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REPORT

of the

STATE GEOLOGIST

1945 - 1946

Maine Development Commission
Augusta, Maine March, 1947

MAINE GEOLOGICAL REPORT
MAINE DEVELOPMENT COMMISSION

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REPORT

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STATE GEOLOGIST

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by Joseph M. Trefethen, *State Geologist*
and Associate Professor of Geology,
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Maine Development Commission
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THE MAINE GEOLOGICAL SURVEY

The Early Surveys

The first geological survey of the state was conducted by Charles T. Jackson in the field seasons of 1836, 37, and 38. The survey was comprehensive and covered much of the state. The results were published as the 1st, 2nd, and 3rd Reports and 1st, 2nd, and 3rd Annual Reports of the State Geologist. These are written in travelog or diary style and provide reading of both geological and human interest. It is unfortunate that the atlas of accompanying illustration is so rare. It is reported that the only complete map covering the entire survey was never published, and but a single copy is known to have been prepared. This hand colored copy was discovered in a second-hand book store in Boston in the 1870's by a Mr. Boardman, Maine Commissioner of Agriculture at that time. Its present location is unknown.

A remarkable number of observations are recorded in the Jackson reports; and while the interpretations in many instances are, as to be expected, no longer acceptable, the field descriptions are serviceable.

In 1861, a second survey, under the direction of C. H. Hitchcock was authorized by the legislature. The reports of this survey appeared in the Sixth and Seventh Annual Reports of the Maine Board of Agriculture. As the preceding survey, the coverage of this second geological survey was state wide. Perhaps the most notable of Hitchcock's contributions resulting from his work as state geologist, is the first geological map of the state to be published. This is found in Colby's Atlas of Maine, 1885 edition.

There was apparently no provision for continuation of the Hitchcock survey, and not until the decade 1910 to 1920 was the office of State Geologist filled when Freeman Burr, under the Water Storage Commission, and subsequently under the Maine Water Power Commission, was appointed to carry on geological work.

In 1929, Lucius Merrill was named State Geologist and E. H. Perkins, assistant State Geologist. Merrill was followed by Twinem in 1931, and Freeman Burr again served for the period 1933-42. Merrill and Perkins, and Twinem and Perkins issued reports. Perhaps the most notable contribution of these reports is the Bibliography of Maine Geology, compiled by J. C. Twinem, 1932.

The Present Survey

Organization. In the spring of 1942, Mr. Burr retired as state geologist, and the present state geologist was appointed by Governor Sewall and directed to work in close cooperation with the Maine Development Commission. The State Legislature subsequently enacted a bill placing the State geological Survey under the Development Commission, thereby effectively removing the survey from politics. As an integral part of its program, the geological work is considered by the commission with the same care given to the other parts of the State development program. Several times each year the plans and progress of the work are reviewed, and the executive secretary of the commission is constantly in touch with the current work.

Personnel. In common with all survey organizations, the difficulty of maintaining adequately trained personnel during the period 1942-46 was well nigh insuperable. The number of field parties has varied from 1 to 3, and the quality and quantity of the work has likewise varied. At present we have a graduate chemical engineer throughout the year on a part time basis, using supplementary student assistance.

Policy. The fundamental function of the survey is to collect accurate information on the rocks, minerals, ores, and scenery of the state and to make this information available to the public. To put this policy into effect the survey is following a program which for convenience is divided into five parts. These are: service, exploration, laboratory research, education, and publication. In order to make this program a little clearer, a brief discussion of each of the phases may be in order.

Service. a) Identification of geological materials is made on request. The variety of material submitted is great, ranging from fossils to fool's gold. Requests for assays are frequently received. No assays are made by the state, however, except on material collected in the field by the state survey. b) Field examinations of mineral prospects are made.

To illustrate this service phase of the work two recent examples will suffice.

A party wired for immediate attention to a silver-lead vein, which assayed fifteen to twenty oz. of silver. As no record of a silver bearing vein at that location was in our files, a visit was made to the area and a grab sample taken from the vein. An assay was made on this material which proved far lower than the reported 15 oz. However, since the sample did run several dollars a ton, and the vein was only exposed at three small points, it was decided to dig it out by trenching across it. Representative samples were taken. The assays were so low as to warrant no further investigation by the state.

Recently, a landowner discovered mica on his farm. Having read of the war time needs and prices for mica, the survey received a call to examine the property. It was found that the mica showing was not of commercial interest. However, the deposit proved to have excellent feldspar prospects, although the volume indicated will not support a large operation.

Exploration. Exploration and mapping projects are set up to secure data on regions deemed to have economic possibilities. Two examples of this phase of the work will serve as illustrations.

Many references have been made to the Catherine Hill molybdenite occurrence in Township 10, Hancock County. In fact, a glowing account of the mineral prospects of this hill was given in one of the popular books on Maine. A plane table map of the hill has been made, and it seems that the molybdenite occurs only along certain fractures which are rather widely spaced and in pegmatite nests of small size and very irregular spacing. The average tenor of the rock is far below commercial grade.

The graphite deposit of Crocker Mt., Oxford County, was mapped in detail. The graphite is small flake disseminated in schists, which are intruded by numerous pegmatites. In the course of this work a detailed map was made, and bulk samples taken for laboratory analysis. In brief, the results of the study show that there is a considerable quantity of graphite-bearing schists that will yield from four to six per cent small flake graphite which is readily recoverable by flotations. The deposit probably cannot compete under present economic conditions with the foreign large flake producing mines operated by cheap labor. As an item of our mineral inventory, however, it is of interest for possible future development.

Laboratory Research. It was felt that the Geological Survey did not completely fulfill its function by field investigations alone. In the case of the graphite deposit mentioned, for example, we wanted quantitative data on the amount of recoverable graphite in the rock and data on the flake size distribution. It was decided, therefore, to install a small laboratory for chemical and physical tests of exploratory and preliminary type, adequate to enable us to supplement the field studies with some quantitative data. We recognize that laboratory research is a necessity in evaluating many deposits.

Currently, we are investigating the physical properties of the glacial marine clays, with view to delimiting their range of commercial applications. In addition, we are investigating the possibilities of bleaching these clays to a degree that might extend their usefulness and greatly increase their exploitation. This project is serving as the basis for a graduate thesis in chemical engineering, and we hope to put through other projects under similar arrangements.

Public Education in Geology. P. E. G. or Public Education in Geology is recognized as an important function of all state geological surveys. We have not yet fully developed an adequate program along this line. The lag is ascribable in part at least to recent war time conditions.

To date, our educational program has consisted solely of giving illustrated talks on the geology of the state to various clubs and organizations, and in supplying a few of the public schools with properly identified rocks and minerals for use in science classes.

Publication. The issuance of biennial reports has been reestablished after a break of ten years (1932-1942) in the series. A series of bulletins has been newly established. To date (Feb. 1947), five bulletins have been issued. In the biennial reports, articles of general interest, reports on survey activity, preliminary reports of investigation, reports on minor investigations, and maps are published. Results of the more comprehensive investigations comprise the bulletins. Besides the publications, prints of the field maps are placed in the open files of the Development Commission office, Augusta, and in the survey office at Orono.

Future Outlook. It is planned to continue the general program as outlined with, however, certain changes in emphasis. We are planning county by county inventory studies that will be based on areal work. We hope to further our educational program both for residents and visitors by making studies of the state parks and the issuance of popular reports on the same. We hope to expand the Pleistocene studies, valuable in all construction projects and especially valuable in highway construction, reconstruction, and maintenance.

In summary of present and future plans, it may be stated that we recognize that as a public agency the geological investigations must have an economic basis or otherwise relate to the public interests.

Some expansion of our mineral output appears inevitable. How rapidly expansion will develop is another question. Field and laboratory work are both laborious and time-consuming. Indeed what we do today may not bear fruit until years hence. Judging from the geological character of the whole Appalachian piedmont of which Maine is a part, the outlook for metals, with few exceptions, is not bright. The most promising chances for development seem to be in the realm of non-metallics, common substances, that by improved techniques can be made useful and profitable.

The economic factors of supply, demand, transportation costs, taxes, government controls, and subsidy, and competition from other areas are as effective in the realm of mineral economics as in any other industry.

It is up to us here in Maine to recognize, realize, and publicize our own mineral resources to our own economic advancement.

PRELIMINARY REPORT ON MAINE CLAYS

By J. M. Trefethen, Henry Allen,
Laurence Leavitt, Robert N. Miller, Carleton Savage

Introduction

The clays of Maine are widespread along the coastal regions of the state. They extend inland up to elevations of 300-400 feet above sea level, occupying thus considerable areas along the principal river valleys and their lower tributaries. Based on these clays are important manufactories of brick. In view of the expanded demand for all construction materials, including brick, the clay deposits are of special interest and importance at the present time. The Maine Development Commission, through the Geological Survey, has been instrumental in locating two new brick plants in 1946.

In addition to brick manufacturing, other local industries are large users of special grades of clay, most of which is imported into the state from outside sources. The specifications for these special purpose clays are exacting and preclude, for the most part, utilization of Maine raw clay deposits. Because special quality clays of high grades must be imported from distant sources, as for example, the large tonnages of paper clays, there is the economic possibility that treatments of local clays might be developed to render them suitable for higher grade uses than the manufacture of heavy clay products. Inasmuch as these high grade clays cost (1946) $18 to $20 a ton delivered in this state, and local raw clay can be produced for less than $2 a ton, it is feasible to do considerable processing of the local raw clay, provided methods can be developed within the economic limits. The clay beneficiation problems are notoriously difficult, however, and the clays themselves highly complex.

In the *Report of the State Geologist*, 1943-1944,[1] attention was drawn to the clay deposits with a brief discussion of the problems and a summary of the Geological Survey program dealing with the clays. This present discussion of the clays is a progress report on that program, which is well underway but far from complete. The aims of the clay program can be outlined as follows:

[1] Trefethen, J. M., *Report of the State Geologist*, 1943-1944, Augusta, 1945, pp. 23-26.

I. Field Investigation

a. To prepare maps showing the general distribution of the clays and to locate specifically the promising deposits.

b. To make quantitative estimates of available volumes of the better deposits by means of auger determinations of depth to complement the surface area measurements.

c. To gather as many geological data as possible bearing on the origin, distribution, variations, and relationships of the clays.

About half of the clay areas of the state have been mapped. The results of this field program are of value, not only in economic appraisal of the deposits but also to engineers concerned with highway or bridge construction, or concerned with other types of construction, in or on the deposits. Furthermore, the differentiation and distribution of the clays have direct application to agricultural problems, as well as soil erosion and conservation programs.

II. Laboratory Investigation

a. To determine the physical and chemical properties of the various clays.

b. To investigate various treatments of the clays which might render them applicable to higher grade uses than presently developed.

The laboratory research is designed to answer such questions as posed in the preceding report of the State Geologist: (1) To what extent can local industries now importing clays from outside the state make use of domestic raw clay? (2) Are there clay using industries not now represented in this state which could develop profitably the local clays and markets? (3) Are there means of beneficiation of our local clays to the extent that they can economically compete for local markets with naturally higher grade but more distant clays?

During the course of the investigations it has become apparent that cognate investigations of shale and slate powders should be undertaken, as these substances have uses and possibilities in part, at least, similar to those of the clays.

Field Investigation

The clay deposits are being mapped on U. S. Geological Survey topographic maps on the scale of one inch to the mile. The superior contouring of the newer topographic maps permits both more rapid and more accurate mapping of the clay deposits.

Nearly all roads that are passable are being traversed. 75-100 miles are mapped in the average day. In critical areas, the clay deposits are traced up the tributaries of the major rivers.

Road-cuts and stream banks where clay is exposed have been examined. When such exposures are lacking, auger test-holes are drilled with a $1\frac{1}{2}$-inch soil auger. These holes vary in depth from 3-15 feet.[2]

The clay samples from auger holes, road-cuts, and stream banks are sealed in Mason jars and sent to the Geological Survey Laboratory at Orono for further study. Fossil localities are noted, but systematic collections from the various locations have not yet been made.

The auger cores are examined and findings recorded, especially the characteristics and minimum depths of the clay.[3] If clay lies within 3 feet of the surface, it is mapped as a surface exposure; where clay occurs at greater depth, a record of its depth is made, and the type of mantle is indicated on the map.

Areas Surveyed

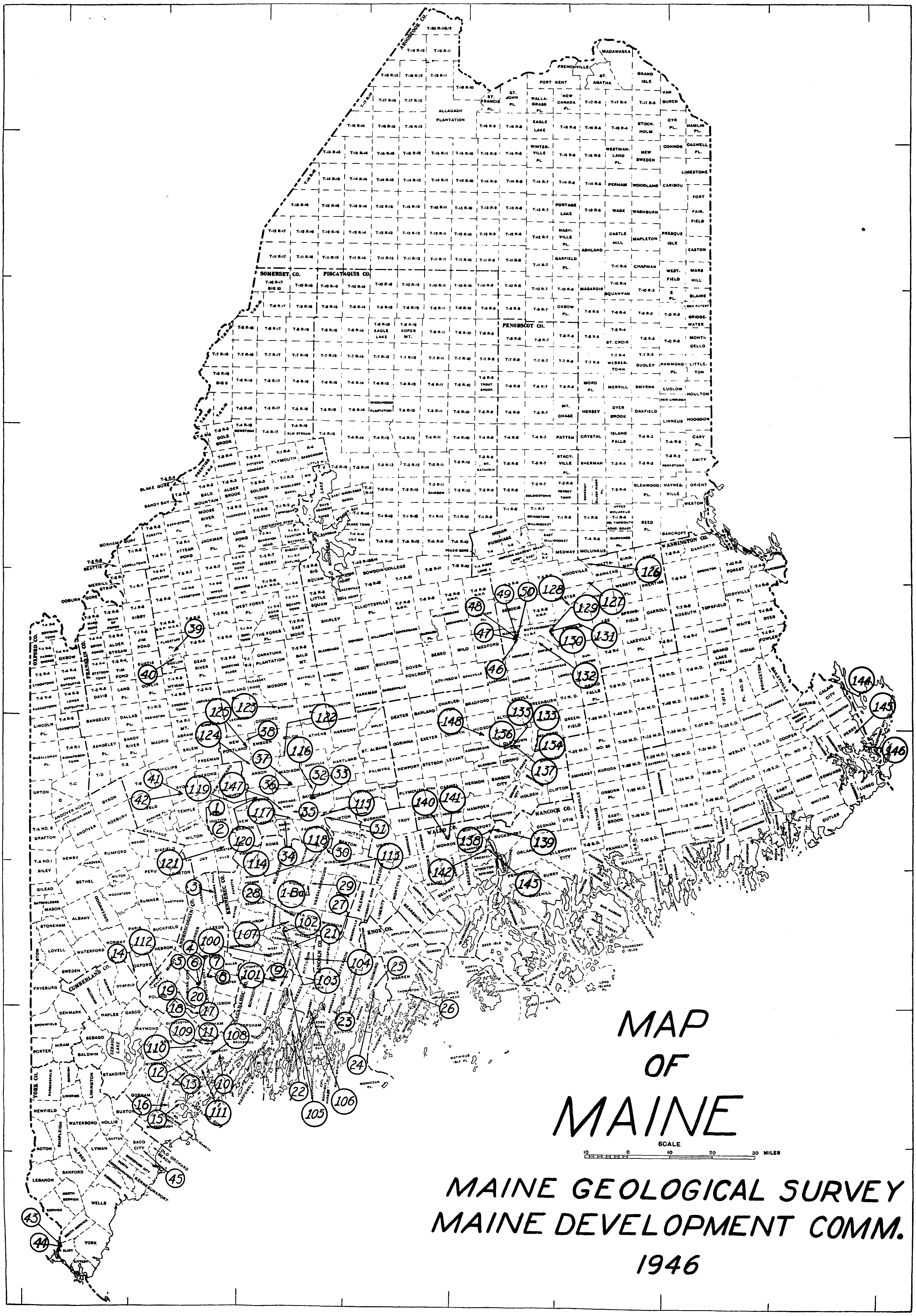
The areas drained by the Androscoggin, Kennebec, and Penobscot Rivers have been mapped, and some work started in the eastern coastal areas. Each of the above mentioned river systems has been mapped and studied from mouth upstream to the highest elevation where clay is found. The regions mapped are discussed briefly in Appendix II. Distribution of samples are shown on the accompanying map. (Fig. 1)

Geology of the Clays

Two major types of clay are available locally with volume large enough to warrant consideration and possible exploitation. The upper, a brown clay, is generally suitable for brickmaking. The lower, a blue-grey clay or grey clay, should be more thoroughly investigated for other uses. The latter may be of more potential economic value than formerly has been supposed.

[2] A list of the locations of testholes and samples is given in Appendix I.

[3] Appendix II; Summary, Clay Areas—Regional and local; drainage, relief, estimated clay volumes, and economic data.


MAP
OF
MAINE
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MAINE GEOLOGICAL SURVEY
MAINE DEVELOPMENT COMM.
1946

Both the brown and blue-grey clays have been recognized in the field by earlier geologists. Dr. E. H. Perkins says that the clays "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 or in fresh or salt water as water-laid deposits." 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.[4]

Many of the Maine clays, especially the brown clays, are composed of a wide range of particle sizes; "clay" is defined as material finer than .005 mm. in diameter. Much of the less silty and sandy of the lower blue-grey clays is composed of clay sized particles; most of the upper brown clays, however, are too coarse, strictly speaking, to be called clays. Nevertheless, since they have a greater or lesser fraction of clay size particles, and in local usage, both by engineers and brick manufacturers, are called "the brown clays," this usage is followed here.

In the areas recently surveyed, an upper brown deposit of silty or sandy nature is generally underlain by the blue-grey or grey clay, but locally the brown clay is found directly on bedrock or glacial till. The two clays differ in color, texture, and water content and hence in physical properties. Both clays are more or less interbedded with sandy or silty layers and have silty partings. The blue-grey clay was probably deposited in quiet estuaries of brackish or salt water and contains less coarse material than the overlying brown deposits. The brown clays are believed, in part, to have been deposited on tidal flats in overlapping fashion near the margin of gradually receding marine embayments—somewhat resembling modern tidal flats. They appear to be reworked and locally contain sand and pebbles.

The brown clay derives its color from its characteristic brown oxides and varies from brown through tan to brownish grey. The blue clay is generally blue-black, blue-grey, or grey in color. In deeper zones it is more uniform and plastic and frequently is grey. The bluer shades are often found in the upper layers of the blue clay. This coloration is probably due to a greater concentration of altered carbonaceous matter and plant remains. The general, overall blue-grey color of the clay ascribed to carbonaceous matter may, however, be due, in part at least, to other impurities.

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[4] Perkins, E. H., First Annual Report, Geology of the State of Maine; p. 76, Augusta, Me., 1930.

Manganese staining is, perhaps, more common and apparent in the upper brown clays although it also occurs in drier, more massive exposures of the blue-grey clay. The manganese staining is secondary and derived from the circulation of ground-water along joints and bedding planes. One to four-inch layers of sand often occur interbedded with the brown clay, and the same is true of the upper portions of the blue-grey clay.

Concretions are common in the brown clays and less common in the blue-grey clay. They are larger with increasing depth and are characteristic of the sandy and silty, highly oxidized zones, growing around fossil shells, roots and root-molds, and larger rock or sand particles. They are often rich in manganese.

Marine fossils are found locally in both brown and blue-grey clays, indicating the deposition in salt or brackish water.

At several locations, where road-cuts or stream banks expose the contact between the two clay types, there appears to be an unconformity separating the two—often there is a layer of highly oxidized sand along this irregular contact. In many places auger driven test-holes penetrate a brown clay which contains particles of blue-grey silt and clay. Some large fragments of brown clay are banded. Due to the plasticity of the blue-grey clay it may be forced up into fractures and joints in the brown clay. Some exposures near roadcuts or stream banks have pockets and bands of blue-grey clay high up along a cut, while brown clay appears at lower elevations along the sides of the exposure. This again may be due to plasticity and flowage of the blue clay when wet; it may have been forced up locally into the brown clay by the weight of the overburden. Engineering projects also may have been locally responsible for disturbing the equilibrium and causing an "intrusion" of plastic blue clay into the brown clay.

The brown clays may be partially derived from reworking of the blue-grey clays with resultant admixtures of sand and silt. The brown is thus less uniform in grading than the blue-grey. According to local brickmakers, the sandier brown clay makes a better brick material than the less sandy blue-grey clay. Consequently, only a small quantity of blue clay is used in brickmaking.

The higher water content and greater plasticity of the blue-grey clay is probably due to its finer texture and its common occurrence below the water table.

Both clay types are underlain by sand, bedrock, or till. At many places, however, the blue-grey underlies the brown clay. Generally the latter is found upstream at a fairly constant local elevation; at no place was the blue-grey clay found overlying the brown clay in undisturbed depositional relation.

Locally, and generally at higher elevations, a clay-till, or mixture of cobbles and angular boulders with clay is easily confused with the brown clay; on the other hand, the brown clay often contains numerous pebbles and cobbles which were presumably rafted in by floating icebergs or washed in by post-glacial stream action.

Tentative Historical Summary of the Late Pleistocene of Androscoggin, Kennebec, and Penobscot Valleys.[5]

1. Advance of major ice sheet burying all of Maine and extending beyond the state limits, accompanied by a lowering of sea level. During this invasion the major part of the glacial erosion and deposition was accomplished.

2. Retreat of the ice, which was, in part, "normal" as evidence by recessional moraines in eastern (Columbia Falls-Machias), south central (Windsor-North Waldoboro), and southwestern (Newington) Maine. Outwash deposits of various types are found.

3. Advance of sea inland to elevations of 400 feet or more above present sea level.

4. Deposition of marine clays in sheltered and quiet waters of the embayments fed by the melt waters of the ice charged with rock flour the blue clay.

5. Colonization of these bottoms and flats by marine organisms.

6. Readvance of a relatively thin and weak ice sheet. Erosion slight and till deposits thin. Stagnation and dissipation of the ice tongues; formation of the principal esker systems. In part, the reworked marine clays of the earlier marine stage form a very clayey till, which is easily mistaken for marine clay.

7. As the ice melted back, as well as downwards, a second marine invasion inundated the lands and locally washed the ice front; esker deltas were built, and on the tidal flats the brown clays formed, while in the estuaries of deeper water, probably quieter, a second marine clay was locally deposited.

8. Withdrawal of the seas, accompanied by wave action, wind, and stream work, modifying and removing parts of the earlier deposits.

[5] In the main, this outline follows the interpretation of Perkins (Bull. 30 Maine Tech. Exp. Sta., 1935). Some modifications have been introduced.

Uses and Properties of Clays

Clays can be roughly classified according to the uses for which they are adapted. On this basis are recognized two major divisions: 1) ceramic clays, that are shaped and "baked" and 2) non-ceramic clays.

Ceramic Clays

China Clays. China clays are those white burning clays used in the manufacture of white table ware, porcelains, and similar products. They contain a very low percentage of fluxing impurities. According to the special properties required in the finished products, they are combined in varying proportions with such substances as feldspar and "ball" clay. In general the china clays are residual clays, essentially composed of the kaolin group of minerals. No china clays are known in Maine.

Ball Clays. Ball clays are plastic white burning clays used in combination with china clay in the manufacture of the ceramic goods mentioned above, that is, white ware bodies. No ball clays are known in Maine.

Structural Clays. Structural clays are those suited to the manufacture of structural products, such as: brick, structural tile, drain tile, sewer pipe, and similar products. For some of these purposes a higher quality clay is admixed. Some of the essential considerations are: available and uniform deposits of adequate size, uniformity, pigments, plasticity, shrinkage, and fired and green strength. Impurities not tolerable in other types of ceramic clays can be allowed, but here it should be emphasized that knowledge and skill are essential to successful manufacture. The shades of color, for example, depend in part on conditions of firing. Adequate tests on the firing properties and the qualities of the finished goods, of course, should precede establishment of a manufactory; but without technically skilled operation the qualities of the small scale preliminary tests may not be reproduced in plant scale operation. There are many undeveloped deposits of structural clays in Maine, and currently at least, an expanding market. Indeed, it is doubtful if since the early days, Maine has produced structural clay products enough to supply local demand.

Refractory Clays. Refractory clays, or fire clays, are those that produce high temperature resistant products. Commonly they are infusible at temperatures up to 2700°F. According to their use, refractory products are tailored to special properties, as for example, resistance to slag or furnace gases, by admixtures of various substances. No refractory clays are known in Maine.

Pottery Clay. The manufacture of pottery from clay is one of the oldest applications. Shrinkage, firing properties, molding or shaping properties, and fineness of grain are the principal factors in choosing a pottery clay. Many of the Maine clays are adapted to pottery work. Skill in fabrication is the prime essential. There is apparently opportunity for great increase in this specialized field. The variety of opportunity ranges from the making of flower pots to the modeling of exquisite figures. There are several nationally known artists, resident in this state, working with local clay, who produce goods of highest quality which retail at corresponding prices.

Slip Clays. Slip clays are low fusing clays that melt readily to a greenish or brownish glass. Mixed with water and applied to the surface of clay products by spraying or dipping, it gives a glaze to the finished product not excelled by artificial glazes. Tinting or fluxing compounds may be added. The market is less than formerly, due to competition of artificial glazes. It is not known whether or not extensive deposits of suitable slip clays are present in Maine.

Non-Ceramic Clays

Paper Clays. Bright, white clays suitable for use in paper manufacture are called paper clays. These are used both in coating and filling paper. Fineness of grain, plasticity, and whiteness are the essential characteristics. As one of the leading states in paper manufacture, Maine is a large consumer of paper clay. No deposits of paper clay are known in Maine.

Filling Clays (other than paper). In addition to use as a paper filler, clays are used as fillers in a variety of other industries.

a) Rubber goods of some types use a clay filler. Tests on one Maine clay showed it to be a moderately satisfactory filler for certain types of rubber goods.

b) Raw clay of the type found in Maine is satisfactory for linoleum and oilcloth manufacture.

c) The use of clay in paints is not as great as formerly. In the past, domestic clay has been successfully used.
d) Textile manufacturers use a high grade white clay similar to paper clay in filling some types of cloth. No clays of this quality are known.

Filter Clays. Clays with specially marked absorptive powers, natural or "activated", are used in an increasingly important volume. Examples of this use are: refining of oils and other liquids; removal of colors, odors, and impurities from liquids; and in air conditioning and moisture control units. The suitability of Maine clays for filtering purposes has not yet been tested.

Binder Clays. In some regions clays are used as binders or stabilizers for traffic surfaces.

Beneficiation of Clay

It was noted in the preceding discussion of clay uses that the higher quality clays are lacking in this state. If, however, processes can be found which make our grey or blue clays acceptably white without impairing their otherwise satisfactory properties or to remove by some means enough of the iron so that they will burn white, the market for the product is enormous within our own state limits, provided the beneficiation can be worked out within costs of say, $10 to $12 a ton. With the incentive of these considerations, research along these lines has been initiated; and some progress achieved. In a subsequent section of this paper the results to date are briefly discussed.

In order to evaluate the clay deposits for various uses, laboratory tests and determination of some of the more important physical properties must be made. To this end some one hundred and twenty field samples have been taken and are being studied. Inasmuch as this is a progress report on unfinished research, the data presented are incomplete.

Physical Properties

At the present time, only the more important ceramic tests, which can be conducted with available equipment in the Survey Laboratory, are being undertaken. These include: fineness determination, specific gravity, liquid limit, plastic limit, and softening point tests. When equipment is available, the firing behavior tests, such as: absorption, apparent porosity, and shrinkage will be made.

Fineness Determination

A particle size analysis is being made of each clay sample by taking readings with an hydrometer after about 35 g. of the clay has been thoroughly mixed with 1000 cc. of water in an hydrometer jar. These readings are taken at progressive intervals of 1 minute, 2 minutes, 4 minutes, etc. This method involves the principle of sedimentation (settling velocities vary according to size of particles).

If more than one quarter of the sample by weight is of a size larger than the number 200-mesh sieve (0.074 mm. openings), and the particles are larger than 0.3 mm., they are screened out prior to the hydrometer analysis of the fine fraction.

Specific Gravity

Specific gravity is a number that shows how many times heavier a given volume of a substance is than an equal volume of water. The volumetric flask method is being used in the Geological Survey laboratory.

Using a calibrated volume flask, the volume of the clay particles is obtained by displacement of water. The weights of the oven-dried sample (Ws), the volumetric flask filled with distilled water (Ww), and the flask filled with sample plus distilled water (Wsw) are determined.

At temperatures not over 20°C —

$$\text{Specific Gravity} = \frac{Ws}{Ww + Ws - Wsw}$$

A vacuum pump is used to draw out the air entrained in the sample.

Plastic Limit

Plasticity is a very important feature of clay. In most clay products, clays must be molded into forms without rupturing. The percentage of water required to put the clay into a plastic condition is, consequently, of importance. In the study of plasticity the plastic limit method is being used on Maine clays. The plastic limit is the lowest moisture content, expressed as a percentage of the oven-dried soil, at which the soil can be rolled into threads one eighth inch in diameter without the threads breaking into pieces.[6]

[6] A.S.S.H.O., *Standard Specifications for Highway Materials. . .*, Method T-90, 1935, p. 235.

Liquid Limit

The liquid limit of clay is the moisture content, expressed as a percentage of the oven-dried weight of a sample at which the clay will begin to flow when lightly jarred ten times.[7]

A Casagrande mechanical apparatus is used in performing the test with equivalent results.

Softening Point

The softening point, or fusion point of clay, is the temperature at which the clay passes from the solid to the liquid state. Since the different minerals which make up a clay have different fusion points, the softening of the clay does not occur at a definite temperature, but rather softening is spread over a range of temperature.

For softening point tests, the clay is molded into the shape of pyramids corresponding to the shape of standard cones of known softening points called Pyrometric Cone Equivalents (P.C.E.). The softening point is reached when the tip of the cone touches the base. It is generally expressed in terms of P.C.E. numbers (e. g. Cone 2-3) rather than temperature. A test cone of clay and Pyrometric Cones of known temperature resistance are fired in the furnace, thus giving a comparison between the clay cone and the Pyrometric Cones and establishing the resistance of the clay to heat within a limited temperature range. Common values of P.C.E. for varied uses are given as follows:

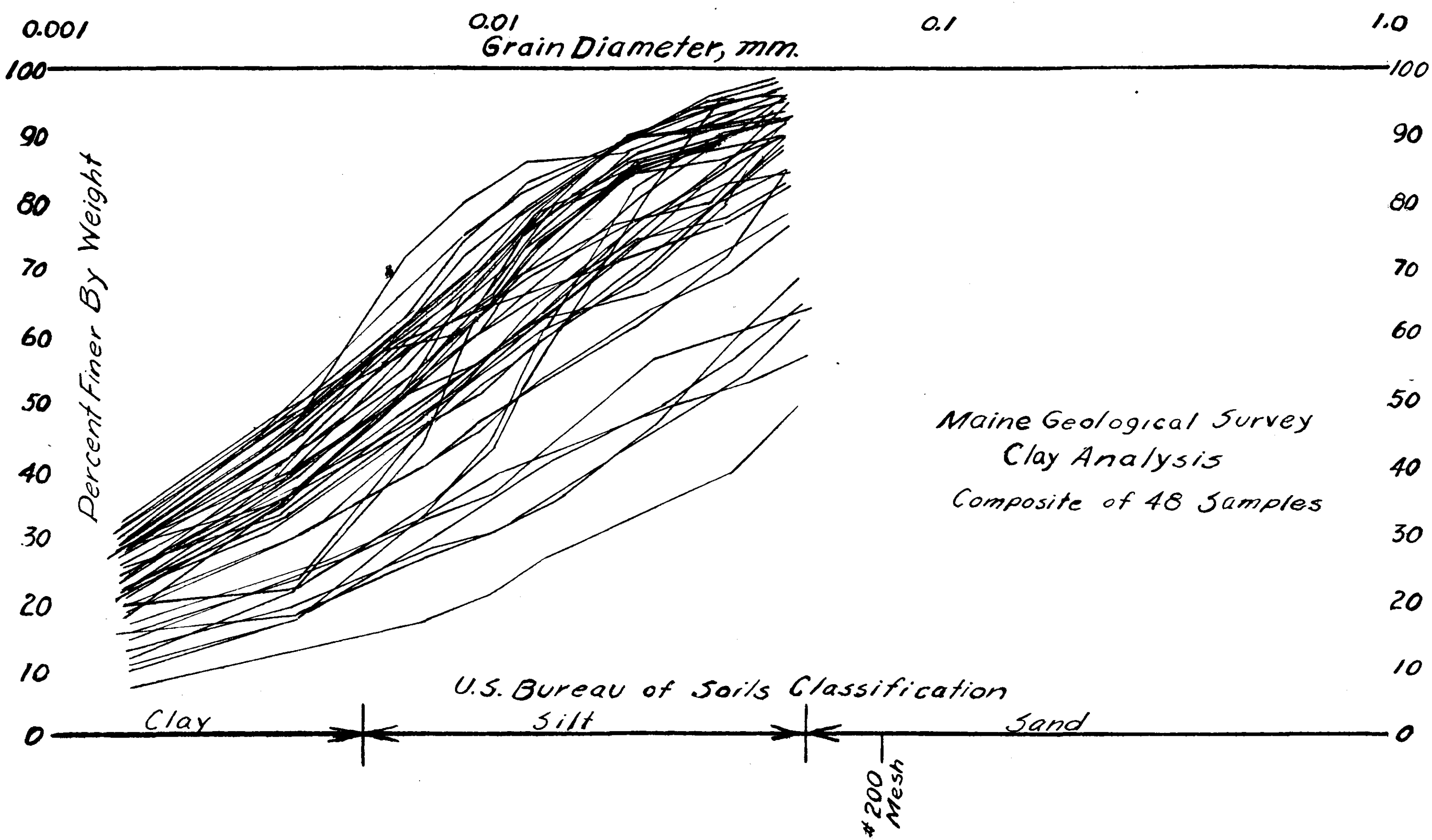
Table One

Cone Numbers Used in Different Branches of Clay Working Industry in the United States[8]

Common brick		012 – 3
Hard-burned common brick		1 – 2
Buff front brick		2 – 9
Hollow blocks and fireproofing		03 – 1
Terra cotta		02 – 7
Conduits		7 – 8
Fire-bricks		5 – 14
Red earthenware		010 – 05
Stoneware		6 – 8
Porcelain insulators		9.5 – 11
White earthenware	Biscuit	8 – 9
	Glaze	6 – 7
	Some glaze at cone	3
China	Biscuit	11
	Glaze	7

[7] A.S.S.H.O., Standard Specifications for Highway Materials. . . . , Method T-89, 1935, p. 233.

[8] Ries, H., *Clays Occurrence Properties and Uses*, 3rd edition, 1927, p. 313.



0.001
0.01
0.1
1.0
Grain Diameter, mm.
Percent Finer By Weight
100
90
80
70
60
50
40
30
20
10
0
Maine Geological Survey
Clay Analysis
Composite of 48 Samples
U.S. Bureau of Soils Classification
Clay
Silt
Sand
#200 Mesh

Figure 2

Results of the Physical Tests

Seventy-three of the total of one hundred twenty samples collected to date have been graded by hydrometer analysis in the Geological Survey laboratory. These analyses show a marked degree of uniformity. Following the U. S. Bureau of Soils classification, particles above 0.05 mm. in size are classified as sand, those between 0.05 and 0.005 mm. as silt, and those smaller than 0.005 mm. as clay. The majority of Maine clays tested so far show about 40-50% of silt size particles, and 35-50% clay size particles. The gradations of the tested samples are shown in Fig. 2.

With few exceptions, the specific gravities of the clays tested to date range between 2.68 and 2.77. (See Table II.)

Sixty-one plastic limit determinations show a range from 14.7 to 30% water required to produce the degree of plasticity called for by this test. (See Table II.) Several samples due to high sand content do not possess enough plasticity for determination by the test.

Only a few liquid limit determinations have been completed at this writing. The range is from 21.4 to 36% water. Plastic index, which is the number obtained by subtracting the plastic limit value from the value of the liquid limit gives results that vary from 3.8 to 15.4. (See Table II.)

The softening points of 20 samples from different counties (Cumberland, Androscoggin, Franklin, Penobscot, and Sagadahoc), fall within narrow limits, ranging only from 2100°F. to 2210°F. or from Pyrometric Cone Equivalents, 01 to 6. (See Table II.)

Progress in Bleaching the Clay

The cause of the grey or blue coloration of the clay is not certainly determined. It is commonly ascribed to organic impurities and ferrous iron compounds. Iron is shown to be present both by chemical analysis and by the characteristic pink, buff, or red tints produced by firing the clay. The first approach, therefore, to the bleaching problem appears to be the removal of iron. If this can be accomplished, a white burning product will be obtained of possible use in many industries. A survey of the literature pertaining to removal of impurities from southern United States clays and British clays shows the following procedures have dominated:

1. Electrolysis, using an osmose apparatus.
2. Sedimentation of the coarser fractions, using various defloculating agents.

Table Two

Summary of Physical Properties of Certain Maine Clays

Sample	Location: Town	Location: County	Color	Specific Gravity	Plastic Limit	*Liquid Limit	*Plastic Index	Softening Point: †P.C.E.	Softening Point: Temp. °F	Fineness Deter.	Remarks
1	Farmington	Franklin	Brown					01–1	2100	Yes	
2	"	"	Blue					01–1	2100	"	
3	Livermore Falls	Androscoggin	Brown					5–6	2210	"	
4	Lewiston	"	Blue					3–4	2165	"	
5	"	"	"					2	2130	"	
6	"	"	"					3	2140	"	
7	"	"	Brown					3–4	2160	"	
8	"	"	Blue					3–4	2145	"	
9	Richmond	Sagadahoc	Brown					4–5	2190	"	
10	Freeport	Cumberland	"					1–2	2125	"	
11	Pownal	"	Blue					01–1	2115	"	
12	North Yarmouth	"	"					01–1	2115	"	
13	Cumberland	"	"					1	2120	"	
14	Oxford	Oxford	Brown							"	
15	Portland	Cumberland	Blue					01–1	2105	"	
16	Westbrook	"	Brown					2–3	2135	"	
17	Auburn	Androscoggin	"					1	2120	"	
18	"	"	Blue							"	
19	"	"	Brown							"	
20	"	"	"							"	
21	Randolph	Kennebec	Blue	2.73						"	
22	Woolwich	Sagadahoc	Brown	2.72						"	
23	Newcastle	Lincoln	"	2.73						"	
24	Waldoboro	"	"	2.71						"	
25	"	"	"	2.74						"	
26	Thomaston	Knox	"	2.75						"	
27	Windsor	Kennebec	"							"	
28	Augusta	"	Blue							"	
29	Vassalboro	"	Brown							"	
30	Waterville	"	"							"	
31	Clinton	"	"							"	
32	Skowhegan	Somerset	"							"	
33	"	"	Blue							"	
34	Smithfield	"	Brown							"	
35	Norridgewock	"	"							"	
36	Madison	"	"	2.72						"	
37	"	"	Blue	2.75						"	
38	New Portland	"	Brown							"	
39	Flagstaff Pl.	"	Blue	2.77						"	
40	Bigelow Pl.	"	"							"	
41	Avon	Franklin	"	2.77						"	
42	"	"	"							"	
43	Eliot	York	Brown							"	
44	"	"	"							"	
45	Saco	"	"							"	
46	Howland	Penobscot	Blue	2.73	14.7	21.4	6.7	2	2130	"	
47	"	"	"	2.71				01–1	2115	"	
48	"	"	Brown							"	
49	"	"	"							No	Peaty, shaly
50	"	"	Blue	2.72				2	2130	Yes	" "
100	West Gardiner	Kennebec	Brown	2.76	26.4					"	
101a	Richmond	Sagadahoc	"		24.4					No	
101b	"	"	"		29.6					Yes	Sandy
102	Hallowell	Kennebec	"	2.68	23.3					No	
103a	"	"	"		—		—			"	Banded, sandy
103b	"	"	"		22.1					"	
104	Pittston	"	"		25.8					"	
105	Dresden	Lincoln	"		25.6					"	
106	Wiscasset	"	"		31.2					"	
107a	Augusta	Kennebec	"	2.72	23.5					Yes	
107b	"	"	"		27.2					No	
107c	"	"	Blue	2.72	23.9					Yes	
108a	Freeport	Cumberland	Brown		—		—			"	Sandy
108b	"	"	Blue	2.74	23.9					"	
109a	Pownal	"	Brown		23.2					"	
109b	"	"	Blue	2.71	25.7					"	
110	"	"	"		21.0	29.3	8.3			"	
111	Yarmouth	"	"		—		—			"	Sandy
112	Mechanic Falls	Androscoggin	Brown	2.72	—		—			"	Sandy
113	Winslow	Kennebec	Blue	2.76	24.6					"	
114	Waterville	"	"							No	
115	Hinckley	Somerset	Brown		22.8					"	
116a	Skowhegan	"	Blue		23.4					"	
116b	"	"	Brown		25.2					"	
116c	"	"	"							"	
117	Norridgewock	"	Blue		23.1					"	
118a	Fairfield	"	Brown		22.8					"	
118b	"	"	"		21.4					"	
118c	"	"	Blue		20.8					"	
119	Starks	"	Brown		21.3					"	
120	"	"	Blue		22.1					"	
121	Chesterville	Franklin	"							"	
122a	Solon	Somerset	Brown		26.2					"	
122b	"	"	"		24.6					"	
123a	Bingham	"	"		25.9					"	
123b	"	"	Blue		23.2					"	
124a	No. Anson	"	Brown		23.0					"	
124b	"	"	Blue		25.0					"	
125a	E. New Portland	"	Brown		21.1					"	
125b	"	"	Blue		24.5					"	
126	Mattawamkeag	Penobscot	Brown		31.3					Yes	
127	Woodville	"	Blue		27.0					No	
128	Chester	"	Brown		25.4					Yes	
129	Lincoln	"	"		24.1					"	
130	"	"	Blue		23.6					No	
131	"	"	"		22.0					"	
132	Enfield	"	Brown		25.1					Yes	
133	Milford	"	"		23.6					"	
134	"	"	"		19.2					No	
135	Old Town	"	"		21.1					"	
136	"	"	Blue	2.75	22.6					"	
137	"	"	"		23.3					"	
138	Bucksport	Hancock	Blue		24.6					Yes	
139	"	"	Brown		20.6	36.0	15.4			"	
140	Monroe	Waldo	"		21.6					No	
141	"	"	"		26.0					"	
142	Prospect	"	Blue		—		—			"	High organic content
143	"	"	Brown		—		—			"	High organic content
144	Calais	Washington	"		24.5					"	
145a	Perry	"	"		26.0					"	
145b	"	"	Blue		23.7					"	
146a	"	"	"		24.2					"	
146b	"	"	Brown		30.6					"	
147	Norridgewock	Somerset	Blue		19.3					"	
148	Hudson	Penobscot	Brown		23.4					Yes	
1-B-a	Sidney	Kennebec	"		19.5	27.0	7.5			"	
1-C-a	"	"	Blue	2.71	19.0	22.8	3.8			"	
2-B-a	"	"	Brown	2.65	19.0	25.2	6.2			"	
4-B-a	"	"	"							"	
1-D-a	"	"	"	2.77	18.0					No	

*Figures are percentages
†Pyrometric Cone Equivalent

3. Froth flotation.

Electrolysis experiments have not yet been run on the Maine clays. A batch of the clay has been submitted to the American Cyanamid Co. for experiment in flotation. Sedimentation of the coarser fraction of the clay does not materially improve color.

Clorination

Straight clorination of the Maine clays has not been successfully applied to bleaching the clay in our laboratory. The passing of SCl_2 and Cl_2 gases over heated ores to remove iron and other similar metals is successful, and this method is now under investigation. Clay from the Old Pond Farm, (Howland-Enfield clay area), was selected for trial. The physical properties of this clay are shown in Table Three.

Table Three

Report on Physical Tests on Howland Clay

Sample: No. 46 — Date: July 8, 1944
Sampled by: Trefethen & Bradford — Owner: Einy Sawyer
Location: Pond Stream Brook, Howland

Results

Fineness		
Sieve Analysis:	Passing #200 sieve (0.074 mm.)	100%
	Passing #325 sieve (0.044 mm.)	98.29%
Hydrometer Analysis:	Silt (0.05 to 0.005 mm.)	30%
	Clay (smaller than 0.005 mm.)	70%
	Colloids (smaller than 0.001 mm.)	28%

Specific Gravity	2.73
Liquid Limit	36.1
Plastic Limit	21.4
Plastic Index	14.7
Softening Point	2130°F. (P.C.E. 2)

Tested according to A.A.S.H.O. Standard Methods of 1942.

Procedure

The apparatus used in these experiments is diagrammatically shown in Fig. 3. Experimental runs at various temperatures and of various durations were made in which SCl_2 and Cl_2 vapors were passed over the clay at constant rate. At the conclusion of each run the clay sample was removed for weighing, and the reaction tube washed thoroughly to remove all the distillate for analysis for iron, titanium and alumina.

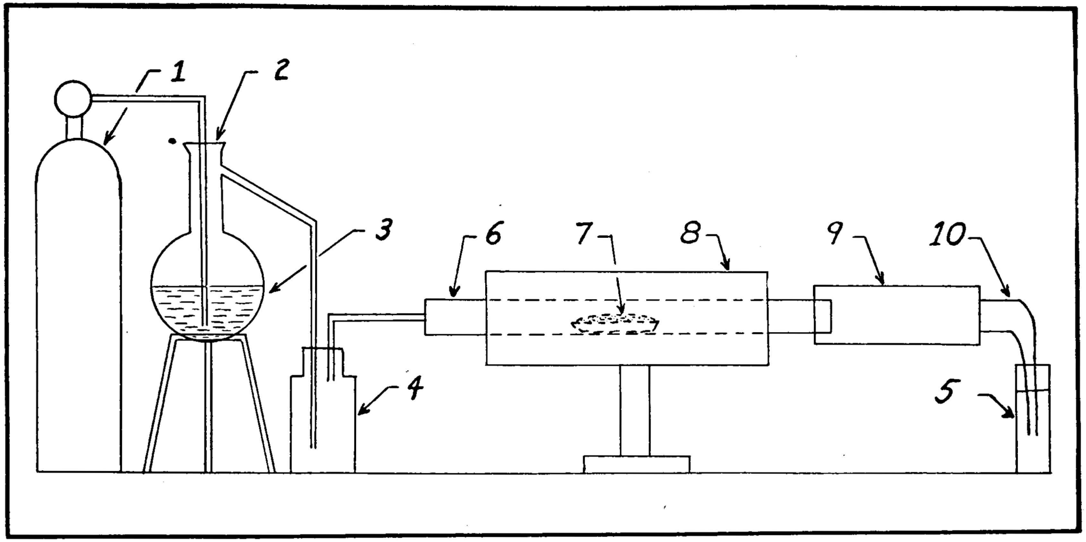


Figure 3

Diagram of Equipment for Removing Iron from Clay Using SCl_2 and Cl_2

Legend

1. Chlorine cylinder with valve for regulating rate of chlorine.
2. Distilling Flask partly filled with liquid SCl_2.
3. Chlorine tube immersed in SCl_2 so as to vaporize the SCl_2 when chlorine gas is bubbled through.
4. Safety trap to prevent any liquid SCl_2 from being blown over into reaction tube.
5. Exit end of apparatus immersed in water so as to dissolve all vapors not condensed in condenser and to control the rate of gas passing over clay by the number of bubbles formed per second.
6. High temperature silica combustion tube in which the chemical reaction takes place.
7. Alundum boat containing the clay sample.
8. Electric resistance furnace for obtaining the various temperatures.
9. Large glass tube for condensing the vapors distilled over from the clay.
10. Glass adapter for passing uncondensed vapors and unused chlorine gas through water.

Results

The results of the runs are shown in Table Four.

Table Four

Results of Clay Bleaching Tests

Temperature	Wt. of Sample	Loss of Wt.	% Reflectance compared with MgO
I. Two hour treatment, hand ground			
650°C	3.4838	7.29	66.3
770°C	3.4900	13.99	72.2
875°C	3.5754	27.82	76.8
II. Three hour treatment, hand ground			
650°C	3.6548	12.33	70.8
770°C	3.4395	14.12	72.4
875°C	3.6248	26.90	78.2
III. Two hour treatment, disk ground			
875°C	3.7222	42.8	90.4
IV. One and a half hour treatment, disk ground			
875°C	3.8706	50.0	91.0

The degree of whiteness of the product increases with the increase of temperature and time of bleaching. It is also to be noted that the finer the grinding, the more complete the bleaching. Although disk grinding introduces some iron, the final product is whiter than hand ground clay. It was observed in the course of the experiments that at temperatures above 770°C. the decomposition of the clay as shown by the loss in weight is more marked than below that temperature. The loss in weight is due chiefly to distillation of silica and alumina along with the iron and titanium. Analysis of the bleached product, with whitest color shows less than .1% iron. Figure 4 shows thermal analyses of the bleached and unbleached clay.

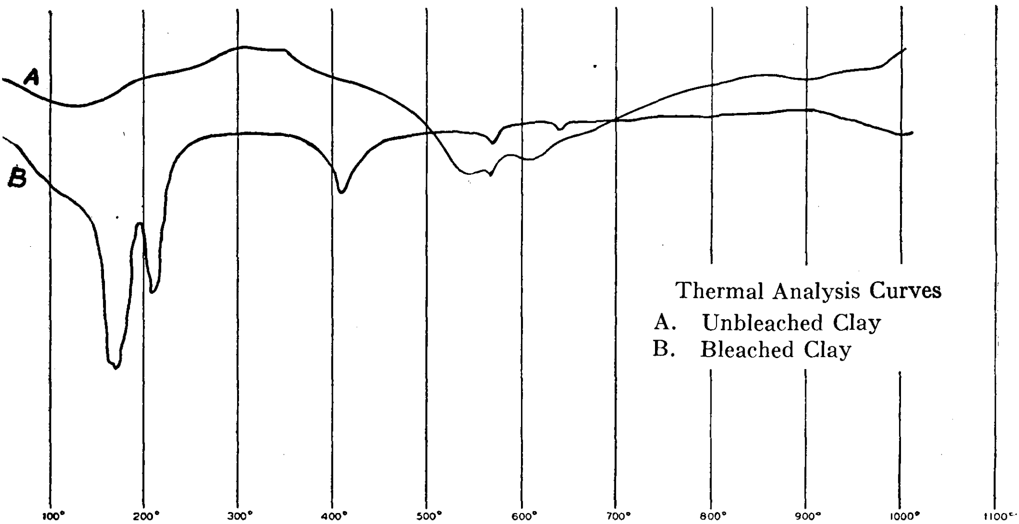


Figure 4

Conclusions

SCl_2 and Cl_2 passed over heated clay at temperatures between 650° and 875°C. improve the color to a satisfactory degree for paper or ceramic uses. At the temperatures used, the structure of the clay minerals breaks down, as shown by the thermal analysis curves, Fig. 4. A and B and further shown by the change in the "fluxing" properties of the clay as applied to paper coating. The rate of the decomposition of the clay increases with elevation of temperature. At the present writing, a modification of the above outlined procedure is under investigation in the attempt to lower the temperature to the range within which the clay structure will not be materially or harmfully affected, and a new model apparatus is under construction.

Summary

Our experiments to date have shown that the clay can be bleached to a satisfactory color. So far as known, this is the first time anyone has rendered clay of this type acceptably white. Our experiments are now directed towards the accomplishment of bleaching within a lower temperature range and towards evaluating the economic factors involved.

APPENDIX I

List of Clay Samples and Testholes

Following U. S. Geological Survey Topographic Maps
Used for Base Maps:
(Maine)

Anson
Augusta
Bangor
Bath
Bingham
Boothbay
Boyd Lake
Brooks
Bucksport
Burnham
Farmington
Freeport
Gardiner
Great Pond
Kingfield
Lewiston
Lincoln
Livermore
Mattawamkeag
Nicatous Lake
Norridgewock
Orland
Orono
Passadumkeag
Poland
Saponac
Skowhegan
Springfield
Stetson
Vassalboro
Waterville
Winn
Wiscasset
Wytopitlock

Testhole No.	Sample No.	Location
1	1-A-a	Sidney, Me. Van Note Prospect
1	1-A-b	" " " " "
2	1-B-a	" " " " "
2	1-B-b	" " " " "
3	None	" " " " "
4	1-C-a	" " " " "
5	1-D-a	" " " " "
5	1-D-b	" " " " "
6	1-E-a	" " " " "
7	2-A-a	Wenona Goff Prospect
8	2-B-a	" " "
8	2-B-b	" " "
8	2-B-c	" " "
9	3-A-a	Leon C. Hall Prospect
10	3-B-a	" " "
11	4-A-a	Reynolds Prospect
12	4-B-a	" "
CS-1	100	W. Gardiner, Me.—3/4 mi. E of Spears Cor., E side of hill; N of Lewiston-Gardiner Highway.
Pit	101a, b	Richmond, Me., 1 mi. S of Richmond Cor., Brunswick-Gardiner Highway; E side road.
CS-2	102	Hallowell, Me.—2 mi. W of Hallowell, I mi. W of Laughton Sch., McPherson Farm.
Pit	103a, b	Hallowell, Me.—I mi. W of Howard Hill; 0.4 mi. NE of Laughton Sch.
CS-3	104	Pittston, Me.—5/8 mi. SE of E. Pittston.
CS-4	105	Dresden, Me.,—1.2 mi. N of Dresden Mills, Highway 27; E side of road.
CS-5	106	Wiscasset, Me.—1/4 mi. S of North School; 35′ W of brook.

Testhole No.	Sample No.	Location
CS-6	None	Augusta, Me.—1.3 mi. W of Stone Sch.; S of Fish Hatchery Dam, on brook bank.
CS-7	107a, b, c	Augusta, Me.—4/5 mi. S of State Capitol, on State Street; W of h'w'y.
CS-8	None	Freeport, Me.—W Branch Merrill Brook; 1 3/10 mi. W of Freeport.
Rd. Cut	108a, b	Freeport, Me.—1 3/4 mi. SW of Freeport; W side of Merrill Brook, rd. cut.
CS-9	None	Freeport, Me.—0.2 mi. SE of Todd Corners; plains area.
CS-10	109a	Pownal, Me.—Floor of pit near Bradbury Mtn. NE side; NW side of h'w'y.
CS-11	109b	Same location as CS-10; SE side of h'w'y.
CS-12	None	Topsham, Me.—W of Cathance Stream; 1/2 mi. W of Cathance RR Station.
CS-13	None	Harpswell, Me.—1/3 mi. S of Dyer Cove; Route 24.
CS-14	None	Pownal, Me.—2.4 mi. SSW of W. Durham; NE foot of Bibber Hill.
CS-15	None	Belgrade Depot—RR cut beside overpass.
CS-16	None	Durham, Me.—0.5 mi. NW of Southwest Bend; SE of road intersection near Androscoggin River.
CS-17	None	New Gloucester, Me.—200 yds. E of MCRR station; E side of Royal River.
CS-18	110	Pownal, Me.—0.8 mi. NW of Pownal State Boys' School; Royal River Valley; Morse Rd.
CS-18A	111	Yarmouth, Me.—0.5 mi. SW of Royal Junction; beside E Branch of Piscataqua River.
CS-19	None	Turner, Me.—1.4 mi. SE of Poplar Hill; 0.7 mi. W of Androscoggin River.
CS-20	None	E. Livermore, Me.—Abandoned brickyard; owner Brooks of Lewiston, Me.
CS-21	None	Lewiston, Me.—1.6 mi. S of S. Lewiston.
CS-22	None	Auburn, Me.—0.2 mi. W of Lewiston Junction, Grand Trunk Line.
Pit	112	Mechanic Falls, Me.—1.5 mi. N of village; gravel pit E side of h'w'y.
CS-23	None	Minot, Me.—3 mi. N of Mechanic Falls, Me., near Bog Brook, opposite cemetery.
CS-24	None	Vassalboro, Me.—1.3 mi. SEE of Riverside, Me.; SW outlet to Webber Pond, E of stream on bank.
CS-25	None	Winslow, Me.—3.5 mi. NE of Sebasticook bridge at Winslow; gulley E side of Sebasticook River.
CS-26	113	Winslow, Me.—Same location as CS-25; 4′ higher on cut.
CS-27	None	Winslow, Me.—Same location as CS-25; 14′ higher than CS-25.
CS-28	None	Unity, Me.—Benton-Unity H'w'y; 1 3/4 mi. E of Libby Sch.; 1/8 mi. W of Twenty-five Mile Stream, W bank.
CS-29	None	Unity, Me.—Same location as CS-28, but near W side of Twenty-five Mile Stream, W bank.
CS-30	114	Waterville, Me.—New Colby; W side of upper portion of gravel pit, just E of Mayflower Hill; W of Messalonskee Str.
CS-31	None	Fairfield, Me.—1.4 mi. SW of Nye's Corner, beside road.
CS-32	None	Benton, Me.—2.2 mi. SW of Clinton; E side of Sebasticook River.

Testhole No.	Sample No.	Location
CS-33	None	Clinton, Me.—0.4 mi. E of Pratt Cemetery; 1.3 mi. SW of Morrison Corner; S side of h'w'y.
CS-34	None	Clinton, Me.—1 mi. W of Clinton; E side of Beaver Brook.
CS-35	115	Hinckley, Me.—1.5 mi. W of village; 0.25 mi. W of Craigin Brook.
CS-36	116a	Skowhegan, Me.—0.8 mi. N of Dudley School; Road Cut.
CS-37	116b	Skowhegan, Me.—0.8 mi. N of Dudley School; 15′ higher.
CS-38	116c	Skowhegan, Me.—0.8 mi. N of Dudley School; 36′ E of CS-36.
CS-39	117	Norridgewock, Me.—0.6 mi. N of Little Bear Mtn.; near Martin Stream.
CS-40	118a, b, c	Fairfield, Me.—E side of Martin Stream; 0.7 mi. S of Hoxie siding; 1.5 mi. E of Green Hill.
CS-42	None	Farmington, Me.—1/2 mi. S of W. Farmington; S side of RR; brickyard.
CS-43	None	Starks, Me.—1.7 mi. S of Red School; W of Sandy River; Rd. Cut—profile of 4 holes across gully (see 44, 45 & 46).
CS-44	None	Starks, Me. " " " " "
CS-45	119	Starks, Me. " " " " "
CS-46	120	Starks, Me. " " " " "
CS-47	121	Chesterville, Me.—0.3 mi. SSW of school at Chesterville; N side of road, NE of stream.
CS-48	122a, b	Madison-Solon Tw. Line; E River Road; E of Moores Island.
Road Cut	123a, b	Bingham, Me.—New road cut; E approach to Bingham Bridge, over Kennebec River.
Stream Cut	124a, b	N. Anson, Me.—4.0 mi. N of Barton Hill; 5.3 mi. W of N. Anson; bank of stream which runs N into Carrabassett River; NW bank.
CS-49	125a, b	E. New Portland, Me.—0.7 mi. SE of E. New Portland; N side of river.
Pit	126	Mattawamkeag, Me.—0.5 mi. SE of Jordan Mills; Mattawamkeag-Medway H'w'y; E pit; 0.3 mi. from river.
CS-50	127	Woodville, Me.—SE side CPRR crossing; 1.5 mi. W of Winn village.
CS-51	None	Winn, Me.—2.2 mi. NW of E. Winn.
CS-52	None	Winn, Me.—1.2 mi. NW of E. Winn.
CS-53	128	Chester, Me.—0.75 mi. SSE of Chester, Me.; just E of Ebhorse Brook.
CS-54	None	Passadumkeag, Me.—2.5 mi. SSW of Enfield.
CS-55	None	Howland, Me.—2.8 mi. W of Howland; W of S flowing branch of Meadow Brook.
Road Cut	129	Lincoln, Me.—0.4 mi. E of cemetery at S. Lincoln; E side of new highway, road cut.
CS-56	130, 131	Lincoln, Me.—0.4 mi. E of cemetery at S. Lincoln; E side of new highway, road cut—testhole.
CS-57	132	Enfield, Me.—3 mi. S of S. Lincoln; new highway; 2 mi. S of Dodlin Road intersection.
CS-58	133, 134	Milford, Me.—0.3 mi. W of Otter Chain Ponds, outlet stream; 1 mi. E of Milford Village; road to Greenfield.
CS-59	None	Milford, Me.—0.6 mi. NE of Costigan, Me. — towards Spearin School.
CS-60	None	Alton, Me.—2.3 mi. W of Argyle; W bank of Birch Stream.

Testhole No.	Sample No.	Location
CS-61	None	Hudson, Me.—2.7 mi. E of Hudson Village; 0.4 mi. from N road to Gerry.
CS-63	135, 136, 137	Old Town, Me.—0.3 mi. N of Stillwater; E bank of Penobscot River; field E of road.
CS-64	None	Hermon, Me.—0.9 mi. N of Hermon Pond; cross-roads; field W of road.
CS-65	None	Brewer, Me.—1.2 mi. SW of Eddington; 0.7 mi. from Penobscot River on road to S; parallels Eaton Bk.
CS-66	138, 139	Bucksport, Me.—0.25 mi. N of N. Bucksport; gulley E of highway; S side gulley.
CS-67	140, 141	Monroe, Me.—1.2 mi. NW of Monroe; new road cut on Marsh Brook Road.
CS-68	142	Prospect, Me.—0.25 mi. SSE of Prospect, Me.; S end of Marsh River; tidal marsh.
CS-41	147	Norridgewock, Me.—4/5 mi. in on access road to new airport; road cut; 3.5 mi. W of Norridgewock Village; E side of h'w'y.
CS-62	148	Hudson, Me.—0.2 mi. N of S. Hudson; field SE of road.

APPENDIX II

Notes on Selected Regional and Local Clay Deposits

(Summary of drainage, relief, estimated clay volume, and other economic data)

I. Richmond-Bowdoinham Area

Drainage

Clay areas drained by upper Cathance River, Kennebec River and Abagadasset Stream.

Relief

Relief is characterized by a flat, low-lying plain in the SE which has a gradual N slope. Clay rises from the S. at 15′ elevation to 180′ elevation, in a distance of approximately 12 miles. Persistent 100′ till and bedrock level throughout the area. Much of the SE region of Abagadasset drainage basin is covered with outwash sand.

Estimated Clay Volumes

Brown clay: Area 20 sq. mi.
Depth 1′-40′ Average 15′

Blue-grey clay: Area 4 sq. mi.
Depth unknown

Brief Summary of Selected Localities

(1) Richmond Village and area 2 mi. to the N.
(2) Bowdoinham Village and area 1 mi. to the N.

The brown clay has a maximum depth of 40′ and a minimum depth of 20′ in both localities. It has a noticeable high pebble content, and is sandy and considerably oxidized. A mantle of approximately 2′ of sandy loam lies over the area, and the brown clay is considerably reworked. At lower elevations, it is underlain by blue-grey clay, and by bedrock and till at higher elevations. The lower portions of Bowdoinham Village near Evergreen Cemetery and near Richmond River are sandy outwash plains.

There is ample quantity of brown clay for brickmaking; the volume and quantity of the blue-grey clay is not known. Excellent approaches, good roads and railroads, exist. The clay deposits are chiefly in open fields. Nearest operating yards are at Lewiston.

In earlier days 3 brickyards were operated in and near Richmond.

II. Gardiner-Pittston-Whitefield Area

Drainage

Clay areas are drained by Kennebec River, Eastern River, and upper Sheepscot River.

Relief

The Eastern River lies in the SE portion of area, and has a broad floodplain; the Kennebec River is the Western boundary. Clay deposits rise from 20′ elevation at Eastern River to 180′ elevation on the N and NE, and then fall again to 20′ elevation towards the Kennebec. The Sheepscot River forms the NE boundary. A persistent 100′ elevation till and bedrock level bounds the N and W portions of the Eastern River, occurring also at the 100′ elevation near the Kennebec. Three land masses rise to 260′-280′ elevation in the interior.

Estimated Clay Volumes

Brown clay: Area 18 sq. mi.
Depth 1′-40′ Average 10′

Blue-grey clay: No data available

Brief Summary of Selected Localities

(1) Pittston Village and areas E ans S of village.
(2) East Pittston Village and area SW of village.

The brown clay has a maximum depth of 30′ and a minimum depth of 10′ over the entire region. It is moderately oxidized, and exhibits manganese staining. Two feet of sandy loam mantles the region locally. The area S of East Pittston is a broad river wash-plain.

There is ample brown clay for brickmaking, and the quality of these clays is considered good. The extent and quality of the blue-grey clay is not known. There are fair highways in the area. The terrain consists of clay valleys, of which approximately one quarter are wooded.

No previous operations of the clay deposits were noted.

III. Lewiston-Lisbon-Durham Area

Drainage

Clay areas drained by Androscoggin River, No Name Brook, Little River, and Plummers Brook.

Relief

Dendritic drainage on a nearly mature topography characterizes the area. Clay occurs at the Androscoggin River about 120′ elevation, in the south near Durham and Lisbon Falls; nearer Lewiston the clay approximates 160′ elevation; out of Lewiston the clays rise to about 240′ elevation in local tributaries to the Androscoggin River. Large portions of the region are covered by wind-blown and water-laid sand. Hills rise out of the plain to 400′ elevation.

Estimated Clay Volumes

Brown clay: Area 25 sq. mi.
Depth 1′-40′ Average 10′

Blue-grey clay: Area 20 sq. mi.
Depth unknown

Brief Summary of Selected Localities

(1) S portion of Lewiston.
(2) Area S of Shiloh.
(3) Area 2 miles W of Lewiston.

The brown clay varies in depths as follows:

Location (1) Maximum of 25′, minimum of 8′.
Location (2) Maximum of 20′-25′, minimum of 10′.
Location (3) Maximum of 15′-20′, minimum of 8′.

The brown clay of the region is silty, highly oxidized, stained with manganese, and mixed with boulders and cobbles locally. The brown clay appears reworked, and locally is interbedded with sand; there is a 5′ minimum sand mantle in most regions, but location (2) S of Shiloh has no overburden where clay valleys are exposed. W of Lisbon, 3′-15′ of sand surrounds the clay valleys. The entire region is a sandy plain, while the area S of Lewiston has esker and river gravels nearby. Sand deltas occur at approximately 320′-340′ elevation, just S of Lewiston.

There is abundant and good brickmaking clay, with plenty of sand available in the entire area. Roads and railroads are plentiful, and the terrain is suitable for brickmaking operations. In the area W of Lisbon operations would have to be confined to a single valley, and at the Lewiston site, operations would be limited by housing development. The Lisbon site is wooded, and the Shiloh site is chiefly open fields.

There have been no previous operations near Shiloh or W of Lisbon that were discovered. Near Lewiston, a brickyard 1 mi. N of the site under discussion, was operated by Arthur H. Brooks, but was closed in 1943; the clay deposit was enclosed by housing, and the bottom good brick-clay was reached. Another location, 1.5 mi. S of the site, and located in Auburn, was formerly the location of a brickyard operated by Dennis & Sons. Wire cut brick was being made in 1944. The Bergeron Brick Co., a yard within the same area, recently sold out to the Morin Brick Co. of Danville, Me. (1946). This yard is to make waterstruck brick.

IV. Brunswick-Topsham Area

Drainage

Clay areas drained by the lower Androscoggin River and tributaries, lower Cathance River, Mare Brook, Miller Creek, and Bunahue Stream.

Relief

The area consists of central plains about Brunswick and towards the east. The north and west portions are irregular, generally mature terrain. The southern region slopes gently southward into several estuarine embayments. To the east and south, elevations average 25′-50′, rising gradually to the north to 140′ elevation. A few small hills occur at 200′-260′ elevation and circumscribe the plains.

Estimated Clay Volumes

Brown clay: Area 25 sq. mi.
Depth 1′-40′ Average 10′

Blue-grey clay: Area 10 sq. mi.
Depth unknown

Brief Summary of Selected Localities

(1) Area S of Rock Hill (N of Deep Cut)
(2) Area N of Bunganuc Landing

The brown clay has a maximum depth of 35′ and minimum of 10′ in both localities. Little is known of its quality. A sandy mantle varies in depth from 1′-5′ locally, and both regions have V-shaped valleys and dendritic erosion patterns over sandy outwash plains. Little data are available on the blue-grey clays.

There is ample quantity of brown clay for brickmaking, and accessibility is good. Exposures are in deep valleys in cultivated regions. Brunswick and Bath are the nearest markets.

Information relative to previous operations was not available.

V. Augusta Area

Drainage

Clay areas drained by Bond Brook, Kennebec River and tributaries.

Relief

Topography is mature with V-shaped valleys cut into a former 200′ elevation plain. Above 200′ elevation, the region is surrounded with hills rising from 340′-640′ elevation. Near the Ballard School and the Augusta Airport, clay rises locally to 260′ elevation.

Estimated Clay Volumes

Brown clay: Area 15 sq. mi.
Depth 1′-80′

Blue-grey clay: Area 12 sq. mi.
Depth unknown (18′ minimum)

Brief Summary of Selected Localities

(1) Area 2 miles SW of North Augusta (Bond Brook Area)
(2) Area 2 miles S of State Hospital (Chelsea Area)

The brown clay has a maximum depth of 80′ in both regions, and a probable minimum of 20′. It is moderately too highly oxidized and silty partings are common. Moderate manganese staining occurs, and one to three feet of sandy loam mantle is common; however, cobbles are rare in the clay itself. There are deltas and kame deposits in the Bond Brook Area, and the eastern portion of this area is intersected by an esker which is partially clay covered. The N and E portions are covered with 3′-15′ of sand. Little is known concerning the blue-grey clay in the area, but it is present with an unconformity between the two clay types. The blue-grey clay is known to contain fossils. In the Chelsea region, till deposits occur eastward at about 200′ elevation and locally below 100′ elevation.

There is ample brown clay for brickmaking, and water supply is adequate. The blue-grey clay is known to have a minimum depth of 18′. Roads in the areas are fair, and the terrain is characterized by V-shaped valleys. Only 30 per cent of the two regions is wooded.

Previously a brickyard was operated one and a half miles southeast of Bond Brook region by George Robichaud. It has been abandoned as the brown clay was nearly depleted. One other site was operated, which was nearer Augusta, but is now a built-up area. No operations were observed in the Chelsea region.

VI. Waterville-Winslow Area

Drainage

Clay areas drained by Messalonskee Stream, Kennebec River and tributaries, and lower Sebasticook River and Chaffee Brook.

Relief

Most of the area lies on a plain near the confluence of the Kennebec and Sebasticook Rivers. This plain averages between 140′-160′ elevation. A portion of the plain extends S of the Sebasticook outlet, along the E shore of the Kennebec for a distance of 4 miles. The Messalonskee Stream Valley is much the same elevation, and trends NW. Mature hills rise from the borders of the plains to 250′-470′ elevation. The clay near the major rivers averages 80′ in elevation, and approaches 200′ as it rises towards the area W of Fairfield Village.

Estimated Clay Volumes

Brown clay: Area 14 sq. mi.
Depth 1′-20′

Blue-grey clay: Area 8 sq. mi.
Depth unknown

Brief Summary of Selected Locality

Region E and S of Hayden Corner, Winslow; near Outlet Stream.

The brown clay has a maximum depth of 20′ and a minimum depth of 8′ over the area. It has a moderate degree of oxidation, and low manganese staining. About 2 feet of sandy loam mantle occurs over reworked clay. Sand overlies the clay locally; blue-grey clay occurs at a depth of 10′ or more, and is unconformable with the overlying brown clay. An esker deposit lies 3 miles to the W, running through Fairfield and Waterville along the Kennebec River. Dunes occur on the northern portion of the plain.

There is ample quantity of brown clay for brickmaking, and plenty of available sand. Blue-grey clay is limited in volume, but its possibilities are unknown. Good accessibility to the selected site. Valleys generally V-shaped and nearly one half the area is wooded. Local markets probably available.

Albert J. Paulette previously operated a brickyard 1¼ miles NW of the region in Winslow; ceased operations about 12 years ago. Colby College owned a brickyard about 4 mi. N of the site in Waterville. It has not been operated for several years.

VII. Hinckley-Canaan Area

Drainage

Clay areas drained by Kennebec River and tributaries, and Martin Stream and Carrabassett Stream.

Relief

Relief is characterized by a broad sand plain rising to the N from Shawmut to Oak Pond in Skowhegan from 65′ elevation to 200′ elevation. In the NW, clay rises up the Martin Stream Valley to 220′ elevation at Larone. Local hills rise from 400′-600′ elevation; in the SE region hills rise from 180′-200′ elevation.

Estimated Clay Volumes

Brown clay: Area 25 sq. mi.
Depth 1′-20′

Blue-grey clay: Area 12 sq. mi.
Depth unknown

Brief Summary of Selected Localities

(1) North Fairfield Area, five eighths mi. W of village (Martin Stream Region)
(2) Carrabassett Stream Area, 1 mi. NE of Hinckley, S of stream.

The brown clay has a maximum depth of 25′ and minimum of 8′ along the Carrabassett Stream, and a maximum of 15′ and minimum of 6′ away from the stream. Many boulders and cobbles appear in the clay in the Carrabassett Area; fewer in the N. Fairfield Region. Both areas have clay with moderate amount of manganese staining and traces of carbonaceous materials. The brown clay has silty partings and overlies the blue-grey clay or bedrock locally. At North Fairfield, the brown clay is covered with a mantle of 2′-5′ of sandy loam. Along the Carrabassett Stream, local areas are free of mantle, but to the SE, sand overlies the clay to a depth of 6′-8′. SW of the Carrabassett Region, sands and river gravels occur near the stream outlet. North of the area a boggy region extends to the W.; to the E an esker runs southward; W across the Kennebec, sand mantles the clay 2′-10′ in thickness.

Ample quantities of brown clay are present in both regions. Sand is plentiful. Both areas are near surfaced highways. Nearly one half the areas are wooded.

No previous operations were noted.

VIII. Norridgewock-Starks-Mercer Area

Drainage

Clay areas drained by Kennebec River, Mill Stream, Sandy River, Bombazee Brook, Lemon Brook, Indian Stream, Witham Brook, and Bog Stream.

Relief

A sand and clay plain lies SE of Norridgewock Village at an elevation of 200′-240′. It extends NW to the outlet of Sandy River, and W to Starks Village, with an elevation ranging from 220′-260′. In the interior, 3 mi. NW of Norridgewock, a sand covered till plain rises to 360′; to the S a series of granite hills rise to 600′-750′ elevation; and to the north bedrock hills rise to 350′-450′ elevation. Much of the area is covered with sand and outwash gravels.

Estimated Clay Volumes

Brown clay: Area 25 sq. mi.
Depth 1′-25′

Blue-grey clay: Area 20 sq. mi.
Depth unknown (minimum of 15′)

Brief Summary of Selected Localities

(1) Sandy River Village (Norridgewock)
(2) Starks Area (opposite Sandy River Village site)

The brown clays have a maximum depth of 25′, a minimum of 6′, and a probable average of 8′ throughout the areas. It is somewhat oxidized and commonly has silty partings along the bedding planes. Moderate manganese staining and concretions occur locally. There is apparently an unconformity between the brown clay and the blue-grey clay which lies underneath. Much of the area is covered with 1′-5′ mantle of highly oxidized sand. River gravels lie along the Kennebec and Sandy Rivers at elevations below 200′. An esker deposit follows the SE bank of the Kennebec and crosses the plain under discussion, 1 mi. W of Norridgewock Village. Water-laid sands occur at several localities near Norridgewock and Starks at an elevation of approximately 300′.

The blue-grey clay near Norridgewock Airport is silty; while S of Red School in Starks, the clay appears darker grey. Both areas are approached by fair gravel and surfaced roads, and are located in easily workable deposits.

No previous operations were located in the two selected sites. Several brickyards were operated in or near Norridgewock in the past.

IX. Freeport-Yarmouth-Pownal-Cumberland Area

Drainage

Clay areas drained by Mill Stream, Sodom Brook, Royal River, East Branch Piscataqua River, Allen Range Brook, and Cousins River.

Relief

Relief characterized by a broad outwash plain which grades N from sea level to a group of hills near Bradbury Bradbury Mt. N, elevations vary from 180′-200′. In general, the entire region has a dendritic drainage pattern. Scattered hills rising from 180′-240′ occur throughout the entire area. Most of the plain is covered with sand varying from 2′-4′ in the northern regions to 20′-25′ in depth near the coast.

Estimated Clay Volumes

Brown clay: Area 28 sq. mi.
Depth 1′-40′ Average 15′

Blue-grey clay: Area 20 sq. mi.
Depth unknown (minimum 14′)

Brief Summary of Selected Localities

(1) Royal River Area (W of Pownal State School)
(2) Area $\frac{1}{2}$ mi. N of Mast Landing
(3) Area 1 mi. W of Freeport Village

In the region near East Gray, on the Royal River, there is about 8 sq. mi. of brown clay with a depth of 20′-40′. The other two areas are deeply gullied, averaging about 1 sq. mi. each. Brown clay is moderately oxidized, and vertical joints are manganese stained. Its bedding is locally pronounced and contains sand layers or silty parting planes. Highly oxidized concretions fairly common. An unconformity separates the brown clay from underlying blue-grey clay. The latter is silty and locally fossil pelecypods were drawn out of an auger testhole. Most of the major stream valleys cut into clay below a sandy mantle. Gravel terraces are common at 140′ elevations.

Abundant clay reserves for brickmaking are found in all areas, especially along the Royal River. All regions are approachable by hard surfaced or fair gravel roads, while the terrain is characterized by sharp V-shaped valleys. Approximately one half the areas are wooded.

At present, the Royal River Region has 3 brickyards: (1) Joseph Blair, Jr.—Property, (2) Lionel E. & Oscar R. Gagnon Property, and (3) Fred S. Liberty Property. Bean & Stetson operated a yard in Freeport many years ago.

X. Hampden-Brewer Area

Drainage

Clay areas drained by Penobscot River and tributaries, Sedgeunkedunk Stream, Felts Brook, Eaton Brook, and Souadabscook Stream.

Relief

General relief is characterized by rugged highlands and lower swampy areas. Most of the clay deposits along the lower Penobscot have been eroded since the glacial period. This area has been partially protected by rugged highlands in S Orrington and N Winterport. The plain N of these regions extends as far as the city of Bangor, W to Herman Center, and E to a range of foot-hills W of Holden Village. Most of the clay deposits appear in the N half of this basin-like region at elevations from 40′ (near the Penobscot River) to 120′ elevation (4 mi. inland). The average elevation of clay deposits is approximately 100′.

Estimated Clay Volumes

Brown clay: Area 8 sq. mi.
Depth 1′-30′ Average 10′

Blue-grey clay: Area 5 sq. mi.
Depth unknown (16′ minimum)

Brief Summary of Selected Localities

(1) South Brewer Area
(2) East Hampden Area

The brown clay is stained with manganese and exhibits some carbonaceous material. It is reworked and has low to moderate oxidation. Concretions are fairly common to both brown and blue-grey clays, the latter generally underlie the brown clays. Ascending from the Penobscot level both sides of the river have a mantle of sandy loam which deepens to 4′-5′ in a distance of one mile. The clay is usually massive. River gravels extend inland for one half mile from Brewer to South Brewer. On the Hampden shore of the river, an esker runs through Bangor to Winterport.

Ample brown clay for brickmaking occurs in both areas. It is easily accessable from hard surfaced roads. Housing developments are encroaching upon both areas. Locally, Bangor and adjoining settlements afford a possible market

In South Brewer a brickyard is now in operation. Several others in the area have operated in past years.

Summary of Minor Clay Deposits by Area

I. Wiscasset Area

Drainage

Clay areas drained by the lower Sheepscot and Montsweag Brook.

Estimated Clay Volumes

Brown clay: Area 3 sq. mi.
Depth 1′-30′ Average 8′

Blue-grey clay: Area 1.5 sq. mi.
Depth unknown

II. Alna-North Newcastle Area

Drainage

Clay areas drained by Sheepscot River and Dyer Stream.

Estimated Clay Volumes

Brown clay: Area 3 sq. mi.
Depth 1′-25′ Average 12′

Blue-grey clay: Data unavailable

III. West Gardiner Area

Drainage

Clay areas drained by Cobbosseecontee Stream

Estimated Clay Volumes

Brown clay: Area 5 sq. mi.
Depth 1′-20′ Average 8′

Blue-grey clay: Data unavailable

IV. Monmouth Area

Drainage

Clay areas drained by Jock Stream.

Estimated Clay Volumes

Brown clay: Area 3.5 sq.mi.
Depth unknown

Blue-grey clay: Depth and area unknown.

V. Farmington Area

Drainage

Clay areas drained by Temple Stream, Wilson Stream, and Sandy River.

Estimated Clay Volumes

Brown clay: Area 2.5 sq. mi.
Depth 1′-15′ Average 8′

Blue-grey clay: Area 1.5 sq. mi.
Depth unknown (18′ minimum)

VI. Bath-Woolwich Area

Drainage

Clay areas drained by Whiskeag Creek, Nequasset Brook, and Kennebec River Tributaries.

Estimated Clay Volumes

Brown clay: Area 4 sq. mi.
Depth 1′-25′ Average 8′

Blue-grey clay: Data unavailable

VII. East Livermore Area

Drainage

Clay areas drained by Scott Brook and Hunton Brook

Estimated Clay Volumes

Brown clay: Area 5 sq. mi.
Depth 1′-15′ Average 10′

Blue-grey clay: Area 4 sq. mi.
Depth unknown (minimum 8′)

VIII. Sidney Area

Drainage

Clay area drained by Goff Brook and Kennebec River Tributaries.

Estimated Clay Volumes

Brown clay: Area 3 sq. mi.
Depth 1′-40′ Average 12′

Blue-grey clay: Depth and area unknown, probably small.

IX. Skowhegan Area

Drainage

Clay areas drained by Currier Brook and Wesserunset Stream.

Estimated Clay Volumes

Brown clay: Area 2.5 sq. mi.
Depth 1′-20′ Average 10′

Blue-grey clay: Area 2 sq. mi.
Depth unknown (Minimum 6′)

X. Madison-Anson Area

Drainage

Clay areas drained by Kennebec and tributaries.

Estimated Clay Volumes

Brown clay: Area 2 sq. mi.
Depth 1′-15′ Average 8′

Blue-grey clay: Area 1.5 sq. mi.
Depth unknown (minimum 10′)

XI. North Anson-Embden Area

Drainage

Clay areas drained by Carrabassett River and Mill Stream.

Estimated Clay Volumes

Brown clay: Area 3 sq. mi.
Depth 1′-15′ Average 8′

Blue-grey clay: Area 2 sq. mi.
Depth unknown (minimum 15′)

XII. Bucks Mills (Bucksport) Area

Drainage

Clay areas drained by Orland River Tributary.

Estimated Clay Volumes

Brown clay: Area 1.5 sq. mi.
Depth 1′-20′ Average 10′

Blue-grey clay: Depth and area unknown.

XIII. Prospect Area

Drainage

Clay areas drained by Marsh River.

Estimated Clay Volumes

Brown clay: Area 3 sq. mi.
Depth 1′-40′ Average 12′

Blue-grey clay: Area 2 sq. mi.
Depth unknown (minimum 4′)

XIV. Frankfort-West Winterport Area

Drainage

Clay areas drained by lower Penobscot River and Marsh Stream.

Estimated Clay Volumes

Brown clay: Area 5 sq. mi.
Depth 1′-40′ Average 8′

Blue-grey clay: Depth and area unknown.

XV. South Orrington-Bald Hill Cove Area

Drainage

Clay areas drained by Mill Creek and Penobscot tributaries.

Estimated Clay Volumes

Brown clay: Area 2 sq. mi.
Depth 1′-30′ Average 10′

Blue-grey clay: Area 1 sq. mi.
Depth unknown

XVI. Old Town Area

Drainage

Clay areas drained by Penobscot River, Stillwater River, Pushaw Stream, and Otter Chain Pond Stream.

Estimated Clay Volumes

Brown clay: Area 5 sq. mi.
Depth 1′-15′ Average 7′

Blue-grey clay: Area 3 sq. mi.
Depth unknown (minimum 8′)

XVII. Chester-Lincoln-Enfield-Howland Areas

Drainage

Clay areas drained by Beaver Brook, Piscataquis River, Seboeis Stream, Barnes Brook, Pollard Brook, Medunkeunk Stream and other unnamed tributaries.

Estimated Clay Volumes

Brown clay: Area 20-25 sq. mi.
Depth 1′-10′ Average 6′

Blue-grey clay: Area 25-30 sq. mi.
Depth unknown (minimum 23′)

SUMMARY OF ECONOMIC INVESTIGATIONS OF SOME PEGMATITES IN TOPSHAM, MAINE[1]

By Vincent E. Shainin

For nearly a century the Topsham area in southern Maine has been the source of a small but steady production of feldspar. Brief descriptions of the feldspar mines have appeared and unusual minerals occurring in them have been studied, but no detailed study of the geology of the belt nor of the pegmatites and their feldspar deposits have been made. In 1945 a three-month cooperative investigation was undertaken by the State and Federal Geological Surveys to provide information on the composition and mode of occurrence of the feldspar deposits and on the form, character, and distribution of the productive pegmatites. A bulletin[2] presenting the results of the study has been prepared. A summary of the investigation is presented below.

The pegmatite-bearing belt is eight miles long and a little over a mile wide, extending from the Androscoggin River at the village of Topsham, north-northeast to the village of Bowdoinham. The area is one of low relief, drained by tributaries of the Androscoggin and Kennebec Rivers. Passable dirt and gravel roads lead into the area from paved highways east and west of the belt.

The Topsham district has been prominent among the pioneer feldspar-producing districts of New England. Two conditions were responsible; nearness to the coast and ease of transportation to potteries near the Atlantic seaboard, chiefly at Trenton, New Jersey. Transportation of feldspar from Maine to Trenton by water was both easy and cheap, and the Topsham district and other districts located on tidewater held a distinct advantage over districts farther inland.

Geology

The Topsham area is underlain by gneiss and by a variety of granitic intrusives. The gneiss is variable in texture and composition. In some places it has been replaced by granitic material; in others it has been injected along the foliation planes by gneissic granite. Large and small bodies of quartz-plagioclase aplite and numerous bodies of pegmatite have been intruded into the gneiss. Small masses of biotite

[1] A cooperative project of the Maine Geological Survey and U. S. Geol. Survey.

[2] Shainin, Vincent E., "Economic Geology of Some Pegmatites in Topsham, Maine," Bulletin 5, Maine Geological Survey, in preparation.

granite are enclosed in some of the pegmatites. The pegmatites cut gneiss, gneissic granite, and aplite, hence are younger than all these rocks. Basic dikes, probably of Triassic age, are the youngest rocks of the area.

The area lies on the eastern flank of a broad anticline. The regional strike of the foliation of the gneisses is northeast, and the dip of the foliation is gentle or moderate to the southeast.

Pegmatites

Distribution and Structural Characteristics

Pegmatites are common in all the rock units in the area mapped. Contacts with wall rock, in the few places where they are exposed, are commonly irregular, and some are gradational. Most of the pegmatites appear to be roughly tabular lenses that range from 6 inches to 1,900 feet in length and from 1 inch to at least 80 feet in thickness. The pegmatites along the eastern side of the area mapped are thin sheets that dip eastward, roughly parallel to the local slope of the topographic surface. They are, therefore, exposed for considerable distances in the direction of dip and occupy areas on a map that are greatly disproportionate to their sizes. Most of the pegmatites strike between N 5° and N 20° W; of the remainder the majority strike between N 5° W and N 30° E. Most of the pegmatites in the eastern part of the area strike northeastward; whereas most of those in the western part strike northward or northwestward. In general, the eastern pegmatites are thinner and more nearly concordant with foliation than those in the western part.

The great majority of the pegmatites dip between 30 and 50 degrees eastward. The opposite walls of some of the bodies, mostly those too small to be shown on the map, have dips indicating downward convergence or divergence of the walls. This divergence is undoubtedly due in some places to irregularities of the walls, but in others it probably indicates tapering of the lenses upward or downward. The crest of one pegmatite plunges 48°, N 50° E and the keel of another plunges 5°, N 25° E. A few other crests and keels are exposed, but their attitudes could not be determined.

Mode of Emplacement

The pegmatites appear to have been formed both by injection and by replacement of wall rock. Some of them appear to have entered by forcing aside the gneiss, for along their margins secondary foliation, parallel to the contacts but markedly divergent from the regional foliation, has been developed in the gneiss. The contacts of certain other pegmatites that likewise appear to have been injected are markedly discordant and seem to indicate stoping.

Many pegmatites in the area contain biotite in thin layers or "streaks" that are commonly parallel to the regional foliation of the gneiss and appear to have been inherited from replaced wall rock. In at least one pegmatite, the biotite layers are folded as though the original gneiss had been contorted during injection and replacement. In some places, biotite-rich layers in the wall rock can be traced into pegmatite several inches beyond the contacts, which are wavy, irregular, and discordant. These features indicate that some of the pegmatites were formed, in part at least, by replacement of the gneiss. To determine the relative importance of injection and replacement in the area as a whole, however, requires further study.

Internal Structure and Composition

The pegmatites are broadly similar in internal structure and composition. Some, in general those that have been most deeply exposed by erosion or mining, exhibit zonal structure. A zoned pegmatite is one in which the minerals are grouped into lithologic units of contrasting composition or texture which have a systematic arrangement with respect to the walls of the pegmatite. The component lithologic units are termed "zones" and have the shape of successive shells concentric about an innermost zone or core.[3] Five types of zones have been recognized in the pegmatite bodies at Topsham. These are, in the order of their occurrence, from the pegmatite walls inward; border zone, graphic granite-quartz-plagioclase-perthite wall zone,[4] quartz-muscovite intermediate zone, perthite intermediate zone, and quartz-perthite or quartz zone. The fifth zone appears to form the cores of the pegmatites. In addition to zones, fracture-controlled replacement bodies cutting the zones are found in one pegmatite.

[3] Cameron, E. N., Larrabee, D. M., McNair, A. H., Page, J. J., Shainin, V. E., Stewart, G. W., Structural and economic characteristics of New England mica deposits, Econ. Geol., vol. 40, pp. 369-393, 1945.
The terminology of pegmatite units employed in the present report was jointly developed and adopted by parties of the U. S. Geological Survey working in various pegmatite districts during World War II.

[4] The term "wall zone" has been adopted for the second zone of a pegmatite body rather than the zone immediately adjacent to the wall rock in conformity with long established usage in the pegmatite mining industry. The outermost zone, here called the "border zone," is thin and of no economic importance, hence has commonly been ignored.

Feldspar Deposits

The pegmatites of the area studied have supplied large amounts of No. 2 feldspar and appear to contain large reserves of feldspar of this grade. The amount of No. 1 feldspar available appears to be small, but in the past larger amounts may have been mined than would be suggested by inspection of the present quarry faces. The bulk of the feldspar produced has come from the wall zones of large pegmatites, and the remainder from intermediate perthite zones and quartz-perthite cores.

Wall zone Deposits

The wall zones are the source of most of the No. 2 feldspar produced in the district. Large quantities of No. 2 feldspar, chiefly graphic granite, still remain in the wall zones of some of the pegmatites. As feldspar containing up to 50% quartz is often accepted by the Topsham mill of the Consolidated Feldspar Co. at $6.00 per ton, not only graphic granite but also other perthite-rich material in the zone can be mined, sorted out, and sold as No. 2 feldspar. Next to quartz, biotite is the chief impurity in wall zones and must be separated from marketable feldspar by hand. Garnet and magnetite are minor impurities that can be removed from most of the wall-zone material by magnetic separation at the Topsham mill. Decomposition of garnet has occurred in the wall zones of some pegmatites, however, and the iron released is probably the cause of heavy staining of perthite and quartz in inner zones.

Perthite-zone Deposits

A perthite-zone deposit has been recognized in at least one pegmatite although it is too small to support mining operations independent of the wall-zone. The feldspar present in it is coarse, pure, and readily separated from impurities by hand. This zone is, therefore, a potential source of small quantities of No. 1 feldspar, which can be sold separately or mixed with the No. 2 feldspar obtained from wall-zone material so as to improve its average grade.

Quartz-perthite Core Deposits

Core deposits are found in a number of pegmatites of the Topsham area. As perthite occurs in them in large crystals readily separable by hand, these deposits have probably been the principal source of

No. 1 feldspar produced in the district. In most of the pegmatites, however, the cores consist of centrally located, small, disconnected segments enclosed in, and therefore separated by, wall-zone material. They form only a small proportion of the parts of the pegmatites exposed, and it seems evident that selective mining of core deposits to obtain a high-grade product is impractical. The pegmatite mined in the Trenton quarry is an exception; its core has an apparent thickness of 60 to 90 feet and a length of at least 240 feet. A considerable part of this core has been removed, but the bulk of the quarry output appears to have been No. 2 feldspar from the wall zone. Coarse milky quartz can be recovered from the cores as a by-product of feldspar mining although at present there is little demand for quartz.

Importance of perthite-zone and core deposits

A casual inspection of the present quarry faces suggests that the perthite and quartz-perthite zones are too small and scattered to supply much feldspar. It is noteworthy, however, that quarrying has almost invariably been confined to the central parts of the pegmatites. Furthermore, quarrymen report that the central parts of many of the larger quarries contained core segments and associated perthite zones in greater abundance than is now apparent. It may well be that the amount of high-grade perthite obtainable from these zones was sufficiently large to improve the average grade of the mine-run feldspar appreciably. It seems equally probable, however, that except at the Trenton quarry, none of these bodies was large enough to warrant selective mining for No. 1 feldspar alone.

During the recent war, mining operations were on a very small scale, conducted sporadically by crews of 1 to 3 men who mined small amounts of feldspar for sale to Consolidated Feldspar Company. Experience with small-scale operations indicates that in all probability the miners tended to concentrate on the better parts of a given pegmatite, moving on to another working upon exhaustion of the higher-grade material in sight. For this reason it seems likely that the present quarry faces are not representative of the average material mined in the past.

Beryl

Beryl is an uncommon mineral in the pegmatites. Crystals up to 10 inches in diameter were reported to be moderately abundant in the William Willes feldspar quarry, $1\frac{1}{2}$ miles northwest of Cathance

Station (north of the area mapped), and some gem beryl was reported found with green gem tourmaline in cavities at the Trenton (G. D. Willes) quarry. During the present investigation scattered crystals were found in the core of the pegmatite in the No. 2 quarry and a few small crystals were found on the dump of the Trenton quarry. Although crystals of beryl may be recovered occasionally during feldspar mining, it seems evident that only trifling amounts of the mineral are present in the area.

Mica

Most of the mica mined at Topsham in the past was wedged, hence usable only as scrap, and the amount available was small. During the present investigation no deposit of muscovite capable of yielding more than a fraction of one per cent of sheet mica was found. The pegmatite in the Trenton quarry contains more scrap mica than any of the other pegmatites studied, but even at this quarry the amounts available are insufficient to support an operation for mica alone.

Outlook for Future Operations

If operators in the district continue to rely principally on hand sorting for procurement of marketable material, the outlook for the district depends primarily on the market for No. 2 feldspar and the cost of producing it. The principal minable material in the quarries is graphic granite, in which quartz and feldspar are so intimately intergrown that they cannot be separated by hand sorting. Addition of pure perthite from a perthite zone or a quartz-perthite core would lower the average content of free silica, but the amount of high-grade material available is probably not large enough in the average pegmatite of the Topsham area to reduce the amount of quartz below 20 per cent.

So far as known, flotation of feldspar from graphic granite of the Topsham area has not been attempted, and whether this type of treatment would be economically feasible is difficult to predict. Graphic granite would undoubtedly yield potash feldspar of No. 1 grade, but as graphic granite itself would have to be hand-sorted from the rest of the pegmatite, the cost of the entire operation might be prohibitive. Mass milling of entire pegmatite bodies would require separation of garnet, magnetite, muscovite, biotite, and quartz in order to yield a product of No. 1 grade. Whether this product would qualify as a No. 1 potash feldspar is uncertain, for the plagioclase content of the wall zones varies from place to place, and no data are at hand to indicate the limits of variation. Reserves of material available for mass milling, however, appear to be large.

Recommendations for Prospecting

The pegmatites in the district are poorly exposed, for most of those that have been quarried in the past are either flooded or backfilled, and those that have not been worked extensively are commonly concealed to a large extent by overburden or vegetation. These local conditions complicate the problem of prospecting. In general, chances of developing a productive deposit appear to be best in the larger pegmatite bodies of the district that show indications of perthite zones or quartz-perthite cores. Examination of the quarries suggests that the central parts of these pegmatites are in general richer than others in coarse graphic granite and in addition their inner zones contain at least small tonnages of readily separable No. 1 potash feldspar.

MOLYBDENITE OCCURRENCE

Township 10, Hancock Co., Maine

By J. M. Trefethen and R. N. Miller

General Information

Catherine Mountain, Township 10, Hancock Co., Maine, has long been known to contain molybdenite. The molybdenite prospect has been described by Frank Hess[1] and W. H. Emmons.[2] It was decided to map the area and study the occurrence of molybdenite chiefly because there appears to be a widespread belief that the deposits are rich, in part, a result of a glowing account of the prospect in a popular book on Maine.[3] Robert N. Miller of the Maine Geological Survey mapped the portion of the hill carrying molybdenite on a scale of one hundred feet to one inch.

Topography and Relief

Catherine Mountain rises to an elevation of 942 feet above sea level. The crest lies about three-quarters of a mile northwest of Tunk Lake in T 10. (Tunk Lake, Quadrangle, Me.) The mountain rises 734 feet above the level of the lake. Route 182 passes along the north and northeast sides of the mountain. Access to the prospects is easiest by means of an old road and trail up the north slope, a climb of approximately six hundred feet, in a distance of about one mile. The trail leads south from Route 182 at a point approximately five eighths of a mile from the west end of Fox Pond. The best exposures are along the south side of the mountain. (See Map I.) Although the deposit was never worked, considerable test pitting and blasting was done in the early part of the century.

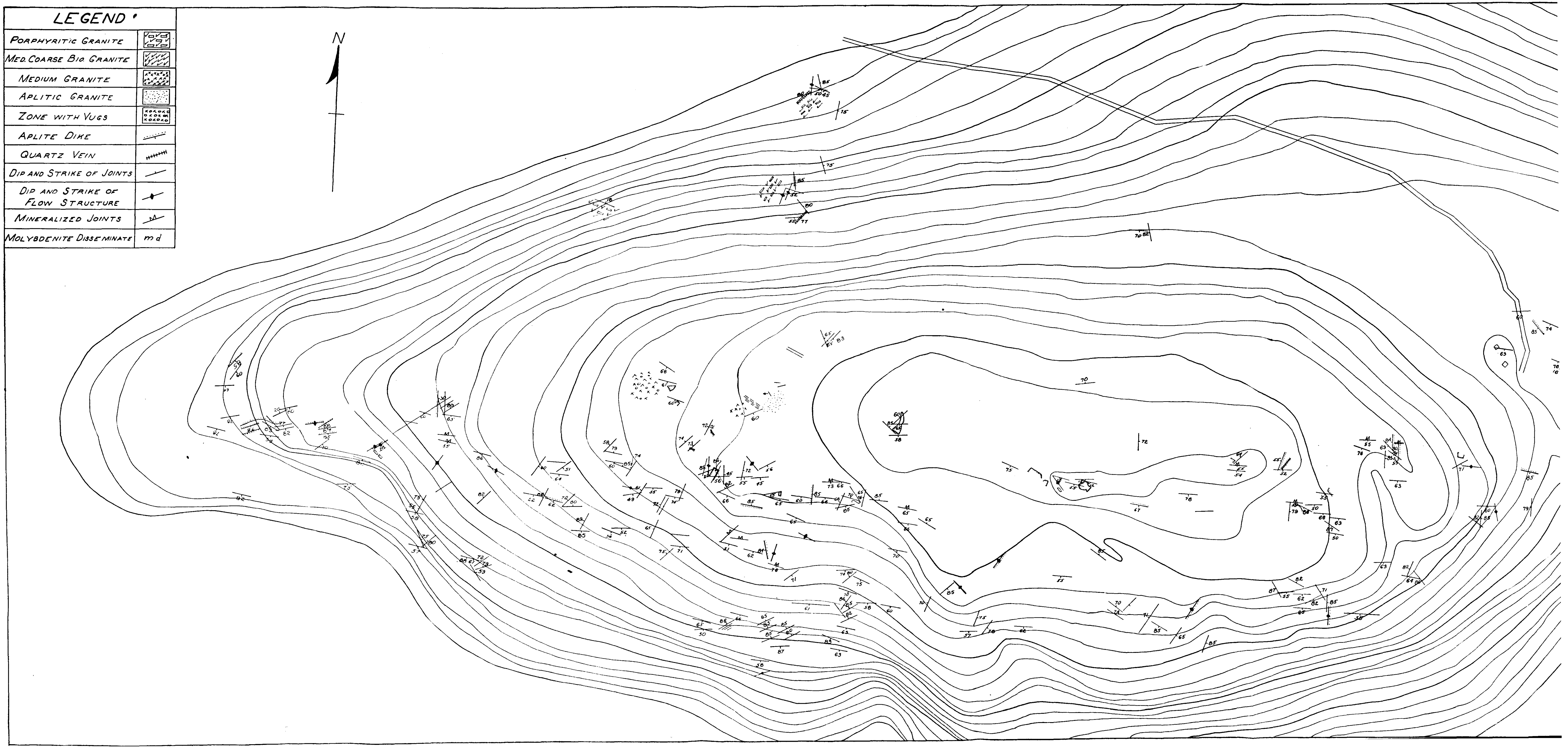
Geology

Catherine Mountain is one of many hills in the area composed of granite, a part of the Tunk Lake batholith. The intrusion contains a variety of associated granite types, varying somewhat in texture and mineralogy.

Lithology

The principal granite, which comprises the bulk of the hill, is a coarse textured biotite granite. Locally it is porphyritic, and the

[1] Hess, F., Bull. U. S. Geol. Survey 340, 1907, pp. 234-235.
[2] Emmons, W. H., U. S. Geol. Survey Bull., 432, 1910, p. 42.
[3] Dunnack, H. E., *The Maine Book*, 1920, p. 230.


LEGEND
Porphyritic Granite
Med. Coarse Bio. Granite
Medium Granite
Aplitic Granite
Zone with Vugs
Aplite Dike
Quartz Vein
Dip and Strike of Joints
Dip and Strike of Flow Structure
Mineralized Joints
Molybdenite Disseminate
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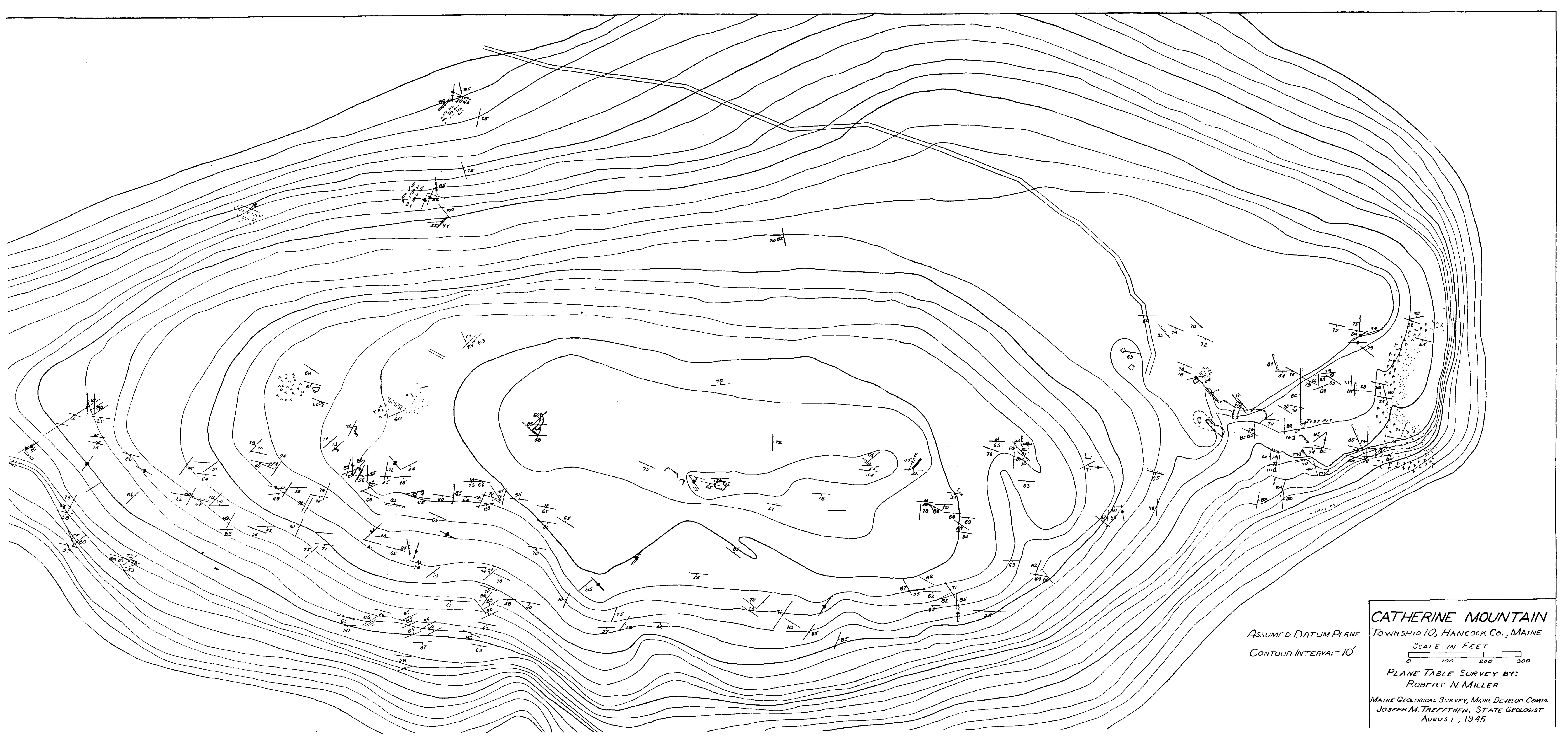
N


CATHERINE MOUNTAIN
TOWNSHIP 10, HANCOCK CO., MAINE
SCALE IN FEET
0 100 200 300
PLANE TABLE SURVEY BY:
ROBERT N. MILLER
MAINE GEOLOGICAL SURVEY, MAINE DEVELOP. COMM.
JOSEPH M. TREFETHEN, STATE GEOLOGIST
AUGUST, 1945
ASSUMED DATUM PLANE
CONTOUR INTERVAL = 10'
TEST PIT

texture is somewhat variable. Associated, is medium grained biotite granite. Small masses of aplite relatively light in color are also present as shown on Map I. In addition, there are small nests or bodies of pegmatite. The medium and coarse grained granites appear to have gradational contacts. The porphyritic phases grade into the coarser textured type likewise. The pegmatites and much of the aplite appear to be slightly later and cut the normal granite. It is probable that the pegmatites and aplites are genetically related to the major granites, being emplaced before final consolidation of the granite mass. Locally the aplite grades into the coarser textured varieties.

Structure

Prominent sheet joints are roughly coincident with the present topographic slopes. On the south side of the mountain, the dip of the sheet joints is somewhat less steep than the topographic slope. Easterly striking joints are prominent with steep dips averaging, perhaps, 60-70° south but showing considerable variation. This set together with the sheet joints form a series of stairlike terraces on the south flank of the mountain. Northerly striking joints with easterly dips are also abundant but lack uniformity in both dip and strike.

Flow Structure

Locally, where the granite is porphyritic, a planar flow structure is clearly present. Elsewhere, platy parallelism of the minerals is faintly developed but is, however, very elusive in most exposures. Most of the granite is megascopically structureless.

Aplite and pegmatite dikes and veins are abundant. The aplites appear to parallel in a general way the flow structure in the granite and, in part, may be a variety of schlieren. However, flow structure is so poorly developed in most exposures as render the relations uncertain.

Occurrence of Molybdenite

Molybdenite is sparsely distributed in exposures at the east end of the hill and sporadically along the south side of the crest to the west for some 4500 feet. There are three types of occurrence of the molybdenite:

1) As scattered crystals, generally less than one quarter inch in diameter, associated with pyrite on joint surfaces. The bulk of these

mineralized joint surfaces belong to the easterly striking set. By no means all joints of this set carry molybdenite. On the contrary, relatively few carry any trace of the mineral. So far as could be determined, the molybdenite flakes of this occurrence are strictly localized on the joint surfaces without dissemination into the granite.

2) Pegmatite bodies up to several inches in diameter, carry the largest flakes of molybdenite seen. The largest molybdenite flake found measures one and a half inches in diameter. These pegmatite bodies appear to be enlargements of pegmatite seams. They also occur along joints which are blind or tight. Some of the pegmatite bodies may be isolated; at least some have no visible connection with either joints or pegmatite seams. Pyrite is commonly associated with molybdenite in the pegmatite. Relatively few of the pegmatites contain molybdenite, certainly less than 30 per cent; and the pegmatite bodies themselves are very sparsely distributed.

3) Associated with some of the aplitic intrusions, particularly at the eastern end of the hill, molybdenite is sparsely distributed along the contact or in the gradation zone of the contrasting granite types.

Disseminated molybdenite is very minor. Dissemination zones are strictly limited so far as observed in the study, to a scant inch or less, adjacent to the occurrences of pegmatites and to very limited areas associated with aplitic phases.

Origin

The molybdenite may have been formed by late magmatic emanations, mineralizing some of the joints, which are probably due to tension. It may be part of the same process which introduced the pegmatites and to a lesser extent the late aplites. The probability of gaseous transfer of pegmatitic material and probably the molybdenite as well was pointed out by Hess.[4]

Conclusions

So far as this study indicates, there is a considerable amount of molybdenite on Catherine Hill but so distributed that enormous tonnages of rock must be handled to recover it. It is noteworthy, however, that whereas very little molybdenite shows at the surface, perhaps a majority of the test blasts reveal traces of the mineral.

[4] Op. Cit.

RECONNAISSANCE OF PORTIONS OF THE SWIFT RIVER VALLEY, MAINE

By Elbert Pratt and Henry Condon

Introduction

A reconnaissance survey of portions of the Swift River watershed, between Roxbury and the Height of Land embracing an area of about 100 square miles, was made in the summer of 1946. The primary purpose of this survey was to gather data on the occurrence, distribution, and richness of the gold placers, long known in the district and to determine, if possible, the source of the gold.

Description of the Area

The Swift River is a tributary of the Androscoggin River, which it joins at Rumford, Maine. Its source is on the Height of Land twenty-five miles north of Rumford. From the source of the Swift River to its mouth, there is a drop in elevation of 2000 feet. However, the change in elevation of the valley floor from Houghton to the mouth of the stream at Rumford is only 700 feet. A range of hills, whose peaks are about 2000 feet above sea-level, roughly parallels the river on the west at a distance of from one half to two miles from it. A second range of similar height and distance from the river parallels it to the east. A hard-surfaced road, the Rumford to Rangeley route, follows the course of the Swift River from Rumford to the height of Land. An unimproved dirt road, the Weld to Andover highway, crosses the valley at Byron, fifteen miles north of Rumford.

Acknowledgment

The party is indebted to the people of Byron for their many kindnesses in making its stay pleasant and comfortable and particularly to Mr. Clarence Young and Mr. Norman Young for loan of certain equipment. Paul L. Cloke served as field assistant for part of the work and ably discharged his duties.

Geology

The geology of the area is complex. Rocks of both igneous and sedimentary origin are present, and metamorphism has altered the original character of much of the rock to a marked degree. Strong folding has affected all of the sediments, and it is quite possible that faulting adds to the structural complexity.

Lithology

The rocks of the region are of rather varied types. Metamorphic rocks, which were originally sediments, underlie most of the area under discussion. They are comprised of several varieties of schists and gneisses. The field work suggests that these can be divided into several formations. However, because the survey was of reconnaissance type, the structural relations of the beds and details of stratigraphy were not worked out. It is felt that it would be unwise for the State Geological Survey to introduce formation names at this time. The rocks are described, therefore, as lithologic types with considerable generalization.

Staurolite Schists

Typical exposures of the staurolite-bearing schists are found well exposed in the stream bed in the vicinity of Byron. The rock is comprised of an alternating series of beds originally of sandy and silty composition. The staurolite is principally confined to the latter which have been metamorphosed into mica-garnet-staurolite schists of fine to medium grain. The staurolite, however, forms crystals up to an inch or more in length. The original sandy layers have been changed into micaceous quartzites. The beds vary from one half inch to four inches in thickness. Locally, at least, the staurolite schists are of more homogeneous character with the staurolite distributed throughout the rock rather than confined to certain layers.

Within the area of staurolitic schists are several non-staurolitic members, principally biotite schists. One of the non-staurolitic members, in particular, may be worthy of special mention because its lithologic counterpart has been recognized at several places beyond the limits of the Swift River area. This rock is an iron-stained schisty biotite quartzite of fine grain. It has considerable pyrrhotite in it, occurring principally as streaks parallel to the cleavage. In this area it is found on the East Branch between 5000 and 6400 yards upstream from the mouth.

The staurolitic beds are distributed rather generally in the Swift River Valley along the East Branch, the West Branch, and Berdeen Stream, as well as minor tributaries.

Andalusite Schists

The andalusite schists are gray in color. They are more massive than the staurolite schists with beds ranging from two inches to two feet in thickness. Lenses of concretionary aspect, many with hornblende rich zones parallel to the margins, are present in sizes ranging from six inches to four feet in length and from four inches to one foot in thickness.

The andalusite schist is well exposed at the mouth of Mott Stream north of Houghton.

Lime-silicate gneiss

A lime-silicate gneiss with alternating light and dark bands makes up another distinct lithologic type. The bedding varies from one-half to two inches thick. The lighter beds are siliceous; the darker, greenish beds are characterized by diopside, hornblende, and quartz. With the gneiss are associated biotite and muscovite schists. The lime-silicate gneiss is well exposed on Mountain Brook, a tributary of Berdeen Stream.

Igneous Rocks

South of Roxbury, a large granite intrusive is exposed. The granite is light in color and contains both muscovite and biotite mica. At the margin of the intrusion, the granite has penetrated the metamorphic schists in lit-par-lit fashion, forming an injection gneiss zone approximately two miles wide. The metamorphic rocks involved in this migmatization are probably schists of the type exposed at Byron.

In addition to the plutonic mass just mentioned, the sediments of the Swift River Valley are cut at many places by dikes and sills of igneous origin. Pegmatites, diorites, and granitic types comprise the bulk of these minor igneous bodies. Quartz veins, possibly of igneous origin, are found in various places, as for example along the East Branch. On the East Branch, about 1600 yards above its mouth, is a small mass of granite with an exposed width of some 70 feet. Granite also outcrops on Berdeen Stream, approximately 4,000 yards above its mouth; and granite, overlain with schist, forms the face of Brimstone Mountain, adjacent to the stream. All of the igneous rocks observed in the region are younger than the schists and gneisses.

There are relatively few pegmatites in the Swift River Valley, principally small bodies of simple mineralogy. Two beryl-bearing pegmatites, however, are worthy of mention. One of these crosses the West Branch about 1600 yards above its mouth. It is twenty-five to thirty yards wide and has an aplitic core thirty to forty feet thick. A few yards upstream from where it crosses the stream, the pegmatite in the valley wall carries numerous beryl crystals, ranging from one-half inch to two feet in cross-section, and also traces of columbite-tantalite. The showing of beryl is better than average and might warrant some test blasting.

The second beryl-bearing pegmatite is found at the top of the granite cliff on Brimstone Mountain overlooking Berdeen Stream. It does not show as much beryl as the preceding.

Two additional occurrences of columbite-tantalite in pegmatite may be mentioned also, although they are not of economic significance. About one hundred yards below the canyon down-stream from the Byron Bridge, columbite-tantalite is found in a small pegmatite in the stream bed. The mineral was also found in a small pegmatite a short distance upstream from the granite exposure at 1600 yards on the East Branch. As with the other occurrences, columbite-tantalite was not present in sufficient quantity to be of economic interest.

The pegmatite occurrences mentioned, at least serve to indicate the possibility of commercial deposits in the region.

Structure

The major structure of the region was not determined. In general the strikes are northeast, ranging from nearly north to N 70° E. The injection gneiss zone, which is from two to three miles wide, swings from a N 10° E strike paralleling West and Walker Mountains, to N 70° E and includes Tumbledown Mountain. The dips range from 45° to 90°, both to the southeast and northwest.

Minor folds are clearly exposed in many parts of the area. Good examples of small scale folds can be seen in the bed of the Swift River at Byron, both above and below the bridge.

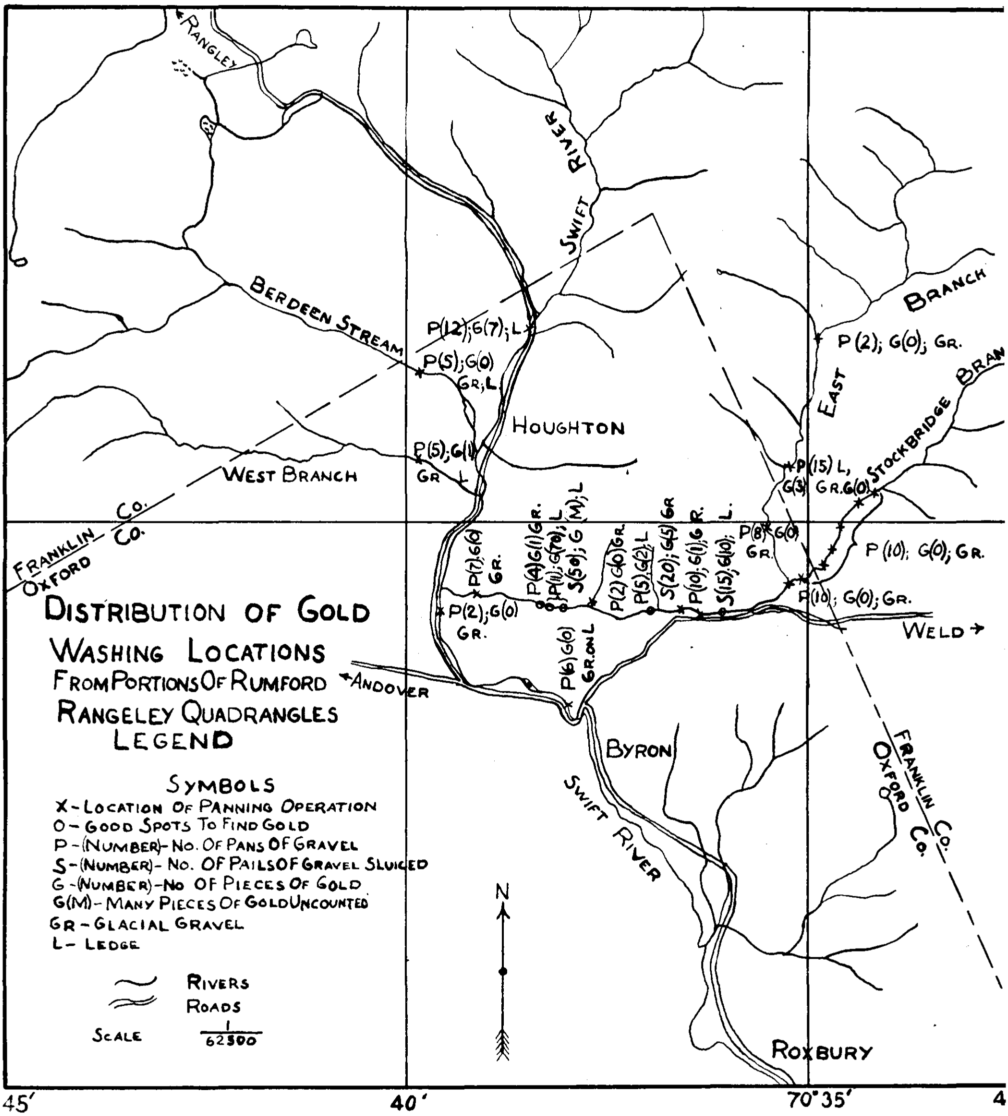
Both fracture and flow cleavage are well developed in many locations.

Gold

The exploration of the gold occurrences was carried out by panning the streams, and using the sluice box, at intervals, working in the up-stream direction. A record was kept of the locations worked, showing the amounts of gold, types of gold, and types of material from which it was separated.

Results of gold panning and sluicing

Map II shows the distribution of gold as found in this survey, and the following notes outline the results of the separations.


Distribution of Gold
Washing Locations
From Portions Of Rumford
Rangeley Quadrangles
Legend
Symbols
X - Location Of Panning Operation
O - Good Spots To Find Gold
P - (Number) - No. Of Pans Of Gravel
S - (Number) - No. Of Pails Of Gravel Sluiced
G - (Number) - No Of Pieces Of Gold
G(M) - Many Pieces Of Gold Uncounted
Gr - Glacial Gravel
L - Ledge
Rivers
Roads
Scale 1/62500
Rangley
Swift River
Berdeen Stream
West Branch
Houghton
East Branch
Stockbridge Bran
Franklin Co.
Oxford Co.
Andover
Weld
Byron
Roxbury
N
45′
40′
70°35′

Map 2

Location Notes

There is little gold in the Swift River below the East Branch which can be recovered by simple panning methods. The West Branch and Berdeen Stream show relatively few flakes of gold as does the upper Swift River above Houghton. The most interesting stream, for gold panning, is the East Branch; and it is the work along this stream that will be considered in the greatest detail.

From the mouth of the East Branch up to a distance of 2500 yards, no gold was obtained.

Up to 667 yards there is only glacial till and boulders. Seven pans of gravel from the stream bed and bank showed no gold.

At 2664 yards up the stream four pans were taken high on the bank in glacial till and broken ledge, but no gold was obtained.

At 2664 yards four pans were taken from gravel on the bank, and one piece of gold was obtained. This gold was barely visible to the eye, a fine thin flake. Sluicing this till and cleaning the gravel out down three or four feet to the rock bed produced many flakes from a size just visible to the naked eye to the size of a pin-head.[1]

One pan of sand and silt was taken from the grass roots at this spot. It contained flakes of gold, showing that the gold flakes extended from the grass roots down through the gravels. It has also worked down into the crevices of the broken ledge.

At the bridge across the East Branch, 4500 yards from its mouth, five pans of gravel, collected from crevices in the ledge and in holes and hollows where gravel had been caught, yielded two gold flakes.

At 5000 yards, with sluicing in gravel bars in the bed of the river, five small flakes of gold were obtained. Two holes were dug in the bar to a depth of nearly three feet, and about twenty pails of gravel were sluiced and panned. The results showed one flake of gold, smaller than a pin-head, for every four pails of gravel.

At 5500 yards eight pans of gravel from near the water-line were washed, and no gold was obtained. Upstream fifty yards, four pans of moss and roots from a hollow of ledge produced no gold.

At 6000 yards from under water and in the shelter of projecting ledges, two pans of gravel showed no gold. At this spot eight pans of gravel from near the water's edge and on the ledge gave one small piece of gold.

[1] Nuggets have been found in this spot as large as a match-head and a few even larger. However, none were obtained on this survey.

From the crevices of the ledges at approximately 6350 yards, fifteen pails of gravel and broken ledge were sluiced; and ten flakes of gold were obtained. Several of these pieces of gold showed an appreciable thickness.

At 9000 yards at the mouth of the Stockbridge Branch, ten pans were taken from glacial gravels at intervals from below the stream level to high above it on the bank. No gold was found.

At 10,000 yards on the East Branch, eight pans of glacial gravels from both high up on the bank and at the water's edge yielded no gold.

At an old dam, 11,500 yards up the East Branch, five pans of gravel from glacial till over a ledge fifteen feet above water-level showed no gold. From the ledge itself five pans of material produced three small flakes of gold. In the stream bed, pockets of gravel yielded no gold in five pans.

In a survey of the Stockbridge Branch, ten pans of gravel were taken at intervals along the stream, under water, in the shelter of ledges and on the bank. No gold was found. It will be shown later that this may not indicate the true condition.

Panning at intervals along the Swift River above the bridge at Byron, in the sands and gravels caught in potholes, in crevices, and behind projecting ledges, showed no gold.

However, 2000 yards north of Houghton on the Swift River, where the Rangeley road crosses the river, 500 yards down stream from the bridge, twelve pans of gravel from crevices in the ledge gave seven pieces of gold the size of a pinhead and thin flakes. From the potholes twelve pans of gravel gave no gold.

Panning gravels on the West Branch and Berdeen Stream from the crevices of ledges indicates that there is some gold there but not in the quantities found on the East Branch.

Summary

It is generally considered by various prospectors in the region that the East Branch is the most productive stream for this mineral. There is little interest in panning for gold in any of the other tributaries although all agree that some gold is to be found. The results of this survey are in accordance with the experience of previous prospectors.

Specimens of gold are fairly easy to obtain on the East Branch. However, to get the coarser nuggets, hard work is involved. Either one must find a broken ledge and tear it apart to get material from the cracks, using dynamite and crowbars to move the larger pieces, or else move large quantities of gravels, digging down (many feet in some instances) to find the larger nuggets which have settled to rock surface. Finally, knowing that gold is present along the East Branch in nuggets the size of match-heads to at least the size of the diameter of the fingernail (by report), the members of this survey think that reports of gold on the Stockbridge Branch, where they found no gold, may well be true.

Source of the Gold

The question of the source of the gold in the Swift River Valley presents a difficult problem. It could be either of local origin, or it could have been brought in by ice during the glacial period.

There is little evidence for local origin of the gold. There are many quartz veins and granite pegmatites cutting the Byron schist on the East Branch, as has been indicated. However, no gold has been found in place either in the quartz veins or in the rocks. In addition, the sulfide minerals, which would be expected to be present with gold, are not found in the quartz veins. Several tiny fragments of quartz attached to gold particles were found, however.

The fact that gold can be washed out of the grass roots at places seems to demonstrate that it is being currently washed out of the unconsolidated glacial deposits and caught by the vegetation at high water. Similarly, the lodging of tiny fragments in the natural riffles found by the irregular surfaces of the more rotten schists, above low water, indicates that it is currently being concentrated. The decomposition and disintegration of the schists is certainly post-glacial; and the vegetation and organic debris associated with the gold in between rotten schist layers must be recent.

Gold bearing veins are known to the north not many miles away, e. g., the Megantic, Que. region. It is quite probable that the advance of the ice over auriferous veins, some of which may be local, picked up some gold which was deposited along with ice-carried debris in the Swift River region. Subsequently, the streams cutting through the glacial deposits have washed out small amounts of the metal. Favoring this hypothesis of origin is the fact that most of the streams and tributaries of the region carry some gold. According to this view there is no "mother lode."

Conclusions

From this report on the gold in the Swift River Valley certain conclusions may be drawn concerning the best places to look for gold and what to expect at these spots.

It was found in most cases that the results of this survey corroborate the experience of previous prospectors in the region although in some cases, the survey failed to check the reports of others. However, the best and easiest places for the visitor to find gold is in the crevices of crumbling or broken ledges along the East Branch between its mouth and up to the bridge at 4000 yards. All the material caught in a crevice should be panned. The size and amount of gold obtained will depend upon the size of the crack and upon how much effort was put into breaking out the section of ledge and the care in securing all the loose material to the bottom of the crevice. The larger pieces are at the bottom.

A good spot for digging also occurs where river gravels have accumulated on bed rock. Digging in these gravel banks, down to the bed rock has yielded some good specimens of gold.

There is not enough gold in the streams of Swift River Valley, even the East Branch, to support mining as a business. Men from the gold country of the West tried it without success. But for those who want a sample of gold and some exercise, it is not too difficult to clean out a few breaks in the ledges and get the gold dust. Some may even be lucky enough to find a larger specimen.

LIMESTONE

By J. M. Trefethen

Limestone and its metamorphic equivalent marble are rocks of multiple use. Pulverized raw, processed in various ways to varying degrees, or shaped into blocks for building, decoration or monuments, it is the raw material for many applications.

A partial list of limestone products arranged according to use follows:

I. Agriculture

- Raw
  - Pulverized
  - Limestone screenings
- Processed
  - Quick lime
  - Hydrated lime

II. Construction

- Raw
  - Dimension stone
  - Decorative and monumental stone
  - Mortar sand
  - Concrete aggregate
- Processed
  - Cement
  - Plaster
  - Stucco
  - Whitewash

III. Industry

- Raw
  - Fluxing stone
  - Paper manufacture
  - Whiting
- Processed
  - Water purification
  - Glass
  - Tanning
  - Paper manufacture
  - Plastics
  - Rock wool
  - Salt and sugar refining, and in addition hundreds of lesser uses requiring in aggregate considerable tonnages.

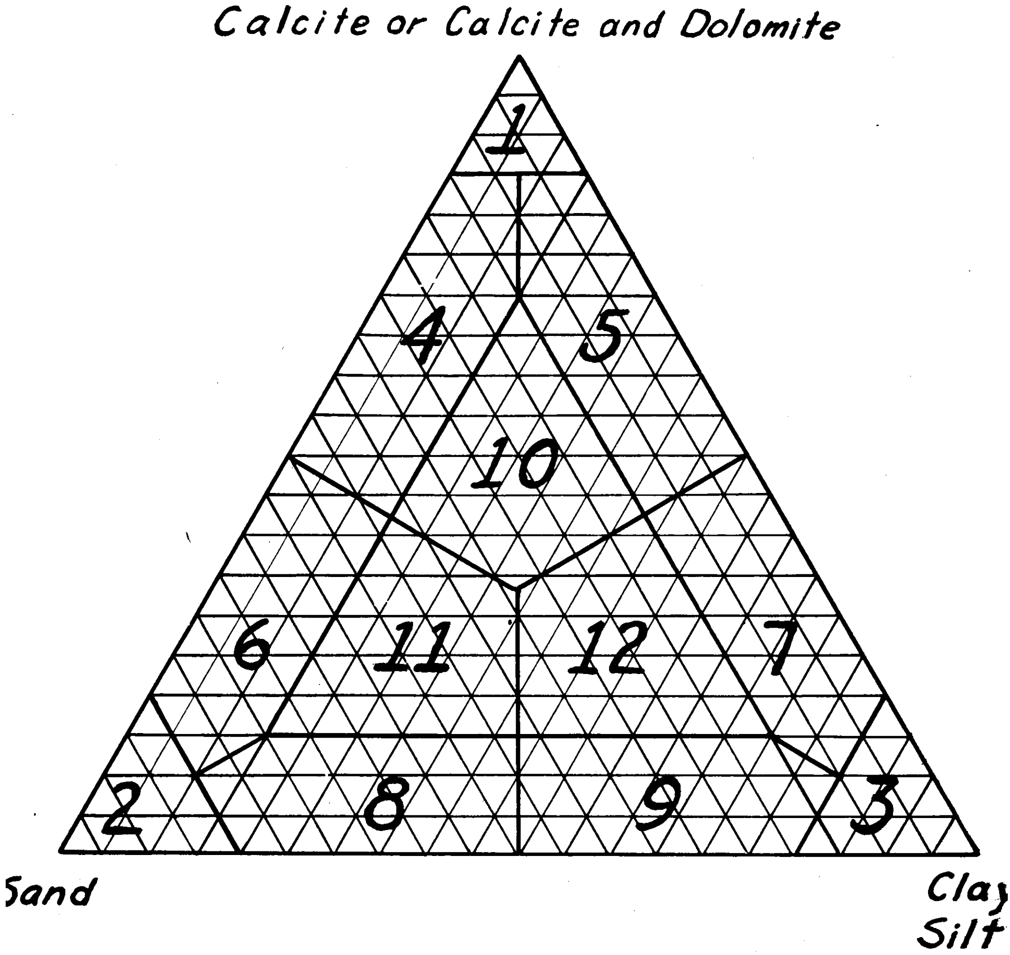


Figure 5

Key

Limestone, magnesian limestone, or dolomite
Sandstone
Argillite, siltstone, or shale
Sandy limestone
Argillaceous limestone
Calcareous sandstone

7. Calcareous shale
8. Argillaceous sandstone
9. Sandy or silty argillite
10. Sandy-argillaceous-limestone
11. Calcareous-argillaceous-sandstone
12. Calcareous-sandy-argillite

Because of the economic significance of limestone and because of a large tonnage requirement within our own state, both for agriculture and industry, a county by county survey of limestone and marble resources has been started. Progress reports will make available the current data accumulated; and when the work is completed, a bulletin incorporating the findings will be issued. In the 1943-44 *Report of the State Geologist* (pages 13-18, 53-54) attention was drawn to several deposits, and it is understood that plans for development are underway for commercial use of at least one of those described in that report.

Classification and origin classification of limestones can be made on a variety of bases. The accompanying diagram, Fig. 5, shows a classification scheme devised by Trefethen, which is based on admixtures of the common impurities, sand-silt and clay. A check on the purity requirements for the higher grade uses of limestone shows 85% or higher content of calcium carbonate or calcium-magnesium carbonate is essential. Limestone, therefore, is limited to the portion of the field bounded by the 85% calcite lime. The classification scheme of Figure 5 is nothing new but does put into quantitative form the somewhat indefinite although commonly satisfactory, field terms used by geologists. Other terms, as *siliceous limestone, ferruginous limestone* and the like are also in common use. A limestone with 5-10% MgO is called a magnesium limestone. If the MgO : CaO ratio is about 1:1, the rock is called *dolomite.*

The majority of limestones and dolomites are marine deposits, deposited through either organic or inorganic action. Some, as the Starbord limestone (Point O'Maine) appear to be consolidated shell heaps; some are inorganic precipitates; and some result from wave action on previously existent limestones.

Squeezing and folding, and heat may alter limestones and dolomites to marble. The "limestones" of the Rockland-Warren-Thomaston area are truly marbles, as are those of Lewiston and elsewhere. Others have been folded and squeezed but not altered into marble, as for example the bulk of the Aroostook limestones.

Because of their origin, limestones are frequently impure as shown on the classification diagram (Fig. 5). Unfortunately, while limestone is abundant in this state, by far the bulk of the deposits are impure. The impure forms are of limited use. The table (Table 5) shows some of the use requirements for large tonnage outlets.

Table Five

(Illinois Geological Survey)

Limestone Uses

Uses	High-calcium limestone	Impure limestone	Magnesian limestone	High-magnesium dolomite
Agricultural limestone or "agstone"	X	X	X	X
Alkalies	X			
Ammonia (cyanamide process)	X			
Calcium carbide	X			
Dolomite refractories			?	X
Fluxing:				
Open-hearth furnace	X			
Blast furnace	X		X	X
Nonferrous metals	X			
Glass manufacture	X			X
Lime:				
High-calcium lime	X			
Low-magnesium lime			X	
High-magnesium lime			?	X
Hydraulic lime		X		
Magnesium metal manufacture				X
Mine dust (bituminous coal mines)	X		X	X
Natural cement		X		
Paper manufacture:				
Sulphite pulp (Tower system)	X			X
Sulphite pulp (milk-of-lime system)				X
Soda pulp and sulphate pulp	X			
Plastics	X			
Portland cement	X	X		
Rock wool	X	X	X	X
Salt manufacture	X			
Sugar refining	X			
Whiting substitute	X		X	X

Aroostook County Limestone Summary

The limestones of Aroostook County belong to three, possibly four, separate geologic formations. The most widespread of these is the Aroostook limestone of middle Silurian age.

Aroostook Limestone. Beds of this formation are recognized throughout the populated eastern part of the county from south of Houlton to north of New Sweden. The formation is divided by White and Cloud[1] into three members, lower, middle, and upper.

The lower (older) member consists of argillaceous limestone layers. Most of the manganese deposits of the northern part of Aroostook County are contained in this lower part of the Aroostook limestone formation, but it does not contain limestones of economic significance.

[1] White, W. S. and Cloud, P., U. S. Geol. Survey Bull., 940-E, p. 129, 1943.

The middle member of the formation is distinctively banded, consisting of limestone layers from one half to six inches thick, very fine grained and dark bluish or blue-grey in color. Between the limestone layers are thin shaly partings. Fractures are locally abundant in this member, and many of these are filled with pure white calcite. Because of the banded appearance of the rock it is called ribbon limestone. Locally the ribbon limestone is sufficiently pure to be of commercial value. It is being successfully worked for agricultural lime and road metal at Presque Isle.

The upper member is largely composed of blue and grey shale, in part calcareous, and locally with limestone lenses. Commercial limestones have not been discovered in this member.

Ashland Limestone. The second of the Aroostook County limestone formations is the Ashland limestone, also of Silurian Age. This limestone, whiter and coarser than the Aroostook limestone, occurs in lenses (see Map III) of relatively high calcium limestone contained in shales. In part, it is conglomerate, consisting of rather angular fragments of limestone banded together by calcareous argillaceous cement. Some of the lenses of the Ashland limestone are sufficiently pure to be commercial, but to date no lenses of large enough size have been discovered to support a large scale operation. It appears possible, however, that such exist; and further field work may well bring larger deposits to light.

Square Lake Limestone. The third limestone formation, and younger than the preceding, is the Devonian limestone found at Limestone Point, Square Lake, where it was at one time burned for lime. It is a grey highly fossiliferous limestone, resembling the Ashland limestone in appearance. It is a limestone of high calcium content and in part at least, is of commercial grade. To date, deposits of this formation have not been found in an economically accessible location.

Drews Lake Marble. The fourth limestone, metamorphosed to white crystalline marble, lies near Drews Lake at the foot of Drews Mountain. It has been mapped[2] and described in a previous report. It is possibly a part of the Aroostook limestone, but its stratigraphic position is uncertain. It is possibly older than any of the limestone formations described in the preceding and is apparently strictly localized in the area mapped. It is of commercial quality, but more volume

[2] Trefethen, J. M., Report of the State Geologist, 1943-1944.

than exposed would have to be proved by drilling for it to merit consideration as the basis of any extensive development. Many years ago it was burned for lime, and more recently it was used for agstone in a small operation.

Table Six shows the results of analyses of Aroostook County limestone samples taken by the Maine Geological Survey and analyzed in our laboratory. The key to locations and notations on the field occurrences are given in the Appendix.

Table Six -- Neutralizing Values of Limestone Samples

Location No.	A	B	C	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Sample No. 1	94.8	91.7	90.9	94.0	54.2	46.5	49.7	74.5	83.7	86.4	88.2	93.3	76.0	70.4	63.9	33.9	73.6	69.1	72.9	62.1	57.0	65.7	61.6	77.4	51.0
2	87.4	90.1	89.8	93.4	45.8	42.3	36.9	76.0	75.6	81.5	86.6	90.0	82.8	66.6	59.3	46.6	74.9	73.9	75.2	68.2	51.2	77.0	65.6	68.0	59.0
3	83.5	89.0	...	93.6	40.5	42.0	47.0	72.7	80.0	74.5	90.7	87.3	83.2	53.6	71.0	74.8	77.4	76.4	75.4	62.9	55.8	65.9	68.6	72.4	59.7
4	90.5	92.4	...	...	36.3	47.8	46.5	83.0	83.5	79.0	...	90.0	80.3	...	...	83.2	71.0	60.5	70.9	38.9	...	64.0	50.0	80.0	56.8
5	90.8	90.8	...	...	39.8	49.2	10.3	64.5	83.2	...	...	95.0	73.2	...	...	76.1	72.6	76.6	64.9	...	...	63.0	65.1	76.8	54.1
6	89.1	90.8	...	...	33.1	47.9	...	66.4	58.6	...	...	95.5	73.6	...	...	81.5	65.6	58.3	72.0	...	...	57.7	63.3	66.7	38.8
7	87.5	91.5	...	...	32.0	49.2	...	70.9	29.3	...	...	...	84.2	...	...	73.5	70.7	58.3	74.1	...	...	58.6	65.0	69.0	50.0
8	86.6	90.5	...	...	30.5	45.2	...	66.5	62.0	...	...	...	86.5	...	...	62.3	71.6	49.7	82.5	...	...	52.5	49.3	83.9	55.4
9	...	...	...	...	28.6	49.9	...	69.2	73.3	...	...	...	77.1	...	...	71.2	72.5	...	76.5	...	...	...	45.9	82.0	72.0
10	...	...	...	...	33.6	45.5	...	65.7	62.5	...	...	...	80.8	...	...	76.5	81.7	...	80.1	...	...	...	61.1	82.8	68.5
11	...	...	...	...	30.8	47.0	...	75.5	59.1	...	...	...	87.0	...	...	54.0	81.7	...	75.4	...	...	...	60.2	80.9	43.5
12	...	...	...	...	33.4	46.8	...	74.0	65.8	...	...	...	50.2	...	...	...	81.8	...	76.0	...	...	...	65.8	72.8	47.2
13	...	...	...	...	37.8	52.9	...	75.5	50.2	...	...	...	64.0	...	...	...	81.4	...	67.7	...	...	...	...	71.5	37.7
14	...	...	...	...	36.5	59.7	...	74.4	62.4	...	...	...	63.1	...	...	...	72.0	...	56.4	...	...	...	...	73.9	78.2
15	...	...	...	...	34.1	38.7	...	64.7	59.0	...	...	...	59.0	...	...	...	...	...	42.0	...	...	...	...	71.2	55.6
16	...	...	...	...	23.2	63.0	...	69.0	58.7	...	...	...	73.6	...	...	...	...	...	...	...	...	...	...	67.4	68.3
17	...	...	...	...	32.6	59.4	...	73.5	72.8	...	...	...	68.4	...	...	...	...	...	...	...	...	...	...	...	48.4
18	...	...	...	...	...	61.0	...	78.0	59.5	...	...	...	69.3	...	...	...	...	...	...	...	...	...	...	...	64.0
19	...	...	...	...	...	61.6	...	75.2	61.3	...	...	...	79.6	...	...	...	...	...	...	...	...	...	...	...	67.0
20	...	...	...	...	...	29.6	...	69.0	78.2	...	...	...	74.0	...	...	...	...	...	...	...	...	...	...	...	51.0
21	...	...	...	...	...	59.0	...	67.1	53.9	...	...	...	72.5	...	...	...	...	...	...	...	...	...	...	...	57.7
22	...	...	...	...	...	...	...	...	62.0	...	...	...	79.8	...	...	...	...	...	...	...	...	...	...	...	54.3
23	...	...	...	...	...	...	...	...	53.5	...	...	...	50.2	...	...	...	...	...	...	...	...	...	...	...	75.1
24	...	...	...	...	...	...	...	...	61.3	...	...	...	73.4	...	...	...	...	...	...	...	...	...	...	...	69.3
25	...	...	...	...	...	...	...	...	76.4	...	...	...	82.2	...	...	...	...	...	...	...	...	...	...	...	44.0
26	...	...	...	...	...	...	...	...	74.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	38.9
27	...	...	...	...	...	...	...	...	73.4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	38.3
28	...	...	...	...	...	...	...	...	66.2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	54.4
29	...	...	...	...	...	...	...	...	46.1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	43.6
30	...	...	...	...	...	...	...	...	56.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	47.5
31	...	...	...	...	...	...	...	...	76.1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	48.9
32	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	47.8
33	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	56.5
34	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	54.5
35	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	46.5
36	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	64.0
37	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	53.4
38	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	44.5
Maximum	94.8	92.4	90.9	94.0	54.2	63.0	49.7	83.0	83.7	86.4	90.7	95.5	87.0	70.4	71.0	83.2	81.8	76.6	82.5	68.2	57.0	77.0	68.6	83.9	78.2
Minimum	83.5	89.0	89.8	93.4	23.2	29.6	10.3	64.5	29.3	74.5	86.6	87.3	50.2	53.6	59.3	33.9	65.6	49.7	42.0	38.9	51.2	52.5	45.9	66.7	37.7
Average	88.8	90.8	90.3	93.7	35.5	52.2	38.1	71.7	65.1	80.3	88.5	91.8	73.8	63.5	64.7	66.7	74.9	65.3	70.8	58.0	54.7	63.5	60.1	74.8	54.4

APPENDIX

Notes on Aroostook Limestone Locations

By Roy A. Bither

Ashland, Maine

Location 1 (Map III)

On the road south from Ashland Village going toward Masardis.

On the farm of Reed Bros. 1.2 miles south of village—directly in front of, across the road and due east from farmhouse—750 feet from highway.

A lenticular lens of conglomeratic limestone. Outcrops were numerous but rock is greatly fractured and contains numerous pot holes. Many of the blocks are tipped and tilted out of position.

Lens is 500 feet long and about 40 feet wide at the north and middle sections—tapering to about 10-12 feet at the south end.

Three trenches were made across the lens, A across the north end—B across the middle and a short trench C across the south end. Eight samples were taken at trench A and B and two at C trench. Samples were numbered 1, 2, 3, etc., beginning on the west side in all cases.

The limestone lens strikes Northerly. No exact structure can be observed but can be inferred from the surrounding rock which has a strike of N 4° E and a dip of 62°-65° west.

The surrounding rock is a somewhat silicious shale slightly calcareous near the contact.

Lens is no more than 10 feet in depth to plenty of water. (Total samples, 18).

Spot Sample 1

Outcropping just south of Location 1 on the south side of a gully. Near a potato field—no trenching could be done.

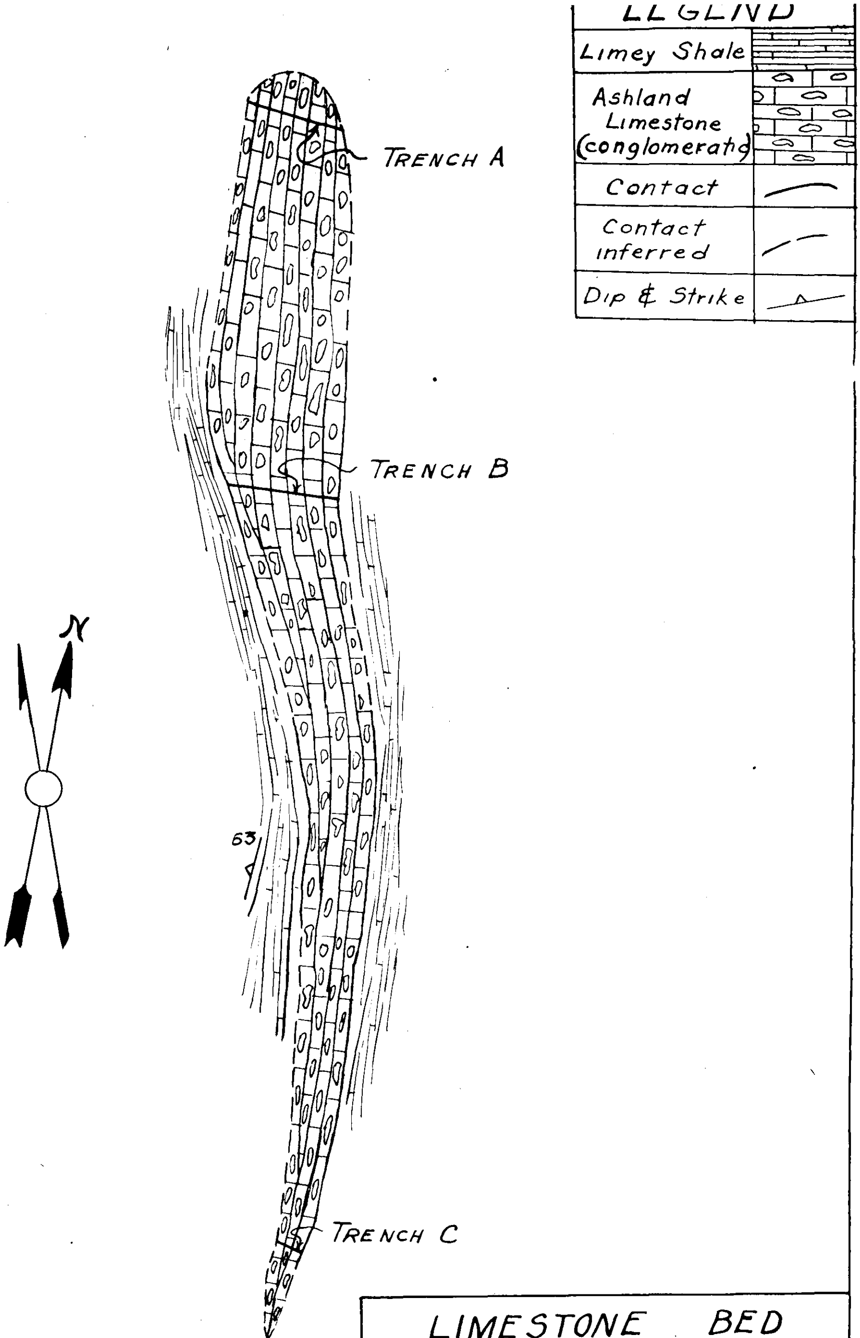
Appears to be a thin layer or lens of conglomeratic limestone bounded on either side by shaly limestone. Total outcrop 8-10 feet wide. Conglomeratic limestone in the center only about 2 feet wide.

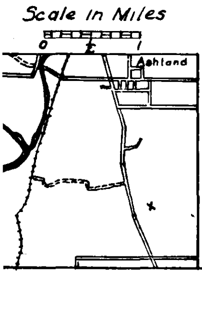
Probably another small lens of several in the area.

Spot Sample 2

9-10 miles from Ashland on the road to Washburn, just south of Aroostook River. On the west slope of the hill showing just inside the eastern edge of the Ashland quadrangle.

Nearly horizontal, heavy-bedded metamorphosed sandstone with some lime. Frenchville section.





LIMESTONE BED
REED BROS. FARM

Ashland, Maine

Scale in Feet

0 20 40 60 80 100

Pace, chain, compass survey by:
Roy Bither and Robert Ham
Maine Geological Survey, Maine Develop. Comm.
Joseph M. Trefethen, State Geologist
July, 1945

Ashland Township
Location 2

Farm of George Pike, Ashland, Maine, 0.4 miles south from Ashland Village on west side of road to Masardis.

Outcrop of conglomeratic limestone—containing many fossils—quite like that at Location 1. Outcrop is located about 1000 feet west of road and about 500 feet from southern boundary of Pike farm.

Many years ago stone was taken from this spot and kiln-burned. The masonry of a house located on the SW corner of the Pike property was constructed with this lime. The house is one of the oldest in the Ashland area, yet the stone and brick work seems as sound as ever.

The old excavation is filled in with field-stone and the field is at present planted to potatoes, so little trenching could be carried out.

A partial trench was made on the south side of the old excavation in an east-west direction. Two samples were taken in the western end of the trench (No. 1 & 2) for a distance of nine feet. A third sample was taken at the eastern end—of a distance of three feet. Center portion was rubble-filled.

Observed area of outcrop was about 20 feet wide and 45 feet long. No structure could be observed—no contacts—no other outcrops near. (Total samples, 3).

Ashland Township
Location 3

Very thinly bedded shales, locally containing many small calcite veins.

Midway between the mouth of the Little Machias River and the B. & A. railroad bridge at Sheridan on the north bank of the Aroostook River.

The outcrop extends about 400 feet along the bank of the river. From 8-15 feet thick, above the river, covered with a thick till overburden.

Strike of beds—N 18° E; dip 65° NW. Seems to be part of a fold plunging northerly.

Eastern end of the outcrop consists of more compact and heavy-bedded shales and seems to contain more lime.

Samples were taken in an east-west direction—every 20 feet—beginning on the west. No samples were taken in the 20 foot section between samples 2 and 3. Also none between 16 and 17.

Field observation indicates no great amount of lime present. (Total samples, 17.)

Wade Township
Location 4

South of the Aroostook River about 1.5 miles from where the road crosses the river at Bugbee.

Outcropping along the road for a distance of about 660 feet rather thinly bedded Aroostook limestones. Locally many calcite veins.

From the top of the hill to the bottom of the river the beds show nearly 200 feet of thickness. They can be traced north for a distance of 1500 feet and the whole hill can be presumed to be the same general type of bedding.

The beds are considerably twisted and contorted. The strike varies from N 15°-20° W. The dip from 80° northwest to vertical.

Samples were taken in 20 feet sections. A section of 125 feet was omitted between sample 1 and 2 and a section of 20 feet between 12 and 13. The samples were taken from west to east. (Total samples, 21.)

Bridgewater Township
Location 5

Farm of Emerson Pryor on the U. S.-Canadian boundary. North of the road at the border station. East of Bridgewater Village.

A very extensive deposit of shaly limestone—considerably metamorphosed. Rock is very hard and contains many calcite.

Strike is N 25° E. Dip vertical to 8° east.

Area offers no great hopes as a source of limestone, but its accessibility by road—nearness to a railroad, size and the ease with which it could be operated gives it possibilities for crushed rock.

Trenching and extensive sampling were deemed inadvisable until the few check samples have been analyzed.

Several general "spot" samples were taken at this location.

Sample 1. At extreme top of hill in woods.

Sample 2. Just inside woods on west face of hilltop.

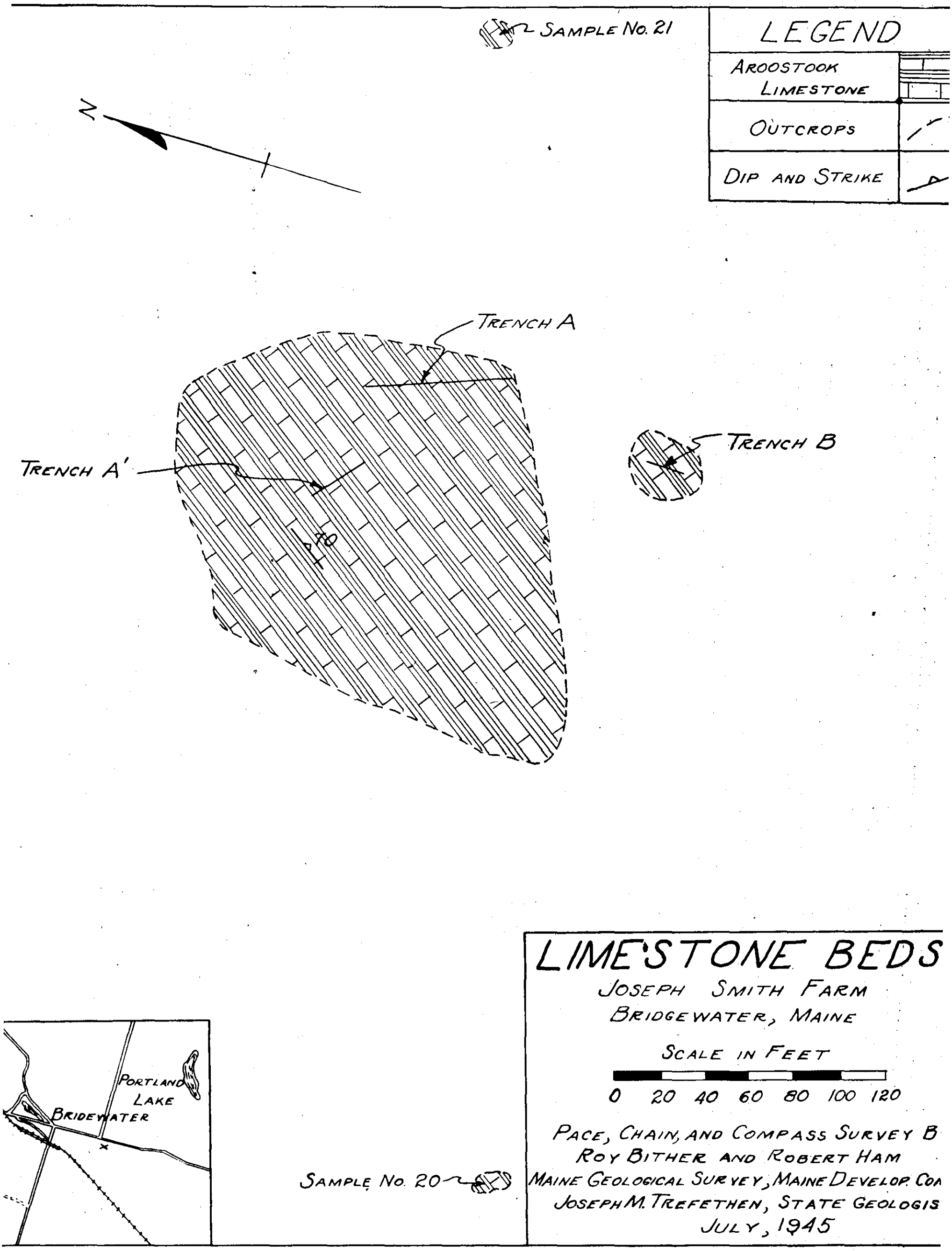
Sample 3. Just outside woods in field on west face of hilltop.

Sample 4. At outcrop in river bed south of Pryor homestead.

Samples 5, 6, and 7 were taken SW across the outcrop directly north and behind the barn.

Bridgewater Township
Location 6 (Map IV)

Farm of Joe Smith on Route 1—just about one mile south of the village of Bridgewater.



SAMPLE No. 21
N
LEGEND
AROOSTOOK LIMESTONE
OUTCROPS
DIP AND STRIKE
TRENCH A
TRENCH A'
TRENCH B
70
LIMESTONE BEDS
JOSEPH SMITH FARM
BRIDGEWATER, MAINE
SCALE IN FEET
0 20 40 60 80 100 120
PACE, CHAIN, AND COMPASS SURVEY B
ROY BITHER AND ROBERT HAM
MAINE GEOLOGICAL SURVEY, MAINE DEVELOP. CO
JOSEPH M. TREFETHEN, STATE GEOLOGIS
JULY, 1945
PORTLAND LAKE
BRIDEWATER
SAMPLE No. 20

Map 4

A fairly large outcropping of the ribbon type of limestone.

A great deal of twisting in the bed locally.

Generally the strike is N 38° E. Dip—70° SE. (Total samples, 20.)

Washburn, Maine
Location 7

Outcrop of ribbon limestone at the bridge across the Aroostook River near Washburn, Maine—at the river crossing known as Bugbee.

The limestone beds vary in width from 1-4 inches. The average is about 2 inches. The lime beds are separated by very thin layers of shale.

Calcite veins are generally abundant throughout the harder limestone layers, along the bedding planes and along the jointing.

Some twisting and contortion but general strike N 10° E. Dip is 85° E to vertical.

Samples were taken for a distance of 140 feet south from the center of the bridge and 170 feet north from the center of the bridge.

Thirty-one samples were taken—beginning on the south end of the outcrop.

Washburn, Maine
Location 8

Farm of Wallace Woodman, Washburn. Along the line between the fields and the woods on the boundary line between the W. Woodman farm and the farm of Charles Jardine.

Small outcrops over an extensive area. Traced over an area of 10-15 acres. Most of the outcrops covered by 6-8 inches of till. (Field planted to potatoes—could not trench or investigate in detail.) No structure could be observed.

The rock drift and type of soil indicates a much wider area.

Much calcite in the field stone.

Four general samples taken.

1 in woods—Jardine Farm.
2 in field—100 yards from road—south.
3 in field—200 yards from road—south.
4 in field—300 yards from road—south.

Castle Hill, Maine
Location 9

Bed or lens of conglomeratic limestone on the Dudley Farm, Castle Hill, Maine.

Appears to be about the same type of material as at Ashland, Maine. Contains many fossils.

Outcrops in field almost due south from house—across the road.

Traced about 700 feet from rock pile almost in the center of the field—to the woods. Traced about 1000 feet through the woods farther south.

Rock rises in small hills or hummocks in some places 15 feet high. More or less ridge shaped throughout its whole length.

Lens strikes generally N 25°-30° E. It is bounded by Mn-Fe. shales with a strike of N and a dip of 62° E.

Observed width is from 8 feet at the southern end, gradually widens to 30 feet, to 45 feet and possibly 60 feet through the central section, and narrows to 12-15 feet at its northern end. Average, from 30-45 feet throughout its length.

Only three general samples were taken here as the area is so well known.

Sample 1. Near the extreme southern end of the lens, at about 1500 feet from the northern end, limestone seems to be no more than 8 feet wide. (Three samples.)

Sample 2. Taken south about 1200 feet from north end of lens at a large outcrop in the woods.

Sample 3. Taken at the edge of the fields and the woods about 700 feet from NE end of outcrop. General sample taken across lens, a distance of about 80 feet. No trenching here.

Chapman Township

Location 10

West side of Chapman Township west of the road going south from Mapleton Village—called the West Chapman Road. About three quarters of a mile south of southern line of the Township of Mapleton, in Chapman.

Outcrop of conglomeratic limestone about same as that at Ashland and Castle Hill.

Outcrops just to the west and parallel the road—about 700 feet from the R. R. crossing to the south.

On farm of Harry Gendell.

No structure observed.

Lens strikes N 10° W.

Six samples—10′ intervals.

Presque Isle
Location 11 (Map V)

Outcropping along the highway—Route 167 from Presque Isle to Fort Fairfield. On the farm of Bill Blanchard and the farm of Harry Bussell. Also extends south of road.

Strike of beds from N 10° E to N 40° E. Dip vertical.

Rock is more or less the typical Aroostook limestone. Limestone and shale interbedded. (See map for distance along road.)

Extends south of road for 150-200 feet. North for indeterminate distance but traced for 800 feet or more north along the strike.

Also extends outside the area sampled, as sample 25 was taken NW in field of Harry Bussell 4-500 across the strike—at an outcrop 50 feet long and at least 15 feet wide.

Topography is low hills or ridges striking N 5°-10° E.

Heavy till overburden—no trenching. All samples except 25 taken at outcrop along road. See map.

Area covered by the inspection—including sample 25—35-40 acres. Spot Sample 3 and 4.

At the Presque Isle-Fort Fairfield town line on Route 167 at the road side.

Massive bedded limy shale—a fair amount of calcite veins present.

Outcrops along road for several hundred feet—but general appearance did not indicate more than a fair amount of lime.

Easton, Maine
Location 12

About one mile west from Easton Corners on the road to Easton Village.

On the farm of James Langley in the extreme north end of his farm —his most northerly or back field.

Outcrop of a limy-shale, apparently a phase of the Aroostook limestone.

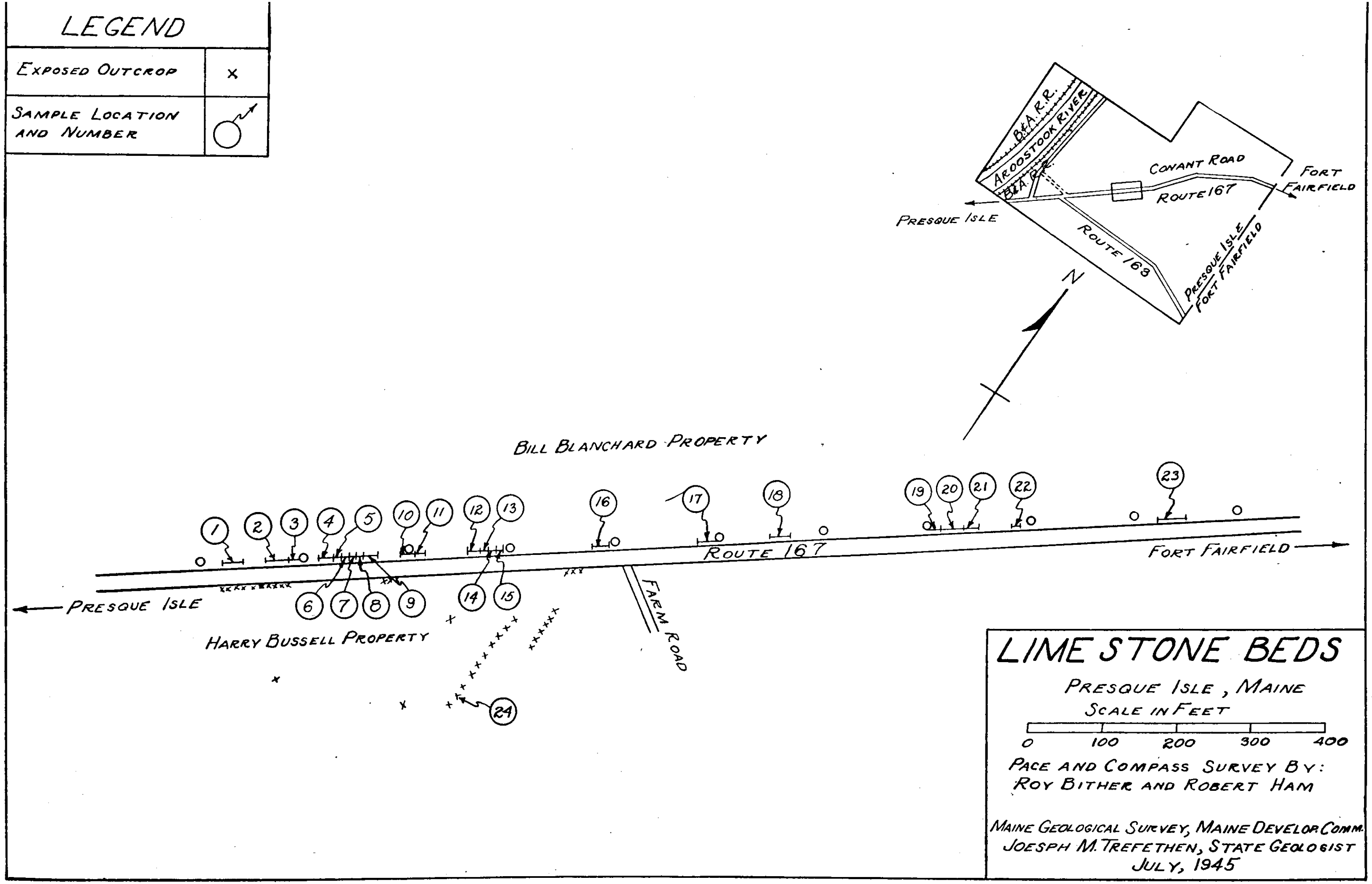
Only a few small outcrops in evidence—no trenching could be done, as the field is planted to potatoes.

Beds strike N 30° E and dip is vertical to 80° NW.

Two beds of limy shale, with shale between and at sides.

Easton, Maine
Location 13

Located on the Sanford E. Smith farm on the Mill Road—first road that turns north from Easton Corners going toward Easton Village.


LEGEND
EXPOSED OUTCROP ×
SAMPLE LOCATION AND NUMBER
B&A R.R.
AROOSTOOK RIVER
B&A R.R.
CONANT ROAD
ROUTE 167
FORT FAIRFIELD
PRESQUE ISLE
ROUTE 163
PRESQUE ISLE
FORT FAIRFIELD
N
BILL BLANCHARD PROPERTY
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
ROUTE 167
FORT FAIRFIELD
PRESQUE ISLE
FARM ROAD
HARRY BUSSELL PROPERTY
LIMESTONE BEDS
PRESQUE ISLE, MAINE
SCALE IN FEET
0 100 200 300 400
PACE AND COMPASS SURVEY BY:
ROY BITHER AND ROBERT HAM
MAINE GEOLOGICAL SURVEY, MAINE DEVELOP. COMM.
JOESPH M. TREFETHEN, STATE GEOLOGIST
JULY, 1945

Many outcrops all over the northern and eastern part of farm.

The rock is about typical of the Aroostook limestone—interbedded lime and shales.

Rock has a strike of N 35° E and a dip about vertical.

Only three general samples taken. All from the most prominent outcrops.

1. Back field.
2. East of back field in pasture.
3. In center of north field just east of saw mill.

Easton Township, Riviere des Chutes
Location 14 (Map VI.)

Eastern part of Easton Township West of Riviere des Chutes.

Principal outcrops on the farm of Charles Cahill and can best be observed directly behind the Riviere des Chutes Roman Catholic Church.

The rock is interbedded shales and Aroostook limestones and can be traced over a large area to the west and extend N-S for at least a mile.

Strikes vary from N 35°-40° E. Dip is vertical or slightly to the east.

The limestones are mainly thick (20′-60′) heavy bedded layers with shaly beds between.

Most generally these limestone layers are very hard and stand out as ridges—like "hogbacks" along the side of the hill which rises above and behind the church.

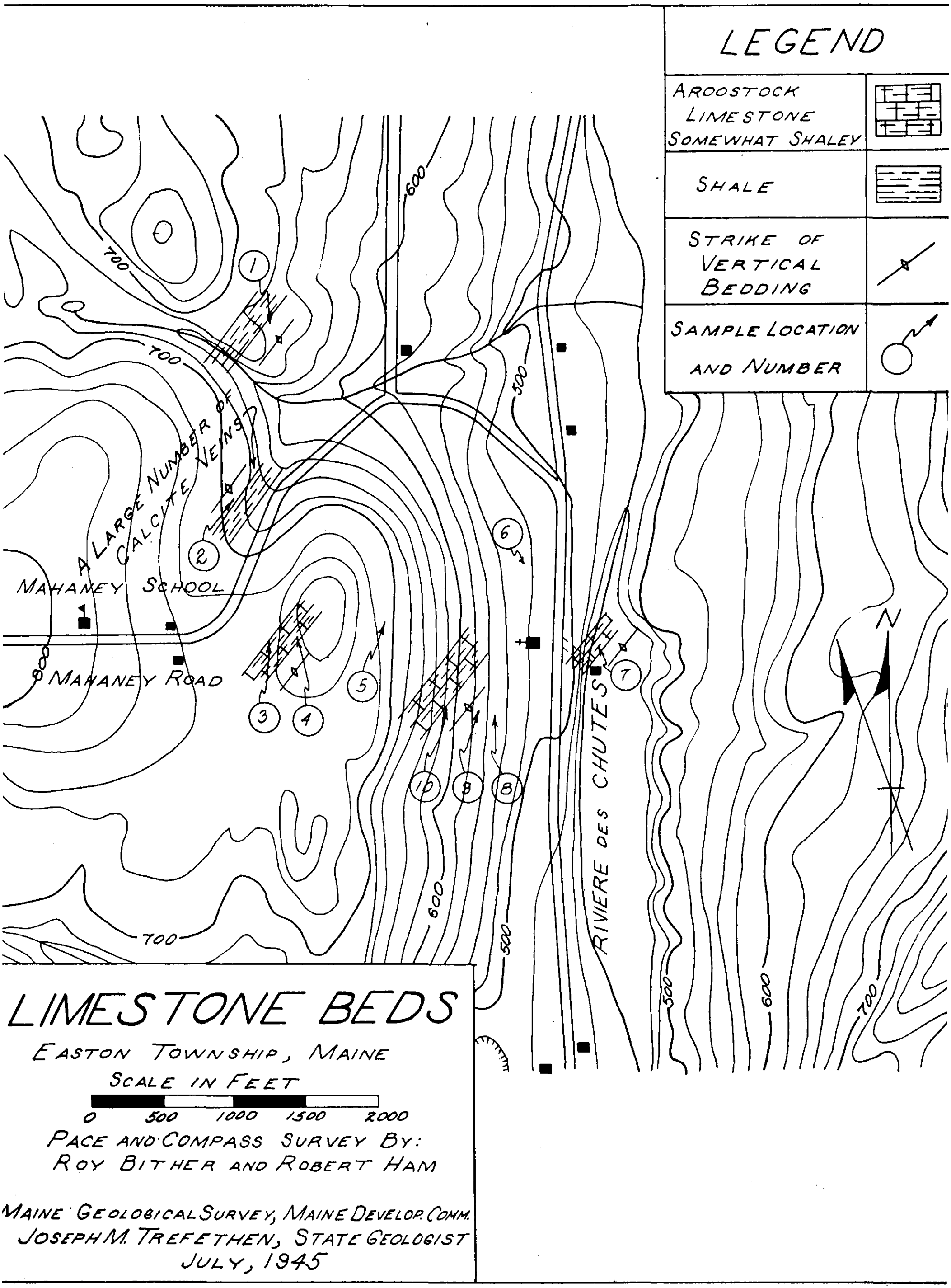
At least four of these ridges can be traced for a considerable distance through the woods.

These beds are similar—hard, compact, and dark grey in color. Few calcite veins present.

To the northwest of the area along the road. (See map). The rock is very weak and shaly—but in the two areas sampled, here the beds held a heavy concentration of calcite in veins and along the joints and the bedding planes. These areas were 20-30 feet wide and seem to contain an abundance of lime.

The soil over the heavy bedded limestones has a most distinctive color—a rich, chocolate brown. Almost like the so-called Linneus soil, though not so dark. This soil type indicates limestone and appears to be a residual soil. The rock (heavy bedded limestone) can be mapped almost by the soil type and color alone.

Ten samples.


LEGEND
AROOSTOCK LIMESTONE SOMEWHAT SHALEY
SHALE
STRIKE OF VERTICAL BEDDING
SAMPLE LOCATION AND NUMBER
A LARGE NUMBER OF CALCITE VEINS
MAHANEY SCHOOL
MAHANEY ROAD
RIVIERE DES CHUTES
N
600
700
500
800
1
2
3
4
5
6
7
8
9
10
LIMESTONE BEDS
EASTON TOWNSHIP, MAINE
SCALE IN FEET
0 500 1000 1500 2000
PACE AND COMPASS SURVEY BY:
ROY BITHER AND ROBERT HAM
MAINE GEOLOGICAL SURVEY, MAINE DEVELOP. COMM.
JOSEPH M. TREFETHEN, STATE GEOLOGIST
JULY, 1945

Map 6

Mars Hill Township
Location 15

At the western slope or foot of Mars Hill—northwest of the village of Mars Hill.

Outcropping principally on the farms of Jack Donaghy and the Graves Bros. farm. A limestone having little or none of the appearance of either the Aroostook lime nor of the Ashland type of lime. This lime seems to be an entirely different type from others in southern Aroostook.

For the most part the rock has the appearance of a breccia with white crystalline lime and darker colored lime or shaly-limestone scattered throughout. It does not weather rough and has a pink or light red color.

The main body of rock lies east of a small stream flowing N-S alongside Mars Hill. It rises in a hill from 60-80 feet high, is mostly cleared land and is well drained.

A brief survey did not determine the structure of the main body of the limestone.

To the east of the stream and at the foot of Mars Hill the rock has about the same appearance but is brecciated. This rock, too, is interbedded with shaly layers. These beds have a strike of from N 30°-40° E and dip vertical to 80° E.

This eastern part of the limestone area rises as a steep slope to the mountain. These beds are bounded on the east by shales which with the Mars Hill conglomerate make up the main part of the mountain.

West of the limestones are interbedded Aroostook limestones and quartzites.

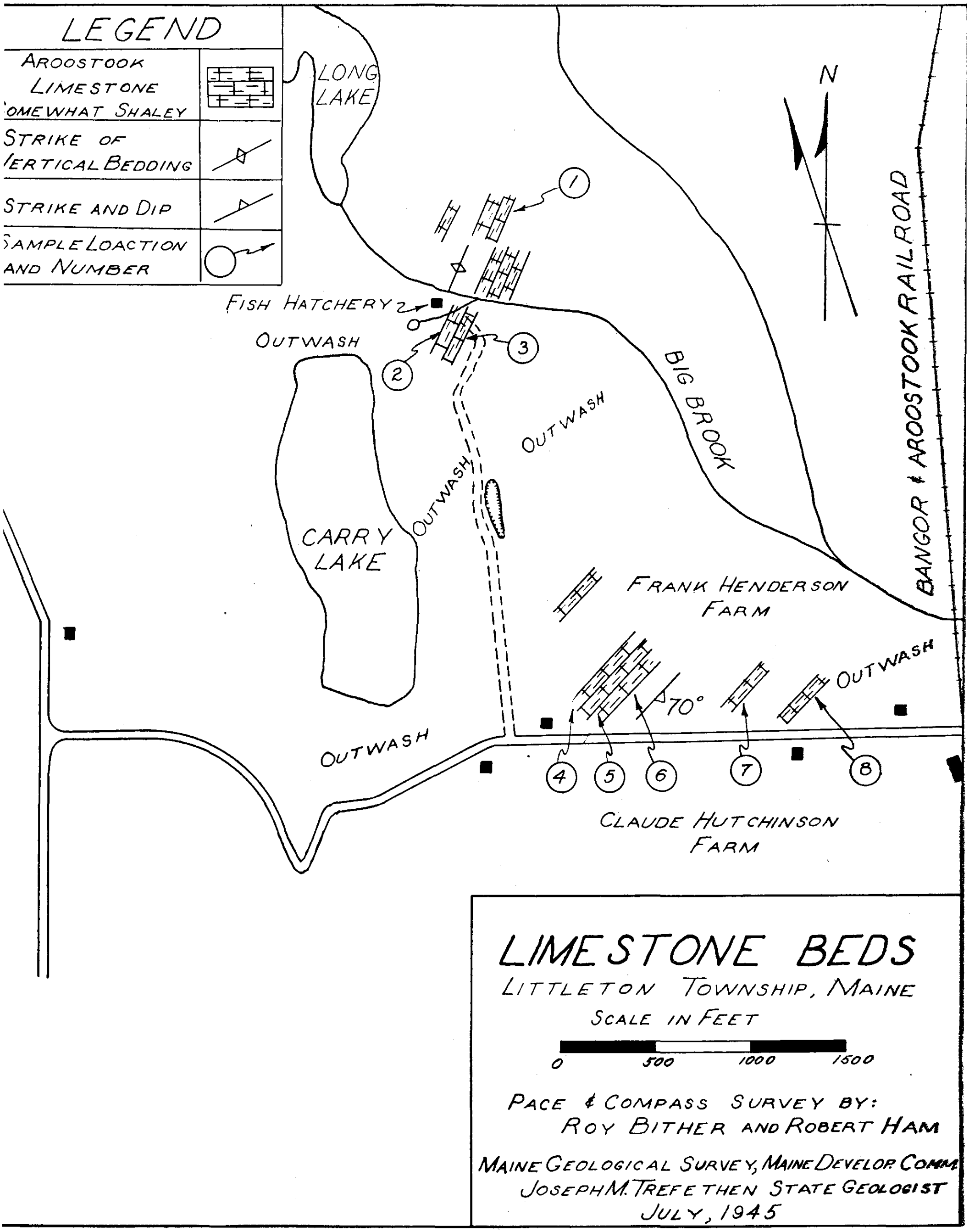
North of the Donaghy farm the bed rock is covered with a deep till.

Fourteen samples were taken in the area.

Littleton Township
Location 16 (Map VII.)

Numerous outcrops in the field west of the house on the farm of Frank Henderson on the Cary Lake Road in Littleton. Also continues south of the road on the farm of Claude Hutchinson. Another large outcrop is located at the fish hatchery on Big Brook and can be traced north for about 400′.

The rock seems to be a "better" phase of the Aroostook limestone. It is interbedded with shale layers but not so many as is common. The soil has a very bright, distinct brown color which seems to be associated with limestone beds. Potatoes scab badly near the outcrops.


LEGEND
AROOSTOOK LIMESTONE SOMEWHAT SHALEY
STRIKE OF VERTICAL BEDDING
STRIKE AND DIP
SAMPLE LOACTION AND NUMBER
LONG LAKE
N
FISH HATCHERY
OUTWASH
BIG BROOK
BANGOR & AROOSTOOK RAILROAD
CARRY LAKE
FRANK HENDERSON FARM
70°
CLAUDE HUTCHINSON FARM
LIMESTONE BEDS
LITTLETON TOWNSHIP, MAINE
SCALE IN FEET
0
500
1000
1500
PACE & COMPASS SURVEY BY:
ROY BITHER AND ROBERT HAM
MAINE GEOLOGICAL SURVEY, MAINE DEVELOP. COMM.
JOSEPH M. TREFETHEN STATE GEOLOGIST
JULY, 1945

Map 7

A good deal of the area is covered with glacial outwash.

Dip and strike varies somewhat.

At the Fish Hatchery—Dip, vertical; strike, N. 24° E.

Along Cary Lake Road—Strike, N. 43° E; dip—70° SE.

Eight samples.

Bridgewater Township
Location 17 (Map VIII.)

Outcropping along the highway one mile north of the village. Interbedded Aroostook limestone and shales.

A good deal of twisting in the beds but the principal strike is N 35° E; dip is 84° SE.

Many beds of shale and some sandstone.

Thirteen samples were taken at the southern exposure. Two, only, at the northern. (See Map VIII.)

Principal outcrop on farm of Dan Bradstreet. Fifteen samples.

Spot Sample 5
Littleton Township.

One mile east of Route 1 on the road going east, opposite the mouth of the Cary Lake Road, past the home of Dr. Perkins. In road cut at top of steep hill.

Generally weak shales but one zone of harder limy beds with few shales between the layers.

Strike N 12° E. Dip vertical.

Spot Sample 6
Littleton Township.

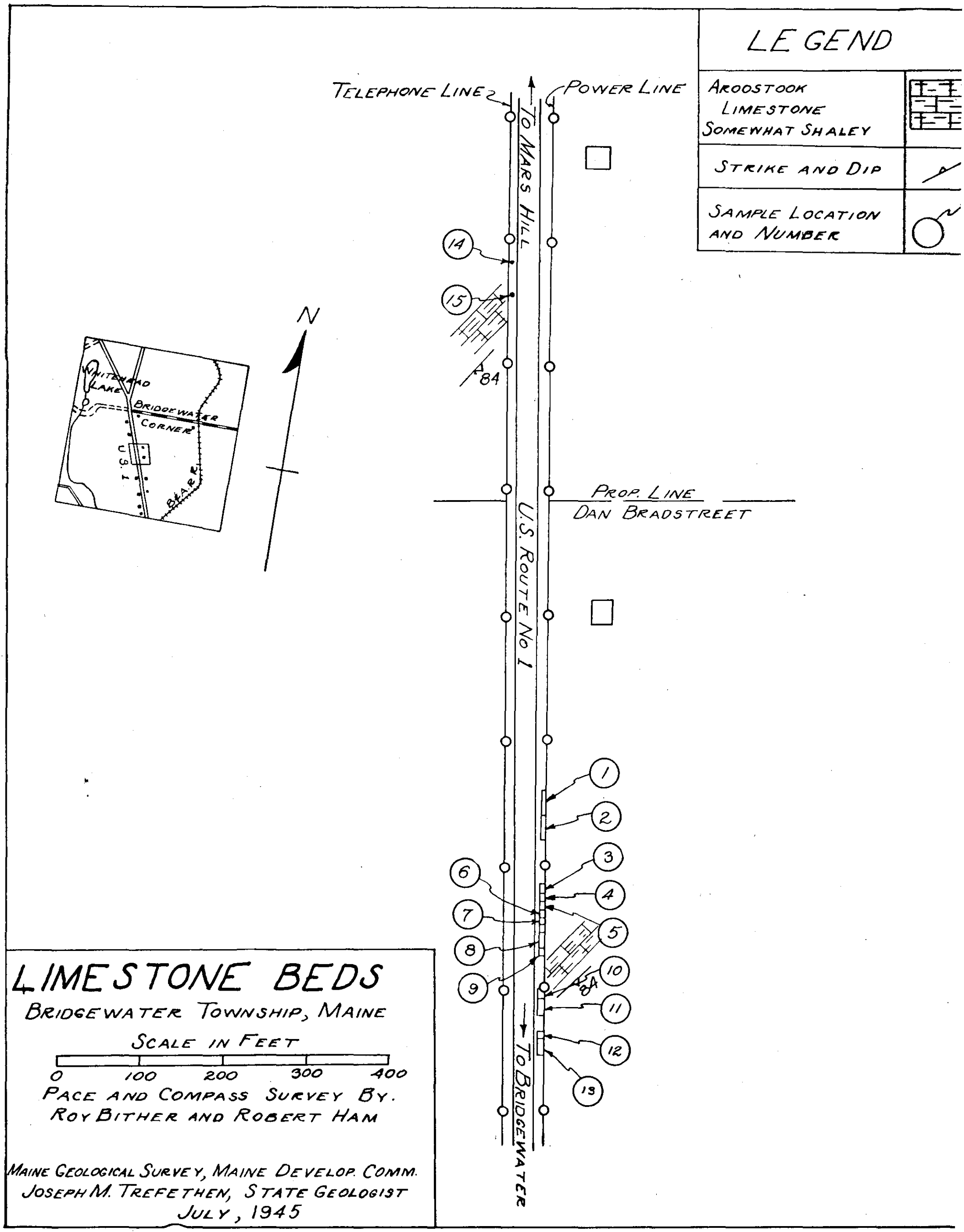
On top of hill just beyond Big Brook going east on the Carson road. Rock quite typical of much of the Eastern Littleton and of the areas mapped by Soil Conservation Service as a limy soil.

Spot Sample 7
Littleton Township.

Farm of Asa Henderson on the Foxcroft Road in Littleton. Small road cut just north of his house. Rather heavy bedded phase of the Aroostook limestone.

Monticello Township
Location 18

Small road cut west of Conroy Lake and just east of the side road that turns north from the Lake Road.


LEGEND
Aroostook Limestone Somewhat Shaley
Strike and Dip
Sample Location and Number
Telephone Line
Power Line
To Mars Hill
U.S. Route No 1
To Bridgewater
Prop. Line
Dan Bradstreet
N
Whitehead Lake
Bridgewater Corner
U.S. 1
B.&A.R.
84
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
LIMESTONE BEDS
Bridgewater Township, Maine
Scale in Feet
0
100
200
300
400
Pace and Compass Survey By.
Roy Bither and Robert Ham
Maine Geological Survey, Maine Develop. Comm.
Joseph M. Trefethen, State Geologist
July, 1945

Map 8

Interbedded lime and shales—mostly very shaly. At the very top of small hill and at the center of the cut there is 10-12 feet of an exposure of thinly bedded limestones. Much twisted and contorted and containing a good deal of calcite veins.

Total thickness of this center zone probably not over 15 feet.

Dip—vertical. Strike—N 40° W.

Can be traced south of the road for 80 feet and north for 600 feet. Three samples taken—1 and 2 at the road cut and 3 about 150 feet north.

Sample 4 is a highly metamorphosed limestone.

Many large boulders but ledge not found.

Three samples.

Houlton Township
Location 19

Ludlow Road at the bridge where the road crosses B Stream.

Shaly limestones, fairly typical of the area northeast of Houlton.

Strike—N 20° E.

Dip—80° E.

Soils mapped as Mapleton, Caribou, indicating limestone.

Three samples taken beneath the bridge over a width of outcrop of about fifteen feet.

New Limerick Township, Hunter Brook
Location 20

On Route 2, west from Houlton in New Limerick town. Just west of the stream flowing from Bradbury Lake. (See Smyrna Quad.)

Outcropping along the road and in field south of road. Extends north of road and outcrops as a cliff as much as forty feet high along the stream.

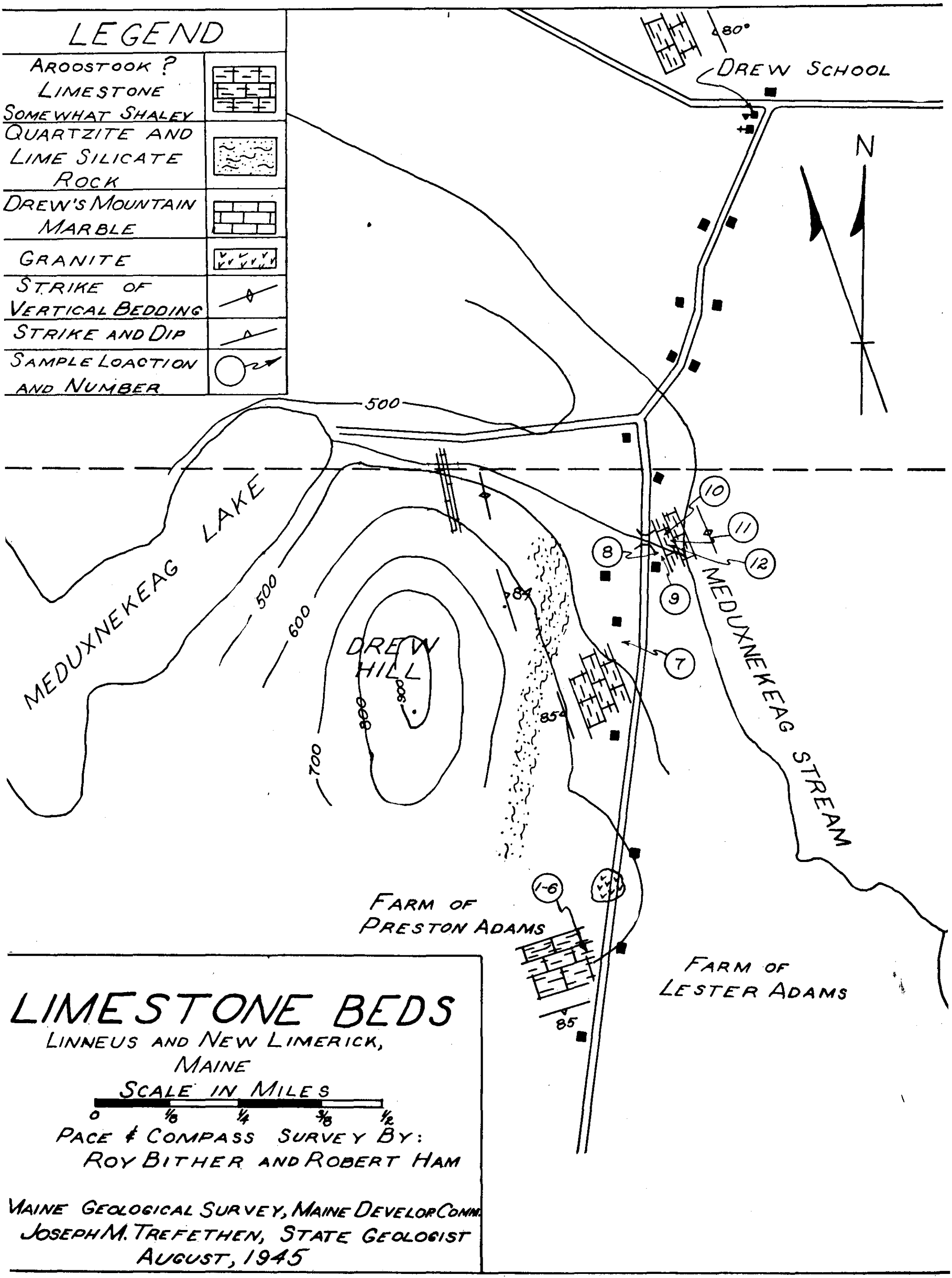
Interbedded shales and limes.

Much variation in strike of beds. At outcrop it is N 80° E; dip, 80° SE. At schoolhouse strike is N 110° E. South of Mrs. Warren's home N 90° E; dip, vertical.

Eight samples at five foot intervals.

These beds are quite typical of those underlying the Linneus soils. They undoubtedly cover a much larger area than mapped here, as it is known that they extend north across Hunter Brook onto the farm of C. D. Watson.

The rock very hard and the locality would offer an opportunity for a crushed rock plant.


LEGEND
AROOSTOOK ? LIMESTONE SOMEWHAT SHALEY
QUARTZITE AND LIME SILICATE ROCK
DREW'S MOUNTAIN MARBLE
GRANITE
STRIKE OF VERTICAL BEDDING
STRIKE AND DIP
SAMPLE LOACTION AND NUMBER
80°
DREW SCHOOL
N
500
MEDUXNEKEAG LAKE
500
600
700
800
DREW HILL
84
85
85
MEDUXNEKEAG STREAM
10
11
12
8
9
7
1-6
FARM OF PRESTON ADAMS
FARM OF LESTER ADAMS
LIMESTONE BEDS
LINNEUS AND NEW LIMERICK, MAINE
SCALE IN MILES
0
1/8
1/4
3/8
1/2
PACE & COMPASS SURVEY BY:
ROY BITHER AND ROBERT HAM
MAINE GEOLOGICAL SURVEY, MAINE DEVELOP. COMM.
JOSEPH M. TREFETHEN, STATE GEOLOGIST
AUGUST, 1945

Map 9

Some of the beds weather a light brown color while others have the typical smooth gray color of the Aroostook limes. However, fresh specimens show little difference in appearance to the eye.

These beds are very probably an extension of those at the Drews Lake area.

New Limerick and Linneus Township, Drews Lake
Location 21 (Map IX. See also Report of State Geologist, 1943-1944)

This area was visited in an attempt to find an extension of the Drews Lake marble. No further extension could be found, however.

Along the eastern slope of Drews Hill Mountain along the west road in Linneus Township samples were taken of interbedded limestones and shales outcropping along the road parallel the mountain.

The rock is about typical of the Aroostook and for the most part heavily impregnated with veins of calcite.

The principal outcrops were along the road at the farms of Preston and Lester Adams and at the bridge across the Meduxnekeag stream. The strike of the beds differs greatly due, no doubt, to the influence of a small granite intrusive seen along the road above the brow of the hill just north of the Lester Adams Farm. At the former place the strike is N 72° E, dip 85° SE. At the stream a strike of N 24° W, dip vertical.

In other parts of the area the rock is highly contorted.

Just to the west on the eastern slope of Drew Hill the rock is a schist. Strike N 18° W. Dip 84° E.

Twelve samples.

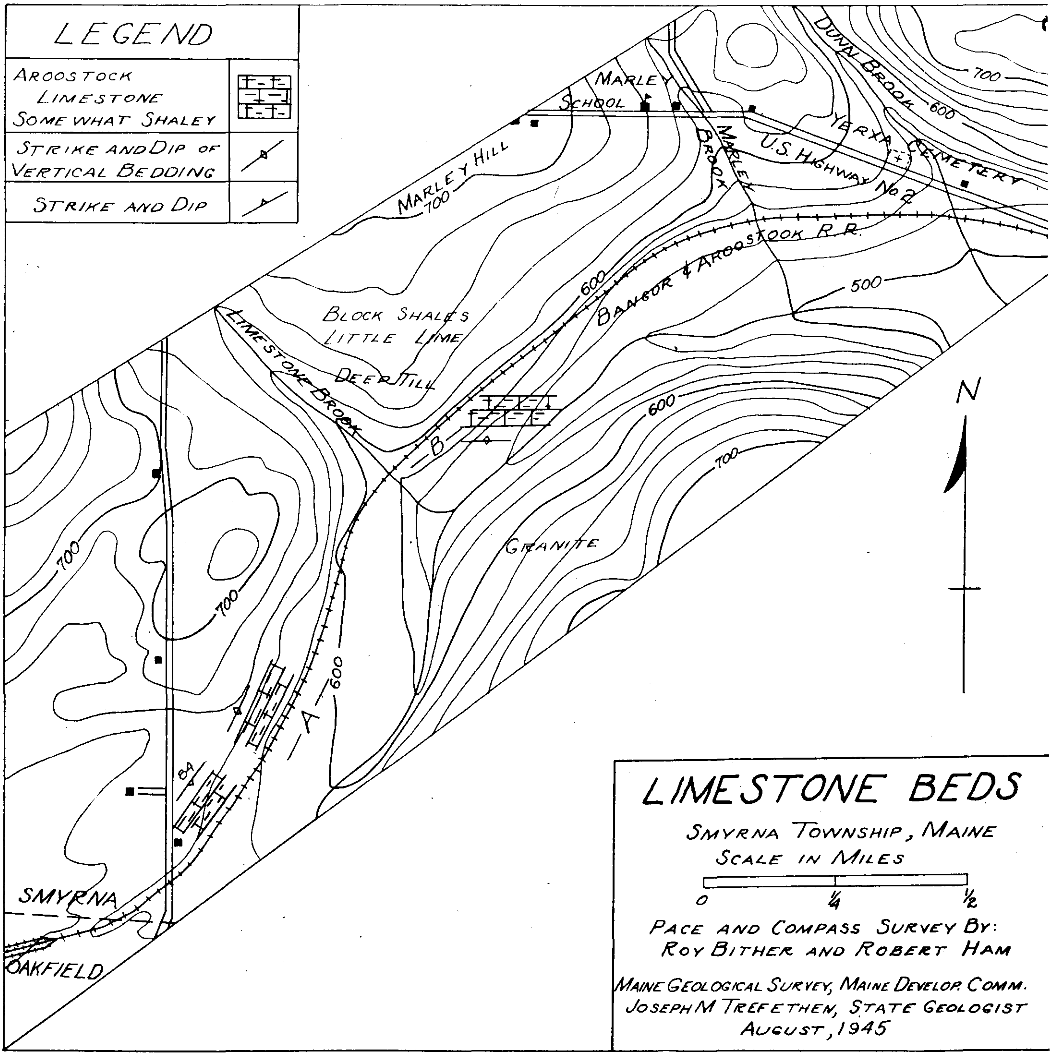
Smyrna-Oakfield
Location 22 (Map X.)

At the B. & A. R. R. crossing on the N-S road, south from Route 2 on the so-called "Back Road" to Oakfield.

Interbedded limestones and shales of the Aroostook type. Many of the beds are rather thin and all are much twisted and contorted.

The principal outcrop and the only one sampled is in a cut along the railway and extending north onto the farm of Ben Marley and south on the farm of Ralph Timoney.

The contortion within the bedding may be due to intrusives of trap rock and granite which outcrop in several places south of the area and are probably connected with the granite intrusive of Timoney Mountain to the south.


LEGEND
Aroostock Limestone Somewhat Shaley
Strike and Dip of Vertical Bedding
Strike and Dip
Marley School
Marley Hill
Marley Brook
Dunn Brook
Yerxa Cemetery
U.S. Highway No 2
Bangor & Aroostook R.R.
Block Shales
Little Lime
Deer Till
Limestone Brook
Granite
Smyrna
Oakfield
700
600
500
84
A
B
N
LIMESTONE BEDS
Smyrna Township, Maine
Scale in Miles
0 ¼ ½
Pace and Compass Survey By:
Roy Bither and Robert Ham
Maine Geological Survey, Maine Develop. Comm.
Joseph M Trefethen, State Geologist
August, 1945

Map 10

Strikes varied at the outcrop samples from N 47° E to N 60° E and the dip from vertical to 80° NW.

Sixteen samples were taken at five foot intervals across the strike. The outcrop extends for about 400 feet along the R. R. track, but only show a width of beds of about 80 feet as they run parallel the tracks for much of the way.

The same series of beds appears to extend one half mile or more as they outcrop along the R. R. and on the farm of Bernard Nadeau, in that direction.

The strike here is NE and the dip SE, so that the whole seems to be parts of synclinal fold.

Sixteen samples.

The limestone series is probably not over 400 feet wide as it grades into shales across the strike to the north and is cut off by granite to the south.

Smyrna Township
Location 23 (Map XI.)

This location can be considered as a part of the same series as at Location 22, but the appearance of the limestone beds differs greatly from the former locality.

To the south lies the so-called "Oakfield" granite hills and outliers of this intrusive mass have cut through the stratified series so that they are now almost marblized.

The limestones are probably the Aroostook limestones greatly metamorphosed outcrop along the B. & A. R. R. in two places in this location. (See Map IX.)—Outcrops A. & B.

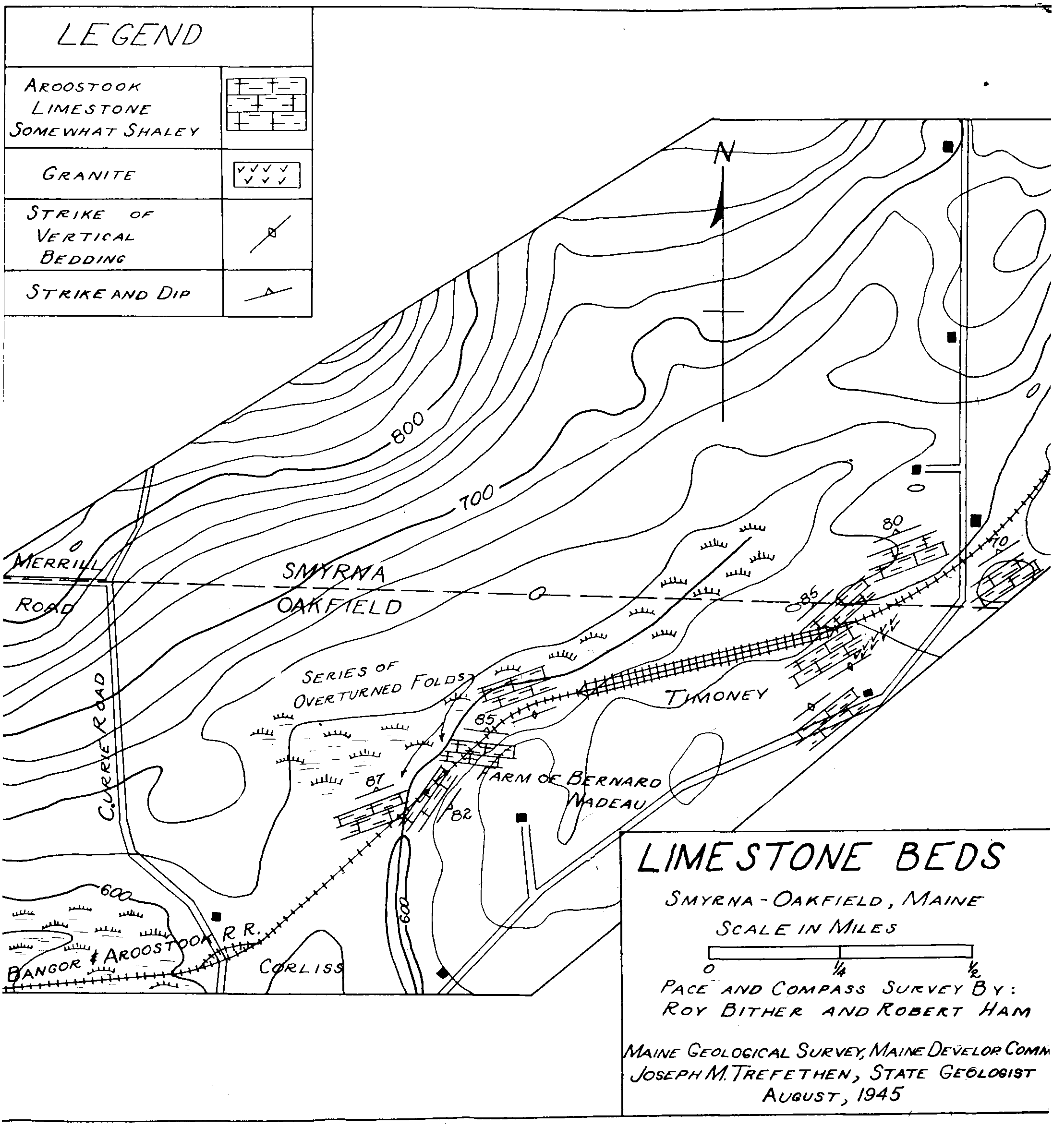
At both outcrops the limestones are interbedded with shales, are highly twisted and contorted and have been almost converted to marble by contact with the granite and trap dikes in the area.

The rock is very hard, fairly thick bedded, yet weathers readily in many places to a fine gray-white somewhat gritty powder.

At Spot A the outcrop is about 680′ along the R. R. and at Spot B about 690′.

Twenty-four samples were taken at A and twelve at point B.

The limestones appear to be in a zone from 350′-400′ wide and stand out in the two points sampled as hills or ridges from 40-60 feet high.


LEGEND
AROOSTOOK LIMESTONE SOMEWHAT SHALEY
GRANITE
STRIKE OF VERTICAL BEDDING
STRIKE AND DIP
N
800
700
600
0
80
70
85
87
82
MERRILL ROAD
SMYRNA
OAKFIELD
SERIES OF OVERTURNED FOLDS
TIMONEY
FARM OF BERNARD NADEAU
CURRIE ROAD
BANGOR & AROOSTOOK R.R.
CORLISS
LIMESTONE BEDS
SMYRNA-OAKFIELD, MAINE
SCALE IN MILES
0
1/4
1/2
PACE AND COMPASS SURVEY BY:
ROY BITHER AND ROBERT HAM
MAINE GEOLOGICAL SURVEY, MAINE DEVELOP. COMM.
JOSEPH M. TREFETHEN, STATE GEOLOGIST
AUGUST, 1945

Map 11

A COOPERATIVE STUDY OF PEGMATITES IN WESTERN MAINE

The Newry-Rumford area, in western Maine, contains some economically important and geologically significant pegmatites. A study of these rocks and their relation to the areal geology is in progress as a cooperative project of the Maine Geological Survey and the United States Geological Survey.

The chief purpose of the project is to provide detailed economic and geologic data on the pegmatites. Attention will be focused on minerals of economic or strategic importance, namely feldspar, beryl, spodumene and others. The Newry gem and feldspar mines, situated in pegmatites within the area, have long been famous for their rare and industrially important minerals. More than one promising new feldspar prospect has been discovered there within the past year. Further discoveries may be anticipated.

It is hoped that factors which control the distribution of the pegmatites and which are responsible for the variety of their mineral constituents, may be determined.

Field work, to be carried out chiefly in the Rumford and Old Speck Mountain quadrangles, will consist of:

1) detailed mapping of selected pegmatites on scales ranging from 10 to 100 feet per inch;

2) areal mapping on scales ranging from 500 feet per inch to approximately one-quarter mile per inch.

Field work on the project began in August 1946. Prof. Vincent E. Shainin is in charge of the investigation under the supervision of Dr. Joseph M. Trefethen, State Geologist of Maine, and Dr. Eugene N. Cameron, Commodity Geologist for Industrial Minerals, U. S. Geological Survey.

A SUMMARY REPORT ON THE BURNING QUALITIES OF PEAT

By Robert Bradford

In Bulletin One of the Maine Geological Survey, a report was made on the peat deposits of Maine with special reference to the use of peat as fuel. Subsequent to the issue of that report, some comparative tests of peat and coal were run in Geological Survey Laboratory at Orono. The results of these comparative tests are summarized here.

Test No. 1

A comparative test of peat and "Red Spot" anthracite coal in a hot air furnace heating a seven-room house. Tests covered the period from February 5 to February 12, 1944.

Table of Results

	Peat	Coal
Lbs./hr. fired	8.5	4.0
Avg. room temperature, °F.	71.3	72.2
Max. room temperature, °F.	83.0	80.0
Min. room temperature, °F.	60.0	66.0
Avg. outside temperature, °F.	9.2	7.3
Max. outside temperature, °F.	19	21.
Min. outside temperature, °F.	–4	–10
Price of coal per ton		$17.00
Equivalent value of peat per ton	$8.00	

Test No. 2

Trial test of peat in a wood and coal burning cook stove.

Peat produced a quick hot fire, producing a hot oven quicker than either wood or coal. Some care is necessary in firing and control of drafts to maintain low oven temperature. Approximately fifty pounds of peat was sufficient to operate the cook stove for one day.

Test No. 3

Efficiency test of peat in a Char-Wood heater.

The Char-Wood heater is a specially designed space heater for the efficient burning of wood by slow destructive distillation. The gas and coke formed are both burned to produce heat.

Following is a heat balance for a seven-hour test.

Heat Balance

	%
Efficiency (available heat)	55.93
Loss due to dry chimney gases	27.20
Loss due to moisture in fuel	1.32
Loss due to burning of H_2	9.65
Loss due to CO in flue gas	5.90
Loss due to carbon in ash (negligible)	.....
Total	100.00

Further test indicated that a fire could be maintained for a period of twenty-four hours on one charging of the heater.

Test No. 4

Efficiency test of hot water or steam heating system.

The boiler used in this test was an H. B. Smith #16, standard squared type, sectional boiler, having a rated capacity of 950 square feet of standard radiation and $3\frac{1}{8}$ square feet grate area. The efficiency for a seven-hour test on this boiler was 38%. Flue gas analysis indicated that there was considerable loss due to poor combustion of the highly volatile portion of the peat fuel.

Test No. 5

Trial test of peat as a luxury fuel in a fireplace.

Peat fuel containing approximately 30% moisture requires a small amount of wood or other kindling material to start a fire. When burning, the peat gives off some smoke but burns with a bright long yellow flame.

When the moisture content of peat fuel is approximately 10%, it can be kindled with paper, gives off very little smoke, and burns with a very long flame. It does not last as long as the better grades of hard wood.

Test No. 6

Comparative test of peat and peat-coal mixture.

One characteristic of peat fuel in most of the common types of furnaces and stoves is that it burns rapidly. To overcome this, peat and powdered coal were machined together into fuel blocks containing approximately 50% by wt. of coal and 50% by wt. of peat.

Comparative test was then run in the hot air furnace used in test number 1. A fire could be held approximately six hours in this furnace using pure peat, and approximately eight hours using the peat-coal mixture.

MINERAL PRODUCTION, 1945-1946

The Maine Geological Survey has attempted to gather statistics on the mineral output of the State for the years of 1945 and 1946. While the data are incomplete, it is apparent that the 1946 production was materially greater than the 1945 production. This is particularly evident in the manufacture of brick. Several new concerns entered the field in 1946, and several concerns inoperative in the preceding year returned to production during the 1946 season. The increase in the output of limestone products is also noteworthy. In addition, the reopening of a number of granite quarries, idle during the war, and the expansion of peat and feldspar production raises the total of mineral output of the State significantly above any of the immediately preceding years. The outlook for clay products, limestone products, gravel and sand, dimension stone, slate, peat, and feldspar for 1947 appears good, and the level of production of all these products will probably rise above that of 1946. Sheet mica production, significant during the war, has come to a standstill, and probably cannot and should not be revived under peacetime conditions.

MAINE GEOLOGICAL SURVEY PUBLICATIONS

Reports

"First Annual Report on the Geology of the State of Maine"
by Lucius H. Merrill and Edward H. Perkins, 1930. *Out of stock.*

"State Geologist's Report on the Geology of Maine 1930-32"
by Joseph C. Twinem and Edward H. Perkins. *Out of stock.*

"Preliminary Geological Map of Maine"
by Arthur Keith and Edward H. Perkins, 1933.

"Report of the State Geologist, 1942-43"
by Joseph M. Trefethen.

"Report of the State Geologist, 1943-44"
by Joseph M. Trefethen.

"Report of the State Geologist, 1945-46"
by Joseph M. Trefethen.

Bulletins

"Domestic Fuel Possibilities of Maine Peat"
by Joseph M. Trefethen and Robert B. Bradford, 1944.

"Geology of the Katahdin Pyrrhotite Deposit and Vicinity, Piscataquis County, Maine"
by Ralph L. Miller.

"Petrology of the Columbia Falls Quadrangle, Maine"
by Ruth D. Terzaghi.

"Geology of the Aroostook County, Maine, Manganese Deposits"
by Ralph L. Miller.

"Economic Geology of Some Pegmatites in Topsham, Maine"
by Vincent E. Shainin. (*In preparation*)

Copies obtainable on request to the Maine Development Commission, Augusta, Maine.