLITE FROM THE STATE OF MAINE

By Edward S. C. Smith

## INTRODUCTION

The paper following is the first of a series which is to deal with the geology of an area of igneous rocks, both intrusive and extrusive in the central part of the State of Maine, together with some associated sediments. Out of these igneous rocks the agents of erosion have carved several mountain groups, the highest of which is that of Mount Katahdin, 5,267 feet in elevation.

## GENERAL GEOLOGY

The rhyolite which is to be described in this article lies somewhat to the north and east of Mount Katahdin, which itself consists of granite. While tracing the extent of the latter rock in 1923, the writer first made the discovery of rhyolite on Pogy Mountain, a lesser eminence, about two miles north of the last exposure of granite. At that time only a small outcrop was encountered, but subsequent field studies have shown that these effusive rocks cover a territory of about fifty square miles and include the above-mentioned Pogy Mountain, South Branch Mountains, Horse Mountain and Traveller Mountain, the last the most extensive arealy and the highest.

The rock varies somwhat in appearance from a black or greenish black rhyolite to a bluish green or bluish black felsite. In certain exposures the flow structure is beautifully preserved, in others absent. When it could be determined, the dip of the flow structure was north at varying angles, usually near 15°. At the Pogy Mountain outcrops the rhyolite becomes amygdaloidal.

There can be no doubt as to the surface character of much of this formation, which evidently represents a series of successive flows. The total thickness must be at least a thousand feet and may be considerably greater. Columnar jointing is common and excellent examples appear along the bed of the south branch of Trout Brook, west of Traveller Mountain.

In the hand specimen the typical black rhyolitic phases appear dense and suggestive of devitrified glass. Minute but identifiable crystals of quartz and feldspar are plentiful and epidote and calcite are present in the amygdules. The felsitic phases vary from a dense greenish rock with no visible phenocrysts to a felsitic porphyry with feldspars ranging up to 1.5 mm. in length in a dense bluish black groundmass. Detailed mapping of the various phases under the difficult field conditions was not considered advisable. The thin sections examined exhibit well developed phenocrysts of orthoclase,

TABLE I

ANALYSIS OF RHYOLITES

| | I | II |
|---|---|---|
| $SiO_2$ | 71.42 | 71.74 |
| $Al_2O_3$ | 13.22 | 13.26 |
| FeO | 1.82 | 1.74 |
| $Fe_2O_3$ | 3.21 | 3.09 |
| MgO | 0.51 | 0.61 |
| CaO | 2.00 | 1.92 |
| $Na_2O$ | 4.40 | 4.49 |
| $K_2O$ | 3.51 | 3.34 |
| $H_2O$ | trace | nil |
| $TiO_2$ | 0.23 | 0.23 |
| $P_2O_5$ | 0.05 | 0.06 |
| MnO | trace | trace |
| BaO | nil | nil |
| Total | 100.37 | 100.48 |

I. Rhyolite from Traveller Mountain.
II. Rhyolite from Pogy Mountain.
Both analyses from the Research Laboratory of the General Electric Company, Schenectady, N. Y.

plagioclase (about $Ab_5An_3$), quartz, magnetite, often enclosed by feldspar, and sericite. Greater magnification reveals green hornblende, a little apatite and a sprinkling of very minute grains with a high refractive index which are probably titanite. The groundmass is a completely crystalline mosaic of quartz and feldspar with the accessories named above. Micro flow structure is well shown and it is quite obvious that a considerable proportion of the feldspars had crystallized while a part of the lava was still in a very mobile state, as stringers of magnetite are seen to have swirled about them. There is no field evidence at present to show the presence of vents, but as no ash or tuff has been observed, the suggestion is made that the lava issued from fissures rather than as the result of explosive eruptions.

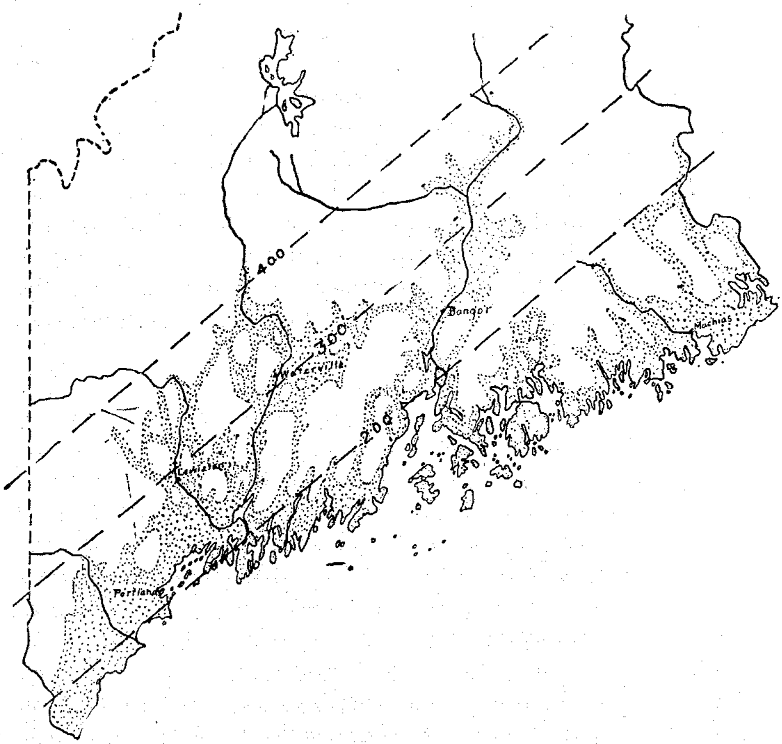
This is the fourth area of rhyolite to be reported from central Maine, others being the Aroostook volcanic area described by H. E. Gregory,[1] the Mount Kineo rhyolite described by E. S. C. Smith[2] and the Coburn Mountain locality discovered by E. H. Perkins,[3] but not yet described.

Two analyses of the rhyolite made through the courtesy of the General Electric Company are appended on p. 73, and it is of passing interest to note that although the specimens analyzed were taken from localities some miles apart they show a striking similarity in chemical composition.

[1] Williams, H. S., and Gregory, H. E., Contributions to the Geology of Maine, U. S. G. S. Bull. 165, 1900. Part 2, Geology of the Aroostook Volcanic Area.

[2] Contributions to the Geology of Maine, Number 2, part 2, The Igneous Rock of Mt. Kineo and Vicinity, this Journal 10, 437-444, 1925.

[3] Personal communication.




MAP OF SOUTHERN MAINE SHOWING DISTRIBUTION OF MARINE CLAYS AND AMOUNT OF POST-PLEISTOCENE UPLIFT

Dots indicate the area overspread following the retreat of the glacier and there mantled by marine clay. Dashed lines are isobases connecting points of equal uplift. Figures indicate the amount of uplift in feet.

# THE POST-PLEISTOCENE CLAYS OF MAINE

By Edward H. Perkins

Previous papers in the *Maine Naturalist* have listed the localities in the State where Paleozoic fossils have been found. It will be remembered that the youngest recorded fossils were the plant remains in the Upper Devonian sandstones and conglomerates of the Perry Basin north of Eastport. The millions of years included in the late Paleozoic, the Mesozoic, and the Ceneozoic eras are as far as is known not represented by any organic record. Certain formations along the coast between Casco Bay and Portsmouth have been mapped as Carboniferous,[1] but no fossils have been recorded from these beds. The remaining fossil beds of Maine belong to the unconsolidated clays and sands which were deposited immediately following the Pleistocene or glacial period.

The term clay has been applied rather loosely to various products of rock disintegration. Typically clay is a product of the chemical decomposition of rock rich in fieldspar and related minerals. The feldspar of such rocks is converted, chiefly by hydration, to the mineral kaolin which has the chemical formula of $H_4Al_2Si_3O_9$. When pure its percentage composition is:

| | |
|---|---|
| Silica, $SiO_3$ | 46.5 |
| Alumina, $Al_2O_3$ | 39.5 |
| Water, $H_2O$ | 14.0 |
| | 100.00 |

Kaolin, however, is rarely found pure on account of the presence of quartz, iron oxides, and other products of rock decay. It is to these impurities, especially the iron compounds, that the color of clay is due, while the change from a blue-gray to a reddish color in the process of making brick seems to be due to the dehydration of the iron oxides.

The post-glacial clays of Maine do not seem to be true clays made up of kaolin and the other products of decay but are composed of undecomposed rock flour ground from the granite and slate ledges by glacial erosion. This material was washed from the melting ice and deposited on land as mud flats or in fresh or salt water as waterlaid deposits.

The physical properties of the clays vary according to the nature of the water body in which they have been deposited. Most of the clays of Maine are clearly of the marine type, having been deposited in the sea when the land was at a lower level than at present. When the rock-flour is washed into the sea the action of the salt seems to precipitate the clay at once so that a dense mass of blue clay is built up with little if any signs of bedding. Marine clays are also characterized by dark purple stains which seem to be due to the action of sea water upon the iron content of the clays. The distribution

[1] F. J. Katz. Stratigraphy of Southwestern Maine and Southeastern New Hampshire. U. S. Geological Prof. Paper 108, 165-177. 1917

of the marine clays in Maine is indicated on the map. It will be seen that the clay was deposited in the bays and inlets of a coast line which was much more irregular than the present one. In fact the marked difference in the irregularity between the seacoast east of Portland and that west of Portland is due to the larger amount of clay in southern Maine.

The level of the clay plains rises from the coast inland until in the Kennebec valley above Waterville the elevation of 340 feet is reached. This difference in elevation is due to uplift since the glacial period. During the ice age Maine was depressed by the great weight of the glacier, and as the thickness of the ice increased inland the sinking of the land was greatest in that direction. With the melting of the ice, uplift started, but on account of the rigidity of the bed rock it lagged behind the retreat of the glacier. The sea, therefore, followed the ice front back until checked by elevation of the land. The inland regions which had suffered the greatest depression underwent the greatest amount of elevation during the period of recovery and therefore the inland clays are now at higher levels than those near the coast. So great was the lag of the earth movements behind the retreat of the ice that northern Maine and Quebec have not yet come to rest as is indicated by our recent earthquakes. In the coastal region of Maine uplift apparently went beyond the point of equilibrium and there have been recent downward movements which may still be in progress. On the map the amount of uplift is indicated by isobases or lines connecting points of equal elevation.

The clay as it settled in the salt water covered whatever happened to be below so that today we find clay resting indiscriminately upon solid rock, glacial till, or esker gravel.

Toward the end of the period of marine deposition the shoaling of the water and perhaps increased melting of the ice as the climate warmed up resulted in stronger currents which deposited sand over the clay beds. Where this sand has been exposed to winds, areas of drifting sand dunes have been developed. A good example of such an area is the so-called "Maine desert" in the town of Freeport.

To a geologist the most interesting feature of these clays are the fossils which have been found in many places in southern and central Maine. Not every clay pit will show fossils but when they do occur they are likely to be found in great abundance. In the Kennebec Valley fossils seem to be especially common where the clays rest upon eskers or "horsebacks". Perhaps these ridges of gravel rose to near the surface where food was more abundant than in the deeper parts of the valley. The most complete list of the post-Pleistocene fauna is the following which was taken from the paper by Dr. Little.[1]

| Species | Present Range |
|---|---|
| Astarte elliptica | Cape Cod northward |
| Astarte striata | Cape Cod northward |
| Asterias sp | |
| Balanus crenatus | Arctic to Long Island |
| Buccinum coerulea | |
| Buccinum cf. groenlandicum | |
| Cancer cf. irroratus | |
| Cardium (Serripes) groenlandicum | Greenland to Stonington |
| Cardium n. sp. (?) | |
| Cyclina sp. | |
| Discinisca cf. atlantica | |
| Leda pernula | Arctic to Long Island |
| Macoma balthica | Maine to Georgia |
| Macoma calcarea | Greenland to Stonington |
| Modiolaria discors | Newfoundland to Connecticut |
| Mya arenaria | Arctic to Florida |
| Mya truncata | |
| Mytilus edulis | Arctic to North Carolina |
| Natica clausa | Grand Manan to Cape Cod |
| Neptunea despecta tornata | Off Georges Bank |
| Nucula tenuis | Arctic to Hatteras |
| Pecten islandicus | Greenland to Connecticut |
| Pecten (Amusium) n. sp? | |
| Polinices groenlandica | Cape Cod northward |
| Polinices heros | Labrador to Virginia |
| Saxicava arctica | Arctic to West Indies |
| Spirorbis nautiloides | |

[1] H. P. Little. Pleistocene and Post-Pleistocene Geology of Waterville, Maine. Bulletin Geological Society of America, Vol. 28, 309-332. 1917.

| | |
|---|---|
| Trichotropis borealis | Cape Cod northward |
| Yoldia (Portlandia) glacialis | Greenland |

"Clapp, quoting Packard and Loomis, mentions *Nucula expansa* and *Purpura lapillus* as also occurring in Waterville."

The present range of the fauna as a whole seems to be in cool northern waters, perhaps a little colder than the Gulf of Maine today. The following plants have been found in the Waterville clays:[1]

| | |
|---|---|
| Populus balsamifera | Labrador to Maine |
| Ilex verticillata | Nova Scotia to Florida |
| Gaylussacia dumosa | Newfoundland to Florida |
| Vaccinium corymbosum | Maine to Florida |

The evidence from the fauna and flora thus indicates that the inlets of sea water were probably cooled by ice water from glaciers at the headwaters of the rivers while the land had a climate not far from that of the present time.

Miss Goldring[2] of the New York Geological Survey has made a study of the post-Pleistocene faunas of New York and has mapped the areas of fresh, brackish, and salt water from the physical conditions of the fossils which reflect the favorable or the unfavorable conditions under which they lived. As yet no such study has been made of the Maine faunas but there is evidence that the fossils vary in different parts of the clay covered area. For example, at Augusta there is a dwarf fauna with individuals averaging not over one fifth of the size of similar forms at Waterville sixteen miles up the valley. This dwarfing is probably due to unfavorable conditions, the water becoming either too cold or too brackish for the best development of the fauna.

Problems relating to the time and methods of deposition of the clays are still unsolved. It has been assumed that they were formed during a period of subsidence at the end of the glacial period which was followed by more or less rapid uplift until the present elevation was reached. Goldthwait and Antevs, however, have found evidence in the St. Lawrence Valley that during the period of clay deposition the land rose and fell several times, each movement being recorded by a

[1] Op. cit. page 320.

[2] Winifred Goldring. The Champlain Sea. Evidence of its decreasing southward as shown by the character of the fauna. New York State Museum Bulletin, No. 239-240, 153-194. 1922.

break or unconformity in the clay deposits.[1] Antevs has recently visited southern Maine but was unable to find evidence of such movements there.[2]

Recent studies by Professor Coleman in the lower St. Lawrence valley have shown that some of the fossiliferous clays were deposited in an interglacial epoch between two advances of the ice sheet instead of after the retreat of the last glacier.[3] In Maine no conclusive evidence of more than one glaciation has been recorded until recently. Last summer, however, Sayles and Antevs found evidence for multiple glaciation near Kennebunk.[4] The clays, however, seem to have been deposited subsequent to the latest glaciation. It is clear that much more study will be required before the complete story of glacial and post-glacial times in Maine can be written.

The fresh water glacial clays may be distinguished from salt water clays by the presence of seasonal bands or varvs and the absence of marine fossils. Unlike salt water, fresh water does not coagulate clay but allows it to remain in suspension for a considerable time. The result is that during the summer months the coarser material washed into the lake from the melting glacier will fall to the bottom while the finer material will remain in suspension until melting is checked by the coming of winter and will then slowly settle in the quiet water of the ice covered lake. Each year will therefore be recorded by a coarse summer layer and each winter by a fine clay layer. These varves will vary with the climate as a long summer with much melting will give a thick varve while a cool short summer will be represented by a thin varve. On the other hand a long cold winter will give a thick varve and a short warm winter a thin varve. A study of the varves of a clay deposit will therefore give some idea of the climatic changes at the time of deposition. The location of the glacial front may also be established from the study of the varves, as the nearer the lake is to the ice the greater the amount of sediment and the thicker the varves. By counting and measuring

[1] J. W. Goldthwait. Personal communication.

[2] Ernst Antevs. Late-Quarternary changes of level in Maine. Bulletin Geological Society of America, Vol. 38, 144-145. 1927.

[3] A. P. Coleman. Glacial and Interglacial Periods in Eastern Canada. Journal of Geology, Vol. 35, 385-409. 1927.

[4] R. W. Sayles and Ernst Antevs. Three Pleistocene Tills in Southern Maine. Bulletin Geological Society of America, Vol. 38, 142-143. 1927.

the varves the time required for the formation of the deposit may be found, the rate of retreat of the ice determined, and correlations made between clay deposits in different valleys. The best study of varve clays so far made in New England is that of Antevs, who found that it required 4,000 years for the ice to retreat from Hartford, Connecticut, to St. Johnsbury, Vermont.[1] In Maine the fresh water or varve clays should occur above the level of the marine clays but as far as the writer knows none have been recognized in the State. This is probably due to the fact that the region in which they should occur is in the forested and unsettled part of the State where the clay and gravel pits so necessary for the study of the formation are lacking.

The writer is making a study of the clays of the State and their associate problems. He will greatly appreciate it if readers of the *Maine Naturalist* will notify him of any localities for fossils or varve clays with which they may be acquainted.

[1] Ernst Antevs. The Recession of the Last Ice Sheet from New England. American Geographical Research Series No. 11.

# EVOLUTION OF MAINE SCENERY

EDWARD H. PERKINS

Maine is justly famous for its scenery; its lakes, streams, forests all play their part in making the state a mecca for the lovers of natural beauty. The lover of the beautiful in landscapes, however, is rarely aware of the long series of events which have all had their part in molding the hills and valleys of today. To the goelogist, however, who sees through the eye of science, each part of the view tells the story of its history; a history which dates back through the long ages to a time when the continent of North America was first taking shape and the lands and seas were in forms strange to modern eyes.

We will begin the story with the time known to the geologist as the mid Paleozoic Era. North America was already ages old and landscape after landscape had developed and passed away. At this time the appearance of North America was very different from today. Over Maine stretched a shallow sea peopled with a life strange indeed, but full of prophecy of what was yet to come. To the southwest the sea extended over what is now the interior of the continent, while to the east the waves washed the shores of the lost land of Appalachia which extended several hundred miles out into what is now the Atlantic Ocean. All through the early stages of earth history this continent has stood along the border of what is now North America. Sometimes it appears to have been a low plains region over which rivers meandered bringing little sediment to the western sea; at other times it rose into mountains whose tops reached the limit of ice and snow and whose mountain torrents washed coarse gravels and sandstones out to the sea margin. But through the ages whether it stood high or stood low, Appalachia contributed its waste to the sea. The bottom of this sea slowly sank beneath the increasing load of sediment so that the upper layers always remained at or near sea level. Finally, when the forested swamps of the coal age built out westward from the shore of Appalachia, the sediments had become forty thousand feet thick. For some time before the border land had been becoming unstable. Signs of uplift appeared in the sediments while volcanoes developed along the western side of Appalachia, now the eastern coast of Maine. The unrest cumulated in the Appalachain Revolution which closed the Paleozoic Era. Tremendous compression developed in the earth's crust and the thick mass of sediments were folded and faulted into mountains. Before and during the revolution great masses of molten rock material, known as magmas, worked their way up into the roots of the growing mountains. Today the upturned strata, folded and sheared over each other, tell the story of the great compression while the granite masses represent the intruded magmas.

The reign of the mountains was short, geologically speaking. Their very height contributed to their decay, for as they rose higher the forces of erosion, winds, ice, snow, rains, and mountain torrents, became more efficient. As long as the uplift was in excess of destruction the mountains grew, but with the decline of the internal forces erosion gained the upper hand and the ranges slowly wasted away. We can therefore picture the ancient Appalachain Mountains as young rugged peaks, snow topped, with torrents rushing down narrow gorges to the plains below. As time went on the peaks became rounded in form, and the gorges became broad open valleys through which enlarged rivers flowed to the sea. This topography was not much different from that of New England today. The end was not yet, however, for the streams continued their work, the rounded hills became still more rounded and lower, the valleys broader and flatter, until a great plain spread over the roots of the ancient mountains.

Once more the earth's crust became unstable and once more mountains lifted their crusts to the clouds. These new peaks, however, were very different from those which had preceded; for instead of folding, the crust broke into great blocks, some of which were tilted up to form uplands, while others dropped to form basins, until a topography developed very similar to the basin and range topography of the southwest of the present time. One great basin is represented by the Connecticut Valley while another was located in the region of the Bay of Fundy. Maine was probably an upland block between the two basins. Like the previous ones, the new mountains were subject to erosion and once more a great peneplain stretched over New England. It was on this plain that the present New England scenery first took form.

We must picture this plain of Cretaceous time as a rolling surface carved across the folded and faulted roots of the old mountains. Where the granite magmas had crystallized these more resistant formations had not been entirely reduced to the level of the weaker sediments about them and therefore rose as low hills on the plain. Such isolated elevations are called Monadnocks from the typical example, Mount Monadnock, in southern New Hampshire. The White Mountains, Mount Katahdin, and the other high mountains of Maine are good examples of such residual masses. On the Cretaceous peneplain they had no where near their present elevation which has been gained mostly by later uplift. The great plain sloped southeastward toward the Atlantic Ocean and down this slope flowed the ancestral New England rivers. As drainage of this type is a consequence of the slope of the land, such streams are known as consequent streams and are the first to develop in a newly exposed region. These streams flowed over the beveled rock structure crossing weak and resistant beds alike.

It was long supposed that the even skyline which is such a characteristic feature of central and southern Maine was the profile of the old peneplain now uplifted and eroded into hills and valleys. Recent study has shown, however, that the skyline is really a composite of plains at various elevations, the uppermost now only preserved in the resistant rocks of the interior representing the Cretaceous plain. The lower plains were formed during halts in later uplifts either by river erosion or landward planing of the ocean. Each of the plains is well developed in the valley floors of the central part of the state and widens out seaward until it forms a broad terrace top facing the sea. On the landward side of the flat the hills rise rapidly to the next level above while on the seaward side there is a similar sudden drop to a lower plain. The supporters of the marine erosion theory look on these terrace tops as wave cut benches and the rise on the landward margin as an old sea cliff now altered by subaerial erosion. Whatever may have been the details of its subsequent history, early in the Tertiary Period the plain was lifted and tilted to the southeast which revived the streams and caused them to intrench their valleys toward the new base level. The rocks over which the streams flowed were the planed off roots of the old mountain ranges. Folding and faulting along northeast-southeast lines had brought rocks of unequal resistance to the surface, forming northeast-southwest belts of varying resistance. As soon as the revived consequent streams began to cut downward they were at once affected by the resistance of the rocks they discovered in their beds and so erosion went on at varying rates. Streams which were working in the weaker beds had an advantage over those which were compelled to cut across the stronger strata and by headward erosion cut back and captured the headwaters of the later streams. These processes were revived with each successive uplift until before the glacial period the most of the streams had become adjusted to the weaker beds and only a few major streams held their course across the resistant beds which now rose as ridges between valleys carved in the less resistant material. Thus a former consequent was transposed into a subsequent adjusted drainage. This adjustment was more nearly complete in the central and southern part of the state where the northeast-southwest trend of the valleys is very pronounced. In the interior of the state, however, adjustment was much less complete and the major valleys still open to the southeast still following the old consequent course. Good examples of such valleys are those now occupied by the southern half of Moosehead Lake and by Pemadumcook, Chesuncook, and Chamberlain Lakes. Valleys of the subsequent are represented by the present Kennebec and Androscoggin valleys of southeastern Maine.

By the beginning of the glacial period the country had reached the stage of maturity. The hills were low and rolling save where masses of granite or other resistant rocks formed monadnocks which rose to higher levels. The various plains formed during halts in the uplift were indicated by hill tops and valley terraces. In general the topography was that of today, all the major mountains and valleys having their present form. The land, however, was higher and the rolling hill country extended far east of the present shore line. But although the general plan of the topography was the same as today the details were very different. Probably hardly a lake or waterfall existed in the state. The valleys were broad and open and occupied by streams which flowed with gentle gradients toward the sea. The rivers in some cases followed courses very different from those followed today. For example, the head waters of the Androscoggin flowed westward to the Connecticut River instead of eastward to Maine. The Kennebec River System probably shows as great changes as any in the state. To the east of the present Kennebec the ancient China River carried the drainage which now reaches the Kennebec from the east. To the west a stream probably rose northwest of Moosehead Lake and flowed south occupying parts of the valleys of the present Spencer Stream and the Dead, Carrabassett, Sandy, and Androscoggin Rivers. The pre-glacial Kennebec was left with a small drainage area passing through the present Belgrade Lakes.

The warm climate of the Tertiary Period gave place to the cold of the glacial period and great ice sheets spread over New England until the highest mountains were overtopped. The glaciers probably came not only once but several times separated by interglacial epochs at least as long as the time since the retreat of the last ice sheet. For a time after the melting of the lowland ice valley glaciers persisted in the mountains forming the great basins or cirques of Katahdin and the Presidential Range. Probably the ice did not recede northwest across Maine leaving a definite front, but melted in place as a mass of stagnant ice riddled by tunnels and caves. In these tunnels and caves, about the irregular edge of the ice, and about the detached ice blocks the waters from the melting ice piled sediments of various types making the eskers, kames, and irregular gravel deposits which mantle the present surface. As the ice melted away the sea took its place and spread a layer of marine sand and clay over the glacial deposits. When the land finally rose from the sea the rivers found themselves faced with conditions very different from those which preceded the ice age. The once open valleys were now choked by marine and glacial deposits and the streams were forced to seek new courses through and over these. As a result the valleys became the site of Maine's many lakes, some of which fill depressions left by melting ice blocks, while others were dammed behind eskers, deltas, or deposits so irregular that no name has been applied to them. The outlets of these lakes would overflow the basin rims at the lowest point which may or may not have coincided with the preglacial valley. In these new courses the streams often found themselves superimposed over ridges of bed rock and the falls which resulted giving Maine its abundant waterpower. In the course of the upper Androscoggin a gravel dam threw the waters of the river eastward into Maine. The old China River valley was dammed repeatedly and converted into a series of lakes which flow northward and westward into the Kennebec. The old river to the west was broken into the sections now known as the Moose, Dead, Carrabassett, and Sandy Rivers, all of which flow into the Kennebec which therefore became much arger than its preglacial ancestor.

Thus the present scenery gains its valleys, ridges, and mountains from the folded roots of the ancient Appalachain Mountains, its level plains from the long periods of erosion which followed the mountain uplifts, and its lakes and waterfalls from the deposits of the ice age.

If "the present is a key to the past" it may also be said that the past is a key to the future. Twice at least in the history of New England two great mountain ranges have been worn down to lowland plains. If in spite of their resistant rock masses these mountains passed away it will be seen that the present scenery in so far as it is based on unconsolidated glacial gravels cannot long endure. We may look forward to a time when the valleys will be cleaned of their glacial fillings, when the lakes and waterfalls will pass away and the country will return to its former mature conditions. Then if no uplift intervenes and the glaciers do not return, this mature topography will give place once more to great rolling plains over which the lazily flowing rivers await a new period of uplift or mountain making to start a new cycle of erosion and the evolution of new scenery and new landscapes.

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