REPORT

OF THE

STATE GEOLOGIST

ON THE

Mineral Industries and Geology

of Certain Areas

OF

VERMONT.

1903-1904.

FOURTH OF THIS SERIES.

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STATE OF VERMONT.

OFFICE OF STATE GEOLOGIST,

BURLINGTON, VT., *October* 1ST, 1904.

To His Excellency, John G. McCullough, Governor of Vermont:

SIR:—In occordance with the provisions of Act Number 6, 1900, I herewith present my Fourth Biennial Report on the Mineral Resources and Geology of Vermont. This report contains a summary of the results of investigations carried on during the years 1903 and 1904.

When all things are considered it will be found that the Geological Survey has made satisfactory progress.

The very moderate appropriation from which all expenses must be met renders work upon any other than a small scale quite impossible. Much of the field work that has been done has cost the State little more than the actual traveling expenses of the geologist, and the very valuable assistance which has been given by Professors Seely, Hitchcock and Marsters has cost very little.

I think that it may be easily shown that in the results of the work done during the two years covered by this Report, the State has received that which is of far greater value than the money expended.

As heretofore, a large number of samples of ores have been tested and an account of the composition of each sort has been sent to the owner. It is believed that in this way much money has been saved which otherwise would have been spent in needless assaying or in useless attempts at mining. The introduction which immediately follows gives a general statement of the work of the two years.

Very respectfully,

GEORGE H. PERKINS,

State Geologist.

INTRODUCTION.

The following pages form the Fourth Report issued by the present State Geologist. The Report immediately preceding this contained—A sketch of the Life of Zadock Thompson, by G. H. Perkins; A Bibliography of Works on Vermont Geology; A sketch of the Life of Augustus Wing, by H. M. Seely; An Account of the Mineral Industries of the State, by G. H. Perkins; an account of The Granite Area of Barre, by G. I. Finlay; a description of The Terranes of Orange County, by C. H. Richardson; a survey of the Geology of Grand Isle, by G. H. Perkins; and a Petrographic Description of the Dikes of Grand Isle, by H. W. Shimer. The chapter on the geology of Grand Isle includes a paper by Professor Seely on Sponges of the Chazy.

During the two years since the last Report was published the whole of Grand Isle County has been explored and mapped, as will appear in pages following. The Brandon Lignite Deposit and its peculiar and exceedingly interesting fossils has been carefully studied; many of the mineral and rock deposits in different parts of the State have been examined and the water supply of Vermont, so far as it is used for drinking, has been investigated under the joint authority of the United States Geological Survey and the Vermont Survey. In addition to what has been accomplished by the State Geologist, valuable investigations have been carried on by Professor C. H. Hitchcock on some of the problems presented by Glaciation found on the high elevations in the State, Professor V. F. Marsters has made a careful study of the Asbestos Deposits and the adjacent rocks, Professor H. M. Seely, who for many years has studied the Stromatoceria of the Chazy and contiguous beds has furnished a paper on the forms of this genus found on Isle LaMotte. The Bibliography given in the previous Report is again published, as important additions have been found since the first list was issued. The biographies of the pioneers in scientific work in Vermont are continued by that of the first State Geologist, C. B. Adams, by Prof. Seely. The Mineral Industries of the State are more fully treated in the present than in some of the previous Reports as their great and increasing importance demands.

It has seemed eminently fitting that a biography of the first State Geologist appointed in this State and one of the leading scientists of the State should find place in such a report as this. Accordingly a sketch of Professor Adams published by Professor Seely, in The American Geologist, is here reproduced with the portrait which accompanied the original article.

PLATE I.

C B Adams.

Courtesy of THE AMERICAN GEOLOGIST.

Sketch of the Life and Work of Charles Baker Adams.

By HENRY M. SEELY, Middlebury, Vt.

PORTRAIT—PLATE I.

Amherst College was greatly honored by the men that graduated in the class of 1834. A member of this class in later years said something very like this: "We led our class, you at one end and I at the other." This playful recognition by Henry Ward Beecher of the superior scholarship of a loved and loving friend and classmate must not be taken too seriously for the great preacher himself was no mean scholar in rhetoric and kindred studies. But whoever was the trailer evidently there was a leader of this class of eminent men. The name of this leader stands as the title of this sketch.

Charles Baker Adams was the son of Charles Jeremiah, and Hannah Baker Adams. His birthplace was Dorchester, Mass., the time of his birth January 11, 1814. He was fortunate in many respects, particularly in ancestry, in surroundings, in taste, and in training.

The father, Charles Jeremiah, was a Boston merchant born at Medfield, Mass., 1789, and of that kind of stock that made the family name Adams famous.

It is not always possible to say what a man is worth, the sum having a sliding scale from the minus of a pauper or the lower down minus of a criminal, to the plus high power of a president of the United States. When Henry Adams stepped out on the landing place at Salem near 1632 there went with him unseen potentialities the value of which one can hardly overestimate. No bound or recoil answered the footfall of this man as he walked forth into the new world to which he was bringing his energies. But later all America became responsive to it. Through his descendents he became a large factor in shaping the fortunes of this new world. The family name runs along the early and later pages of American history.

From the labors of an immediate ancestor of Charles Jeremiah has come mostly what is known of the early relationships of the family, he having compiled the first known genealogical record of the family in this country, threading almost untrodden regions on horseback for the purpose.

Charles Baker Adams was in the seventh generation of the American family, having come down through lieutenant Henry Adams the oldest son of Henry Adams the immigrant.

This founder of the family settled in Braintree, Mass., and here was gathered a household of eight sons and one daughter Ursula. The names of the sons were Henry, Thomas, Samuel, Jonathan, Peter, John, Joseph, and Edward. These children he had probably brought with him from England.

Henry, the oldest son, was the first town clerk of Braintree and the first record of a marriage was that of himself with Elizabeth Payne, November 17, 1643. The second marriage entry was that of his brother Joseph and Hannah Baxter. These were the great grandparents of John, the future president, as well as of the second cousin, Samuel, the revolutionary patriot and state governor.

A paragraph giving the genealogy of Charles Baker and, incidentally, at the same time showing the size of families of earlier times will be interesting. Henry Adams 1st, eight sons and one daughter; Henry 2nd, seven sons and one daughter; Henry 3rd, three sons and four daughters; Henry 4th, four sons and seven daughters; Elijah, eight sons and eight daughters; Charles Jeremiah, two sons; Charles Baker, five sons and one daughter.

Near the time Henry 2nd made the record of the marriage of his brother Joseph he removed from Braintree to Medfield and was the first town clerk of Medfield. Here his branch of the Adams family became numerous and distinguished, and here Charles Jeremiah was born.

It would be interesting to know something of the pursuits of the lad Charles Baker, of his friends and associates in his Dorchester home, but the years have gone by without record of remembrance

further than that he was early inclined toward natural history, "fond of bugs," as was said of him.

His tastes led him away from the mercantile pursuits of his father and pointed him towards the life of a scholar. From Dorchester he went to Phillips Academy at Andover and in 1830 entered the freshman class at Yale. The next year, 1831, he entered Amherst College and graduated with the class of 1834.

The college curriculum of the day was thought to be a well rounded one, framed by the experience of renowned educators of both the old world and the new, designed to give a complete scholarship. It was not the purpose to fit a young man for a special profession but rather to ground him in the principles that might be needed in any of what were then the learned professions. So young Adams had the full benefit of training in ancient languages, mathematics, mental and moral science, and whatever of natural science was then taught. In many ways this was a good course. It was strong meat for strong men. Adams took well to this nourishment and grew on it. His diligence with his endowment enabled him to forge forward in scholarship and his scholarship placed him at the head of his class.

The wide world opened before the graduate, but apparently the young man was not quite sure where his field lay. It might be that of theology so he turned his steps towards the Theological Seminary at Andover. Here he spent the first two years of his post graduate life.

In 1836 he was tutor at Amherst College and during the year gave a course of lectures on geology at Bradford Academy, and assisted president Hitchcock for a brief time in a geological survey in New York state.

In 1838 he was called to Middlebury College, Vermont, to take the professorship of chemistry and natural history. While occupying this roomy chair and doing all the exacting work connected with it, he in some way found time for creating a cabinet of natural history which under his diligent hand grew to symmetrical proportions.

The rocks of the state, the minerals at hand and far away, the insects of the surrounding country, many of the vertebrates and especially the mollusks from foreign waters, as well as a complete suite from the state were collected and here systematized in this museum.

While Professor Adams was busy with the large work to which he had set himself, the blooming time of early state geological surveys had come. The studies and lectures of Professor Amos Eaton, had had a widely beneficent influence. His labors with those of others created at that time a great wave of geological enthusiasm. The people of the various states became wonderfully interested in the rocks and minerals of their lands, and this interest brought about by legislative action the organization of state surveys. The subject of a state geological survey had been brought before the legislature of Vermont as early as 1836. In and out the legislature the matter was discussed until 1844, when late in October of that year a statute was enacted making an annual appropriation for the three succeeding years for a geological survey.

Early in the spring of 1845 governor William Slade in whose hands the selection of the head of the survey was placed, appointed as such head, Professor Charles B. Adams.

Professor Adams, who had had preliminary training and experience under his college professor Edward Hitchcock, entered at once upon the work assigned him. He was fortunate in the choice of his assistants. He called to his aid Professor Zadock Thompson, of Burlington, who years later became successor in the work of the survey, and Rev. S. R. Hall of Craftsbury, who had chief oversight of the agricultural features of the survey; Denison Olmsted, Jr., and later T. Sterry Hunt gave help in mineralogy and chemistry. Also volunteer and temporary assistants gave excellent help. The state was taken under general survey. According to the directions of the governor, seven suites of specimens were to be assembled for the state; an eighth was to remain in the hands of the principal of the survey, to be disposed of by him at his discretion. The complete suite was for the state collection; the less complete were to be placed in the cabinets of various schools in the state.

Much preliminary work was done the first year of the survey.

The personal work of the principal was directed to ascertaining the character and limits of the geological formations. Six thousand specimens were collected and a first annual report on the Geology of the State of Vermont, a paper of 92 pages, was presented.

A busy year, that of 1846, followed. A map of the surface rocks was projected, several sections were worked out, all the counties of the state were visited and in some cases revisited, drawings for future illustrations made, specimens of fossils, rocks, and minerals were collected, bringing up the number to 12,000, and a second annual report, a work of 267 pages, was presented.

This second report contained, besides much other matter, a brief treatise on geology, for the instruction of the people of the state, with illustrations from the rocks of the state, prepared by the principal of the survey. A careful, comprehensive statement of the economical geology and mineralogy as well as the agricutural features of the state was made.

The results of a collection of sixty samples of soil by S. R. Hall, the altitudes of the mountains of the state by Zadock Thompson, and analyses of rocks and minerals by Denison Olmstead, Jr., were put on record.

A third annual report, that for the year 1847, was briefer, a paper of 32 pages. In it the work of the year is sketched though not largely. Careful sections from Lake Champlain to the Green Mountains had been carefully worked out by the chief of the survey, the geological map continued and corrected; 3,000 specimens had been added to the previous collections. The collection—that for the state now numbering 2,000 specimens—had been ticketed with number, formation and locality, and made ready for distribution among the institutions to which they were assigned. The assistants on the survey had been diligent. T. Sterry Hunt had reported the analyses assigned him. The principal had had the deep satisfaction of the presence of Professor Desor and Professor Agassiz for a little time, and at Burlington and vicinity he had their suggestions in regard to the drift of Vermont.

The work of the three years had been leading up to the preparation of a final report. At the close of the third report Professor Adams made estimates, very moderate estimates, for each of the two years required for making out the results of the geological survey.

Near the close he had previously said: "The remainder of the winter will be occupied in collating the field notes and in making the necessary plans for the preparation of the final report. . . ."

"The time and funds provided by the bill for the geological survey will be exhausted on the first of March, 1848, and additional funds and time will be necessary for making out the results of the survey. In the annual reports but a small part of these results has been given and this has been done in a disconnected way. If we may be allowed a familiar illustration the process of the geological survey thus far has consisted in finding and bringing together the various materials which are yet to be used in the construction of the edifice. Some benefits we hope have already resulted from the survey, but it still remains to make it a source of permanent utility."

But to the loss of the state of Vermont, and perhaps a greater loss to the science of geology the master builder who had so carefully and so laboriously selected the material, was not permitted to build into a harmonious whole the edifice so wisely planned.

Professor Adams, in the last year of the survey, 1847, had accepted a position outside of the state, a professorship at his Alma Mater, Amherst College, Mass.

The state legislature at its succeeding session neglected to make an appropriation for this work. The cause of this failure is not at this day quite clear. It may, in great probability, be attributed to the absence from the legislative body of those members who early were the advocates and supporters of the survey.

The work stopped. Professor Adams issued a thin fourth report now exceedingly scarce, the mere shade of the final report which was so near his hand.

The results of this period of three years' work may be partly summarized in the following statements. There was exhibited an eminent example of a careful systematic geological survey, there were published annual reports of the progress of the work; a map was prepared of the geological formations of the state as these formations were then understood. Labelled collections of rocks, minerals and fossils were placed at Montpelier and with various literary and medical schools of the state, a mass of geological notes was accumulated. These last, however, were made in a private shorthand and not readily deciphered except by the one who had made them.

Near this time Professor Adams, in connection with his friend and Amherst classmate Professor Alonzo Gray, published a text book, Elements of Geology. A person familiar with his annual reports, recognizes that in illustration and in thought this book is the outcome of his geological work in Vermont.

The deepening of the groove that Professor Adams was impressing on the science of geology apparently stopped here. A suggestion as to the possible cause for his turning abruptly aside from contributing to geology is that he found in his new college associations one whom he looked upon as a master in the science, his old teacher President Hitchcock. With him he would not enter into competition. Whatever may have been the cause, he turned easily to another and a much loved field that was awaiting him, that of zoology. This he entered with the same enthusiasm that had characterized his work in Middlebury, and the wider border, the mountains and valleys of Vermont. Here at Amherst as at Middlebury he put his fashioning hand on the Museum of Natural History to which he transmitted his personal collections accummulated in the Vermont survey.

His more especial original study was in connection with the class Mollusca. The shells of Central America and the West Indies received his careful attention, and in pursuance of his object he made thither successive voyages. He visited Jamaica in 1844-45 and again in 1848-49, Panama, 1850-51, and St. Thomas, 1853-54.

In some parts of his work Thomas Bland, Esq., an English lawyer of New York City, and resident of Brooklyn, was in connection with him, and later Robert Swift a merchant of Philadelphia and St. Thomas.

Frequent published papers came from his study and his pen and between 1849 and 1851 successive contributions to conchology appeared to the number of ten. These had been read before the various scientific societies and were mostly printed in the Annals of the New York Lyceum of Natural History. Various Molluscan collections, largely the work of his own hands, were examined and catalogs prepared and printed. In April, 1851, there appeared a catalog of the land and fresh water shells that inhabit Jamaica giving a number of land shells, 364, fresh water, 25, in all 389. His great work in connection with Mollusca was with these forms in and around Jamaica. He hoped to prepare a monograph which should be a complete study of the species and varieties of that region.

From such opportunities for collection and having the gift of making accumulations it is not strange that the Museum under the charge of Professor Adams took on an unique character and large proportions. Professor Hovey of the chair of physics had accumulated what may be considered the nucleus for the marvel that crystallized around it. A marvel it was, the hundreds and thousands of specimens grouped as to relationship and bearing a peculiar personality by the labelling in the beautiful handwriting of Professor Adams. At the time his formative hand left it, a half century ago, it contained about 8000 species and Professor Louis Agassiz said "I do not know in all the country a conchological collection of equal value."

A somewhat similar collection made by Robert Swift, for the sum of $30,000, passed into the keeping of the Smithsonian Institution.

Teaching at Amherst with collecting in the West Indies went on year after year with Professor Adams as had his teaching at Middlebury and the geological survey of Vermont.

But the year 1853 was a sad one for Amherst College; an overwhelmingly calamitous one to his family there. While at work at St. Thomas, W. I., he was attacked by the Yellow Fever. He was most faithfully cared for by his co-laborer in the conchological field, Robert Swift. But the grip of the fearful malady was too powerful to be loosed by any loving ministration. The strong, the courageous, the hopeful naturalist,

yielded his life, dying January 18, 1853, aged thirty-nine years.

Some time later a memorial stone, the appreciative gift of scientific friends, was placed at his grave, the spot at which on St. Thomas his body was buried. So in a way St. Thomas at this early date was pre-empted to the United States, by the deposit of the body of Professor Adams, and the erection of the stone that stands sentinel at his dust.

In person Mr. Adams was not large but sturdy, his countenance was that described as intellectual, his eyes large, black, lustrous, his hair abundant and black, early showing of gray. He was a good horseman, a strong swimmer. The sons recall the incident of the father's gathering the four small boys together at sunrise one summer morning for a stroll with him. He led them a mile away across country to a creek, at the time swollen to a torret from recent rains. But it seemed to invite the professor who prepared himself for a plunge telling the youngest, a mite of a boy, to do the same. Then leading him to the brink, he, poising him for a moment in his hands, tossed him far out into the current. The little fellow did not cringe or cry, was not afraid, for his father was there. He floated with his head well above the water and when swept down stream turned his eyes expectantly towards his father. The father looking for a little at the wholly trusting boy, dashed headlong into the stream, swam with vigorous strokes until he reached the little waif, when turning his broad back to him, told him to climb up and hold fast. Then such a ride as the boy had! To and fro the strong swimmer went with his small load to the joy of all the party and until the lesson ended.

In demeanor he was quiet and self contained, with a grave cast of countenance. In physical endurance he was tough to a degree, never suffering from lack of sleep, not knowing what it was to be tired. Obstacles in his way he pushed aside, was reckless in the matter of expenditures when such were needed in accomplishing his work. He neither cared for nor feared danger even when, as his friends knew, the peril was great.

An associate of Professor Adams speaks of him as a typical scientist, one who possessed a greed of collecting, a remarkable power of classification, an ability to so marshall his individuals and groups that they gave expression to his thoughts. He was diligent, methodical, a tremendous worker. For a little he was brought in company with Agassiz, and one who knew them both thinks, that in brilliancy of intellect he measured up equally with this world renowned naturalist.

In the classroom he had the fullest confidence of his students. Chemistry and natural history were not then the hand to hand sciences between teachers and scholars as today, but the instruction he gave in these departments commanded the careful attention of his listeners. While fast becoming a master in his own realm his work and study were not bounded by special science alone. He was alert to all that was going forward in the world of thought, keeping abreast with the recent discoveries that were at the time famous. His early scholarship never deserted him and so in emergencies he would for the time assume the chair of Greek or Latin, logic or moral science, to the delight of his classes. The expression "All round scholar" found an exemplification in him.

Quiet humor, laconic speech, and the enjoyment of a happy turn not unfrequently enlivened his class experiences. One or two incidents may show this. The college class of 1842 of Middlebury never forgot one day's exercise. The students, as was the custom of those days, were called on in their turn to recite. When H. M., fleet of tongue but not always careful in his preparation, was called, he went glibly with a long disquisition that had no real relation to the assigned topic, and coming to a halt, the professor quietly said "Not correct." Tacking, he again tried his skill in improvising and at length coming to a rest he heard the same words "Not correct." The young man at his wits' end then impulsively exclaimed, "Then I don't know anything about it." "Correct, " instantly, from the professor; "Next," and the recitation proceeded—proceeded as well as the electrified condition of the class permitted.

Another incident that has gone into print, rather fantastically dressed, really belongs here. Some of Professor Adams' boys at Amherst College did, as they thought, a nice bit of work, and it was well done. Taking the head of one insect, the mid body of another and the hind body of a third they neatly joined the fragments. Then bringing the triple monstrosity to the professor they confessed their perplexity in regard to the class and name of the object. The professor looked at it a moment then remarked, "Gentlemen this is a hum-bug."

The classroom and laboratory work at Middlebury college must have been exacting yet he found time to make a complete collection of the Mollusca of the state. And this was a small portion of his outside work. The collections illustrating the various branches of zoology in addition to geology and mineralogy, bear evidence of his swift and certain hand. He duplicated and more than duplicated this work at Amherst.

Life was full of promise to himself, his family, and to the scientific world. Near ten years of professional life had been spent in connection with Middlebury college, and half that time with Amherst. With slender help from without he was pushing his favorite study when attacked by the fatal malady, which in comparatively early life took him from his chosen field. Science lost a zealous, helpful promoter, when in the early blooming of his powers the promise of great fruitage was sadly and suddenly cut off.

To the family the loss was more than can be told. One son had died in infancy. The wife, four sons and a daughter survived him. In 1839 Professor Adams had married Mary Holmes, a woman of strong mental endowments and noble character, the daughter of the Rev. Sylvester Holmes of New Bedford, Mass., and to her care the young household of five children was unexpectedly committed. How these children were trained to honor their father and their father's name, and how they exhibited their loyalty to their country may be learned by a recital of their career. Two of his sons, Charles Breck and Sylvester Holmes, died in 1861, members of the Union Army in the Civil war. One, Edward Hitchcock, served twelve years in the navy during the latter part of the war of the rebellion and the period of reconstruction that followed, and

Henry, the fourth son, was in one of the hundred day regiments made up of men called away from pressing business. And later his grandson Charles Melbourne Atwood, son of his only daughter, Mrs. Lillie Adams Atwood, gave his service and his life in the recent Spanish-American war.

A portrait of Professor Adams, the gift of his son Henry, appropriately honors the library of Amherst college. On the shelves and in the cases of both colleges, Middlebury and Amherst, are abiding evidences of his work in the form of suites of Vermont rocks collected during the state geological survey. These with his mineralogical and zoological specimens stand just now at the half century mark, as a memorial of the ability and incessant activity of Professor Adams.

He was a member of many societies, chiefly the following:

Association of American Geologists, Boston Society of Natural History, Philadelphia Academy of Natural Science, Lyceum of Natural History of New York, American Academy of Arts and Sciences, Natural History Society of Nuremburg (Corresponding Member), Honorary Member of Jamaica Society.

It may not be possible now to obtain a complete list of the publications of Professor Adams, nor can the date and order of appearance be certainly indicated. The greater part, however, will be comprehended under the following titles:

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Mineral Resources.

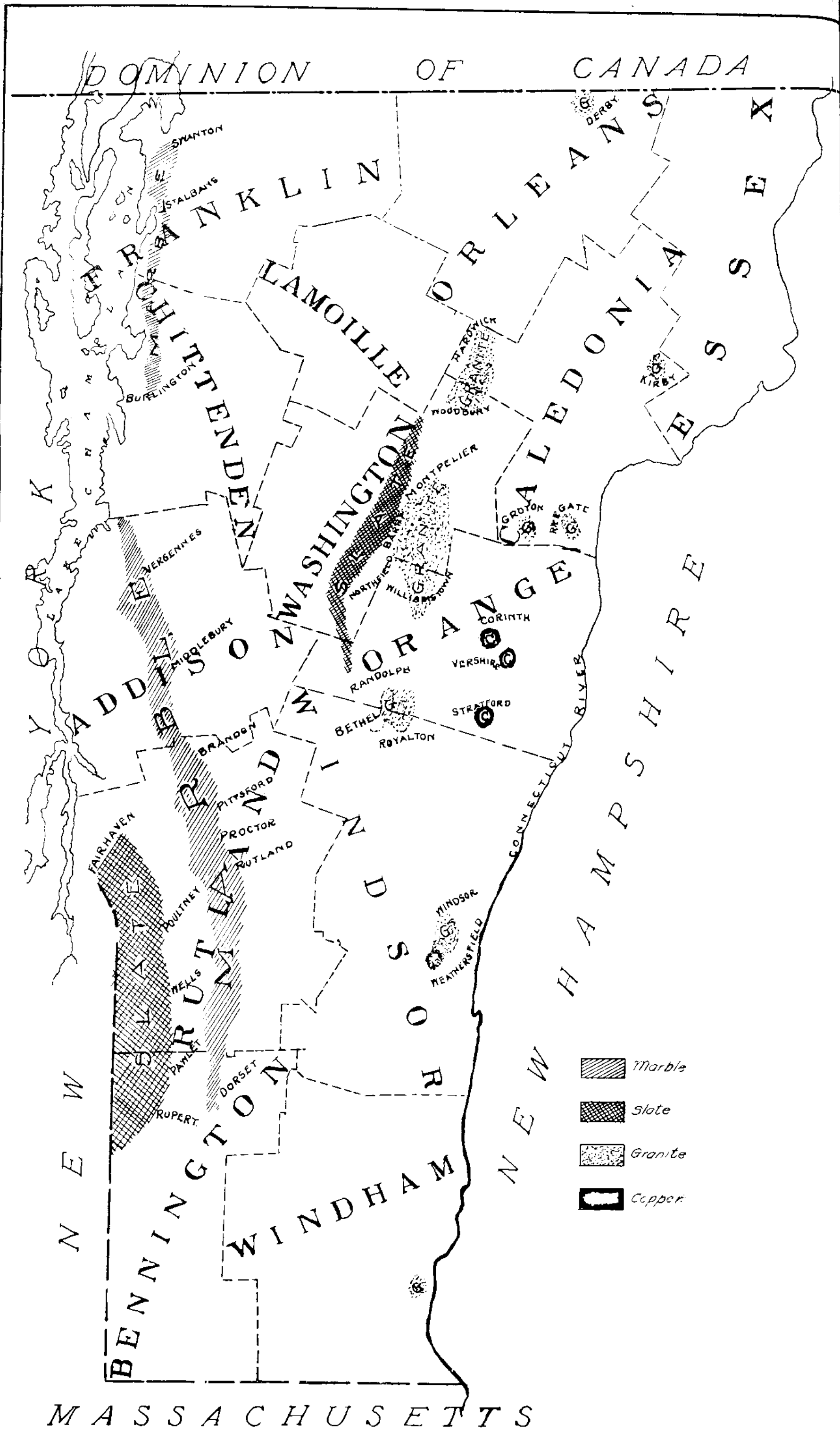
The very large sums of money invested in the mines, and especially quarries, of Vermont is sufficient indication of their importance. For twenty years the value of the product of the quarries has steadily increased.

The total value of the principal products of Vermont quarries in 1880 was $1,757,283; in 1890 it was $3,593,449 and in 1900 it was $4,516,102. Thus it will be seen that the value of the stone product doubled in the decade from 1880 to 1890, and that it was $1,000,000 greater in 1900 than in 1890. In the two years from 1900 to 1902 the increase in the value of these products exceeded $1,100,000, equal to the total gain in the ten years from 1890 to 1900.

During the present year probably not less than $7,000,000 worth of stone has been quarried and sold. The amount invested in this industry is at least $12,000,000; the number of men employed being fully 10,000. There is also a considerable quantity of other stone quarried in Vermont, including limestone used in making lime—soapstone, and limestone and sandstone for building purposes.

The stone industry has been very prosperous during the year now drawing to a close. Quite a number of new marble, granite and slate quarries have been opened and developed, and new shops and mills, or additions to the old ones, have been built in 1903. Extensive granite deposits have been developed in Barre, Hardwick and Bethel during the past twelve months. Several new and extensive quarries of marble have been opened in Rutland county. There has also been increased activity in the slate industry in the Rutland county slate belt and at Northfield. It is estimated that the production of marble, granite and slate during the present year has been increased from 20 to 25 per cent. (according to the various

PLATE II.



Map of Vermont showing Areas on which Granite,

estimates made) over the output in 1902. This fact makes 1903 the banner year in this industry.

Vermont marble, granite and slate are sold not only in America, but are sent to the most distant parts of the world, so that there is probably not a civilized country in which Vermont stone cannot be found.

BUILDING AND ORNAMENTAL STONE.

The accompanying map, Plate II, will be useful as it shows the distribution of each of the principal building stones found in the State and also copper.

GRANITE. As has been noticed in previous Reports, Granite has become one of the most important products of the State. Moreover the value and amount of Granite produced are increasing with gratifying rapidity. Although the total capital invested in the Marble business is greater yet there is a very much larger number of companies, and of course, persons, interested in granite. The distribution of granite in numerous portions of the State may partly explain this, but the two industries have developed in somewhat different ways. The great number of granite companies, those that are engaged in either quarrying or working and finishing the stone is seen in the fact that in and about Barre there are this year, 1904, not less than 160 firms engaged in this business. This includes, besides those located at Barre, those at Montpelier, Northfield, and Calais. At Hardwick and Woodbury, chiefly the former, there are twenty seven, at Ryegate and Groton there are twenty two, at Bethel, Dummerston and Newport there are also quarries and cutting sheds. In all there are not less than two hundred granite companies now in active operation in Vermont. Naturally, some of these are not very large concerns, but most are at least of respectable size and some of them are as large, if not larger than any to be found elsewhere. As in past years, blank forms were sent to each firm the address of which could be obtained with the request that the inquiries given be answered as fully as possible and the form returned to the Geologist.

Although this request was made as courteously and urgently as possible, only fifty out of the whole two hundred replied. Obviously, it is not possible to make as creditable a showing out of the statistics of fifty companies as it would be were the reports of the entire number available. Still, as most of the large firms have reported fully, the totals are more nearly representative of what is being done than their number might indicate. The fifty companies reporting have a total capital of $2,350,800. They employ 2,243 men and the stone finished and sold during 1903 amounted to $2,778,000. How much should be added to the above figures in order that they include the many delinquent companies I cannot estimate, but, as has been noticed, all the larger companies are included and probably not more than twenty-five per cent., or at most fifty per cent. of the above should be added to represent the nonreporting firms. If we take the latter as nearest the truth, we find that in the whole State there is invested in the granite business not less than $3,525,000 and 3,364 men are employed, while the total output reaches the sum of $4,167,000. These figures are much larger than these given by the U. S. Geological Survey in "Mineral Resources of the United States" for 1902, but they are based upon the figures received directly from the various firms and are more accurate. It is greatly to be regretted that more of the companies do not see the importance of attending to the circulars sent out by the Geologist since their sole design is to accumulate material which can be used for the advantage of the State.

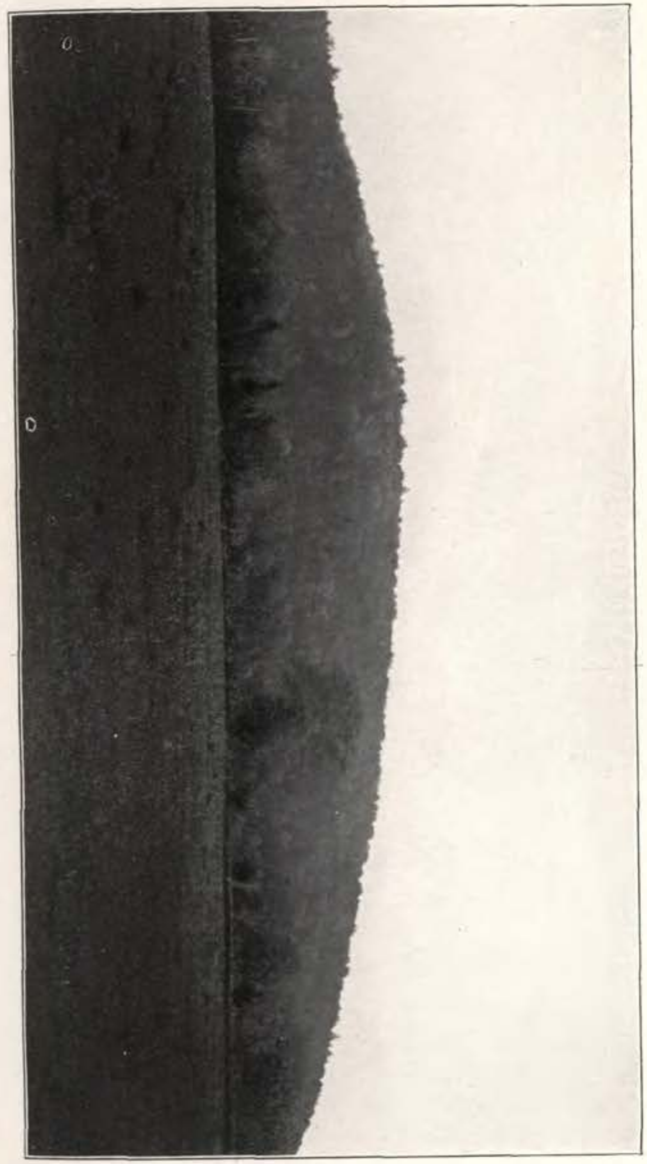
According to the figures of the U. S. Geological Survey, Vermont is first in the production of the finer kinds of granite, such as are used for monuments and carved work, while Massachusetts and Maine furnish a larger amount of building and paving material, so much larger that their total amount is in each case greater than that of Vermont. However, if the figures I have given are anywhere nearly correct, and I believe that they are, Vermont considerably exceeds these other states in the amount of granite sold. Until within two or three years Vermont has not supplied a large amount of building stone, but during these last two years, there has been a large increase in this part of the business. The Woodbury Granite Company alone sent four hundred car loads to Chicago for a single building and are now furnishing a much larger quantity for the new Pennsylvania Capitol, while the Union station at Washington is to be built of the white granite quarried at Bethel.

As would be expected from its wide distribution, the Vermont granite varies greatly in shade, texture, hardness and other qualities. It is all gray. varying from the white of Barre or Bethel to Barre dark which is probably the hardest and finest in texture of all.

There is no red granite in the state. So far as quantity is concerned, Vermont hills contain enough granite to supply the world for a very long time. Of course individual quarries may give out, but the general supply is practically inexhaustible. Many of the largest quarries are only just beginning to get at their best stock and some have not yet reached it. In strength, durability, brightness of color, elegance when polished or carved, it is certainly unexcelled. Most of the Vermont granite contains very little iron and therefore it remains clear and unstained when exposed to the weather. The difference in the shades of gray found in granite from different localities or different layers in the same quarry, is mainly due to the greater or less amount of black mica, though there is a difference in the color of the feldspar, this being bluish in the dark and white in the light granites. In most of our granites the mica is of the two species, biotite and muscovite. The granite is mostly, and probably wholly, of igneous origin and almost always is found in masses which form elevations of greater or less height. On this account most of the quarries are on hillsides or often the hill is a small mountain. The illustrations show the character of typical quarries. Most of the quarries are "open face" and none is deep. Most of the large quarries have branch railroads running into them or along side so that blocks can be swung from their place in the quarry around to waiting cars and are thus loaded. Thus the Barre R. R. extends from the tracks of the Cent. Vt. and Montpelier and Wells River R. R. at Barre to over sixty quarries on Millstone Hill and the adjacent region, going near over a hundred derricks. It is, with its branches, thirty miles long. It rises over a thousand feet from Barre to the quarries on Millstone Hill. At Hardwick there is a branch road which runs from the St. Johnsbury and Lake Champlain R. R. six miles to Woodbury and there enters the great quarry of the Woodbury Granite Company at three levels. In fact a railroad into or at least alongside of the quarry is a necessity if any large business is to be gained. Not that the old method of transporting stone by teams is yet superseded, for many tons of stone are annually moved in this way, but where possible the railroad takes the place of the team. The principal granite centers of the State are as follows:

BARRE.—There is, I presume, nowhere a locality in which in an area of equal extent so much first class granite is produced as at Barre, or near it, rather, for there are no quarries at Barre. They are four or five miles away and some of them farther. The sketch map, Figure I, shows this and Plate III shows Millstone Hill on which many of the quarries are located. For a comprehensive and scientific report on the Barre granite area the reader is referred to the chapter published in the last, third, report, byMr. G. I. Finley. There are probably not less than a hundred quarries in and about Millstone Hill. These are owned or worked by about thirty five different firms. From the quarries the stock which is sold in the rough, as a considerable amount usually is, can be shipped directly to any part of the country. That which is to be cut is taken to the various "Sheds" where it is wrought into whatever form may be desired. Some of the companies own both quarry and cutting plant, but by far the larger number of the latter carry on no quarry, but buy their rough stock as needed. There are now seventy quarries worked in the immediate vicinity of Millstone Hill in which at least fifteen hundren men are employed. Some of the large quarries cover a half dozen acres or more. In most the granite is so located and the beds of such shape that sheets or

PLATE III.



Millstone Hill, on which many of the Barre Granite Quarries are located.

shafts of any size which can be handled can readily be gotten out. The only limit appears to be that of the machinery necessary to move and transport the masses of stone. Some very large pieces have already been taken out and placed in distant localities after suitable working and there are derricks that can

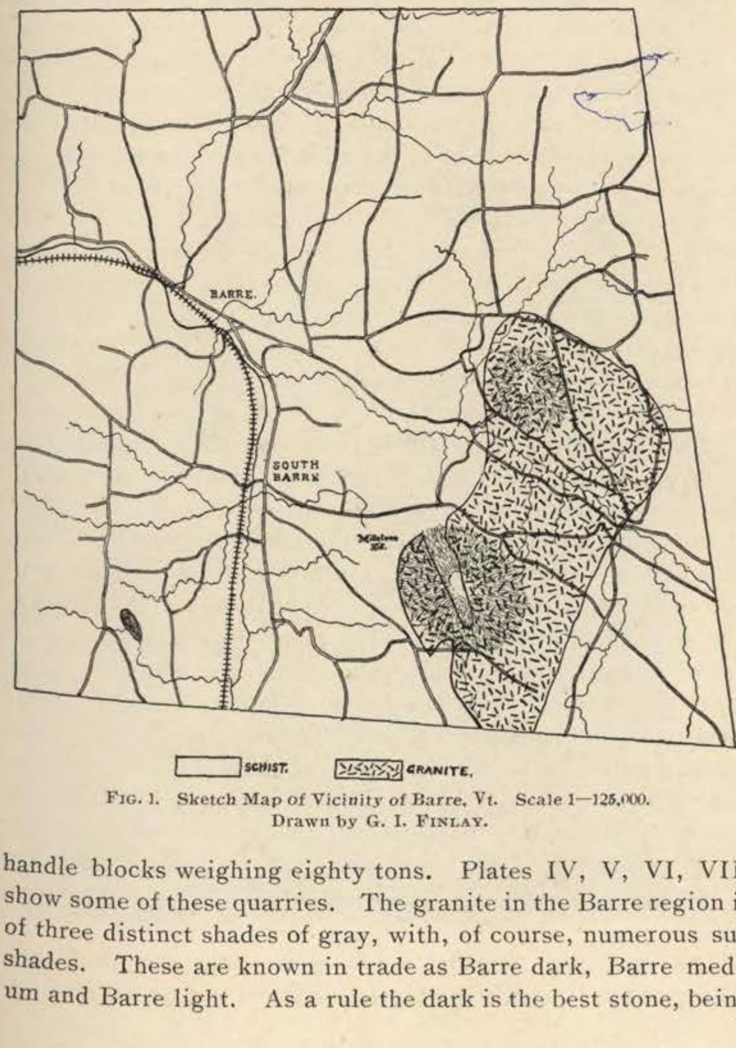


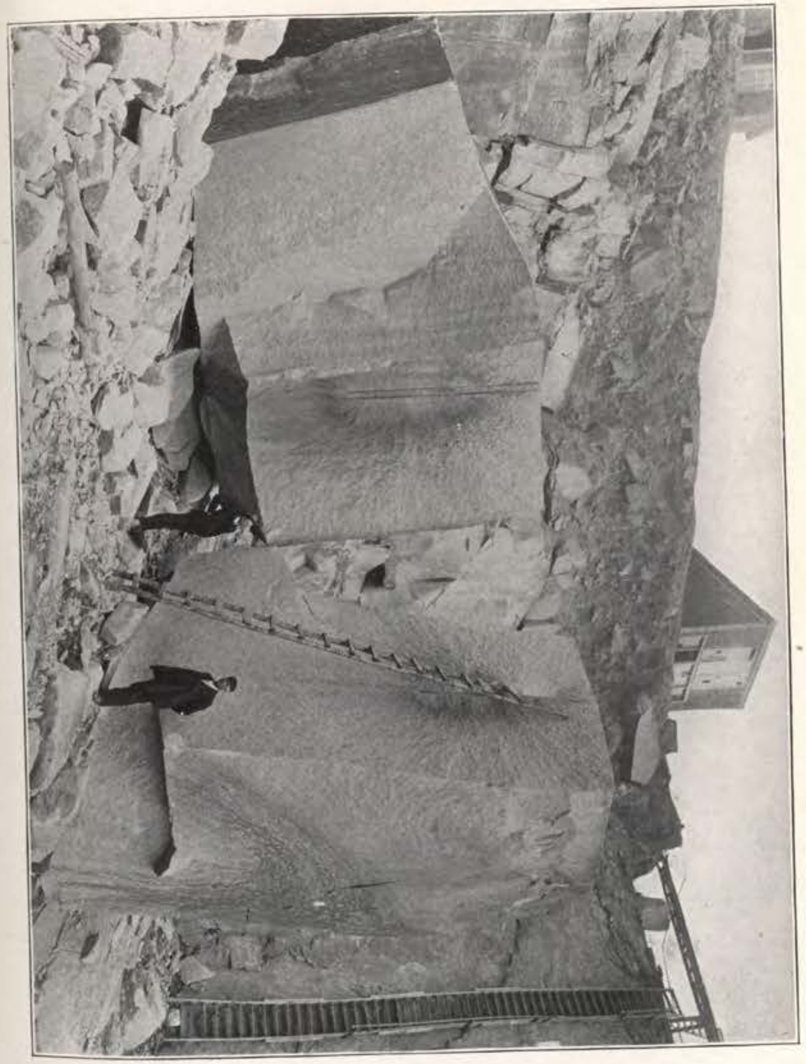
FIG. 1. Sketch Map of Vicinity of Barre, Vt. Scale 1—125,000.
Drawn by G. I. FINLAY.

handle blocks weighing eighty tons. Plates IV, V, VI, VII, show some of these quarries. The granite in the Barre region is of three distinct shades of gray, with, of course, numerous sub shades. These are known in trade as Barre dark, Barre medium and Barre light. As a rule the dark is the best stone, being harder and finer in grain and it sells for the highest price, usually about 25 per cent. more than the next grade. This is especially because of its value for monuments. It may not be any better for building purposes than some of the cheaper grades. The "medium" is an excellent and very handsome stone and so is the "light" which is listed about 20 per cent. less than the medium. These prices may very likely be changed as the demand for the lighter granite for building increases as seems likely. As those who have seen monuments which have been cut from Barre granite or, best of all perhaps, the beautiful Burns monument at Barre, will agree the stone is capable of receiving the finest work of carver and polisher. Originally the stone was used only for foundations and for mill stones. Millstone Hill takes its name from the fact that in early days stones, which were considered excellent for the purpose, were quarried for use in the grist mills of the State. From a booklet printed to accompany the exhibit of Barre granite at St. Louis I quote a few paragraphs which are instructive.

"In 1881, according to the statistics of the Vermont Register, the population of the entire town was 2060, now that of the city alone is fully 10,000. At that time only 50 granite cutters were employed by half a dozen companies, now there are thirty five times that number of artisans and more than 100 firms in the business. The granite works have an aggregate floor space of 550,000 square feet. Seventy five derricks reach over an area of fifteen acres. The number of lathes, column cutters, and polishing machines in operation is 250. If all the plants in the city engaged in finishing granite could be combined into one manufacturing center they would occupy a tract of land one hundred acres in extent. The total number of men directly or indirectly connected with the business in Barre and vicinity is about five thousand and the average monthly pay roll is $350,000. Several companies have been organized for the manufacture of the tools and machinery required in granite work."

Lists are not usually very interesting nor profitable reading and it is with some hesitation that I introduce lists of

PLATE IV.



Boulder Quarry, Granite, Barre.

Plate V.

Boutwell Granite Quarries, Barre.

the firms engaged in the stone business in Vermont. My reason for occupying space with mere lists is found in the fact that for several years and especially during the last two, this office has been frequently asked for just such as are here given. These requests are not only numerous, but they have come from all parts of the land and this is an indication of the increasing interest which the people of the whole country are taking in Vermont granite, marble and slate. Any corrections or additions to the lists given in this Report will be gladly received by the Geologist. Great pains have been taken to secure fullness and accuracy, but there are numerous chances of error. For much valuable assistance in compiling the list given below I am indebted to Mr. William Barclay Jr. Secretary of the Barre Granite Manufacturers Association. The list is intended to include all who are engaged in any sort of granite business. Those marked Q. own or manage Quarries, the rest manufacture the rough stock.

List of firms quarrying or manufacturing granite in and about Barre:

Anderson & Sons, Barre. Q.
American Granite Co.,Montpelier.
Adie & Milne, Barre.
Allen & Newcombe, Barre.
Abbiati, E. Barre.
Barclay Brothers, Barre. Q.
Barclay, Andrew S. Co., Barre.
Barney, Auguste Websterville. Q.
Barre Granite Co., Barre. Q.
Barre White Granite Co., Barre. Q.
Barre Quarry Co., Barre. Q.
Bartoli, H. J. Montpelier.
Beck & Beck, Barre.
Bedard, Joseph Websterville,
Bessey Granite Co., Barre.
Bianchi, Joseph East Barre.
Bianchi Granite Co., Montpelier.
Bianchi, Chas., & Son, East Barre.
Bilodeau, S. O. & Co., Barre.
Bird, Alex. & Sons Barre.
Bond, G. E. Barre.
Bond & Whitcomb, Barre. Q.
Boutwell, Jas. M. Montpelier. Q.
Brown, John & Co., Barre.
Bugbee & Alexander, Barre.
Burke Brothers, Barre.
Canton Brothers, Barre. Q.
Capitol Granite Co., Montpelier. Q.
Carrle, E. W. Barre.
Carroll & McNulty, Barre.
Carusi, E. A. Barre.
Clarihew & Gray, Barre.
Coburn & Trail, Barre.
Cole, W. & Sons Barre.
Comolli & Co., Barre.
Corskie, J. P. & Son Barre.
Craven, E. E. & Co., Montpelier.
D. B. L. Granite Co., East Barre.
Davis Brothers, West Berlin.
Densmore, C. D. East Barre.
Dewey Col. Cutting W'ks, Barre.
Dillon & Haley, Montpelier.
Dineen and Co., Barre.
Doucette Brothers, Montpelier.

Eclat Granite Co., Barre.
Eagan, T. W. Montpelier.
Emslie & McLeod Co., Barre.
Frazer, R. M. Montpelier.
Frazier & Parkman, Montpelier.
Giudici Brothers & Co., Barre.
Gill, C. P. & Co., Montpelier.
Globe Granite Co., Montpelier.
Glysson, Eugene Barre.
Grearson-Beckett Co., Williamstown.
Gillander & Keough, Montpelier.
Hall, John S. Montpelier.
Harrison Granite Co., Barre.
Hill, Felix A. Montpelier.
Hopkins, Huntington & Co., Barre.
Hoyt & Lebourveau, Barre.
Imlah & Co., Barre.
Jones Brothers, Barre, Q.
Jones, A. S. Barre.
Jurras, J. & Co., Montpelier.
Kane, P. T. Granite Co., Montpelier
Kidder, W. D. Barre.
Langfield Granite Co., Barre.
LeBarron, W. J. J. Barre.
Leland & Hall Co., Barre.
Littlejohn & Milne, Barre, Q.
Lynch Brothers, Montpelier, Q.
Libersont, Innes & Cruickshank, Q.
McCann & Maroni, Montpelier.
McDonald & Buchan, Barre.
McDonald, Cutler & Co., Barre. Q.
McDonnell & Sons, Barre.
McGee, William, Barre.
McIver & Matheson, Barre, Q.
McMillan, C. W. & Son, Barre.
McMinn, J. & Sons, Barre.
Macchi, Z. Barre.
Manufacturers Quarrying Co., Barre, Q.
Marciasi & Mortimer, Barre.
Marr & Gordon, Barre.
Marr, Alex & Sons, East Barre, Q.
Marrion, J. T. Barre.
Martell Brothers, Barre.
Martinson, John & Co., Barre.
Melcher & Hadley, Barre.
Mills & Co., Montpelier.
Milne, Clarihew & Gray, Barre.
Milne & Odgers, Barre.
More, C. H. & Co., Barre.
Moore Brothers & Brault, Barre.
Mortimer & Campbell, Barre.
Murry, J. F. Barre.
Mutch & Calder, Barre.
Noonan Brothers, Barre.
North Barre Granite Co., Barre.
Novelli Calcagni, Barre.
Oliver & Co., Barre.
Operative Granite Co., Barre.
Osborne & Son, Graniteville, Q.
Patch & Co., Montpelier, Q.
Pecue Brothers, Montpelier.
Peduzzi, Bonazzi & Co., Montpelier.
Pellegata, Magnaghi & Galli, Barre.
Pioneer Granite Co., Montpelier.
Pirie, J. K. Graniteville, Q.
Prospect Granite Co., Barre, Q.
Provost & Bussierre, Gouldsville.
Pruneau & Giguere, Websterville, Q
Rae, Jas. & Son, Barre.
Reinhalter, J. B. & Co., Barre.
Rizzi Brothers, Barre.
Rizzi, L. G. Barre.
Robins Brothers, Barre.
Ross, Clifford & Co., East Barre.
Ryle & McCormick Co., Montpelier.
Scott Brothers, Barre.
Sector, James & Co., Barre.
Sibley, Clark, East Montpelier, Q.
Smith, E. L. & Co., Barre, Q.
Smith Brothers, Barre.
Standard Granite Co., Barre, Q.
Stephen & Gerrard, Barre.
Straiton, Geo. Barre.
Sunnyside Granite Co., Barre, Q.
Sullivan, Eugene Barre.
Sullivan, Tucker & Co., East Barre.
Summers & Co., Barre.
Swasey & Co., Barre.

PLATE VI.

Granite Quarry, Barre, McDonald, Cutter & Co.

PLATE VII.

Dark Granite Quarry, Barre.

Sweeny Brothers, Montpelier.
Tayntor, C. F. & Co., Barre.
Theriault, Paul & Son Montpelier. Q.
Thom, Clark & Co., Barre.
Vermont Granite Co., Barre. Q.
Walker, Geo. & Sons, Barre.
Wells, Lamson & Co., Barre. Q.
Wetmore & Morse Granite Co., Montpelier.
Williams D. R. & Co., Barre.
Wilson Brothers Granite Co., Barre.
Young Brothers Barre.

List of firms manufacturing granite in Northfield:

Brusa, P. & Co., Northfield.
Cannon & Slack Co., Northfield.
Cross Brothers, Northfield.
Devine & Burns, Northfield.
Ellis, E. B. Northfield. Q.

GROTON.—About twelve miles north east of Millstone Hill, at Groton there are several masses of granite. Pine mountain is a low elevation mostly of this material and west of this is a large quarry known as the Weber Quarry where active operations have been carried on for some years. There are also several cutting sheds near the Wells River R. R. The Weber Quarry is the only one in this neighborhood which has been extensively worked and it is well equipped with channelling machines and other appliances for getting out the stone. The quarries on Pine Mountain have been worked somewhat and some very good stone taken out. There are two quarries in which the granite is of a more bluish shade than common and of good quality in the best blocks. At its best, so far as I can judge, this stone is equal to any other, but in some of the layers there are frequently what the quarrymen call "knots" that is, dark spots caused by an accumulation of dark mica, which spoil the stone for nice work.

Through the kindness of Mr. H. W. Goodine of The Blue Mountain Quarries I am able to give the following revised lists of the granite workers of Groton and South Ryegate.

The following were in business at the beginning of the present year in Groton.

M. T. Benzie & Co., Cutting Plant,
C. L. Booth, Cutting Plant,
W. R. Carbee, Cutting Plant,
G. E. Coruth, Cutting Plant,
B. J. Darling, Quarry,
Donald Fraser, Cutting Plant,
Hosmer Brothers Cutting Plant,
McRae, Benzie & Co., Cutting Plant andQuarry,
Pine Mountain Granite Co., Cutting Plant and Quarries,
W. J. Stevens, Cutting Plant.

SOUTH RYEGATE.—A few miles farther north east is South Ryegate where there is a granite elevation known as Blue Mountain. At this place there are six quarries, all of them worked to some extent. They are all sheet quarries and are on the south side of Blue Mountain. The stone is light colored and rather coarse grained. On this account it is not much used for monuments, but makes good material for bases, foundations and building. A great drawback here, as at Pine Mountain, is the distance from railroad. The latter quarries are nearly two miles and the Blue Mountain three from the nearest station. The South Ryegate quarries are shallow, but of considerable extent.

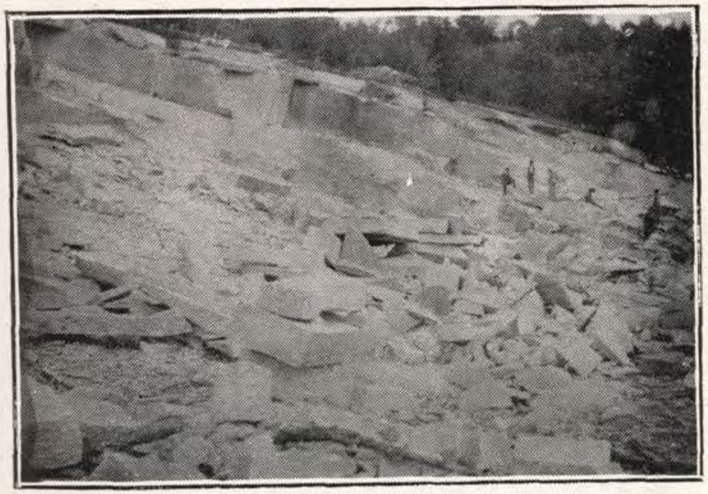
Plate VIII shows Blue Mountain Quarry.

There are at present the following firms engaged in the granite business at South Ryegate:

A. Anderson, Cutting works,
Blue Mountain Granite Works, Quarry and Works,
James Craigie, Cutting Works,
T. D. Gray, Cutting Works,
M. F. McDonald, Cutting Works,
Edward Metcalf, Cutting Works,
D. A. Morrison & Co., Quarry,
Joseph D. Rabaioli, Cutting works,
George Roben, Cutting works,
Rosa Brothers, Cutting works,
Ryegate Granite works Co.,Quarry, and works.

WOODBURY and HARDWICK.—The stone known as Hardwick granite is nearly all of it quarried at Woodbury, there being only a few and comparatively small quarries in Hardwick. The stone quarried in Woodbury is, however, mostly cut in Hardwick the adjoining town on the west and that from which all must be shipped as it alone is on the main line of railroad. The quarries are about six miles from the Hardwick sheds, but there is a railroad from the line of the St. Johnsbury and Lake Champlain road at Hardwick to the large quarries of the Woodbury Granite Company. The road is largely owned by this Company and with its branches is twelve miles long. Prior to 1896 the granite business of this locality did not amount to very much, but it has developed with great rapidity during the last three years and now the plant of the Woodbury Granite Company is not exceeded in size or equipment by any in the world if it is

PLATE VIII.



Blue Mountain Granite Quarry, South Ryegate.

equalled by any. The quarry from which this Company obtains most of its stock (Plate IX) is also one of the largest. It is on the eastern side of a considerable elevation and the quarry has cut off the face of this part of the hill so that a solid face of granite, of wonderfully uniform color and texture, three hundred feet high is exposed. The beds extend for many rods north and south and all in all, this is one of the finest quarries to be found. The stone is "medium" in shade. It is especially adapted for use as a building stone as it is not as hard as the Barre and hence can be more cheaply worked. Like nearly all Vermont granite, it contains little or no iron and is unaffected by weather and therefore retains its bright, clear appearance through long and severe exposure. From this Quarry was taken the stone from which the Rock Island R. R. Station at Chicago was built recently and there is now great activity in getting out the granite for the new Pennsylvania State House at Harrisburg. This Company cut all their own work and also work a quarry in the light granite at Bethel. While this quarry is larger than any other in this region it is not the only one. Immediately above it on the top of the hill is a fine quarry owned and worked by E. R. Fletcher (Plate X). As would be expected this furnishes substantially the same sort of stone as the Woodbury Company's Quarry as both are in the same granite mass. Mr. Fletcher also has sheds at Woodbury.

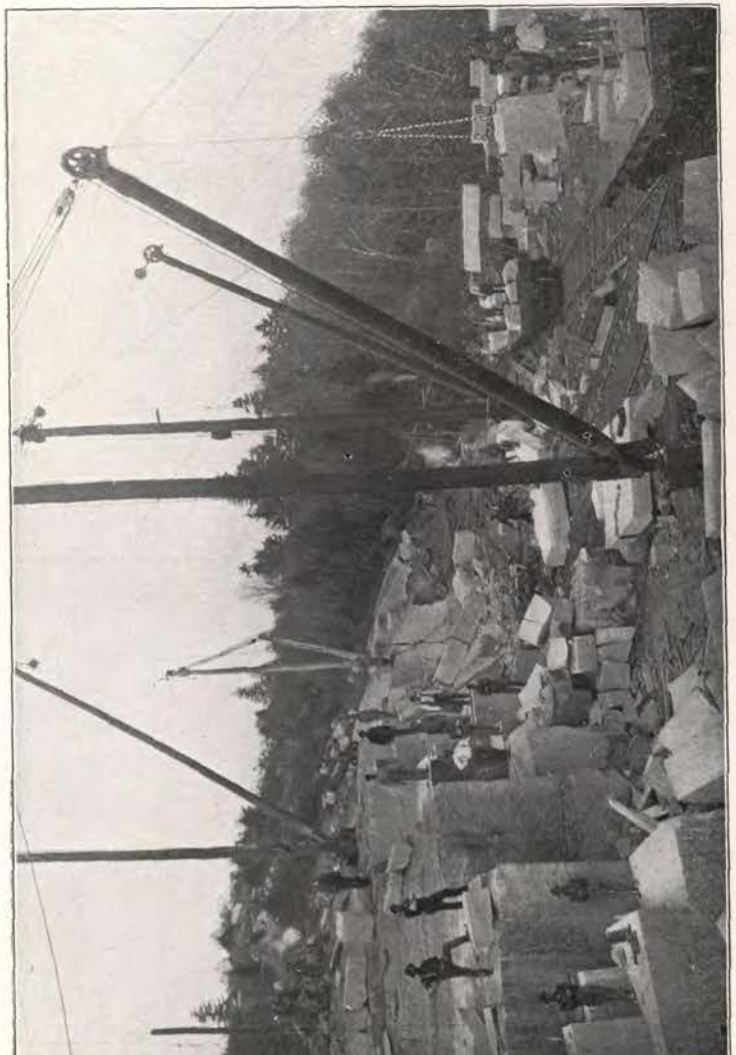
The pedestal of the Sherman monument in Washington was taken from this quarry. This has received very high commendation for the quality of the stone and its beauty. These are the only quarries at present worked in this locality so far as I have reports.

Through the kindness of Mr. G. H. Bickford, manager of the Woodbury Granite Co., I am able to give the following list of Granite Companies doing business in Hardwick and Woodbury.

HARDWICK, VT.

Hardwick Polishing Co.,
F. A. Emerson,
R. Brodie,
Union Granite Co.,
Ross & Imlah,
T. T. Daniels,
E. R. Fletcher,
E. R. Murch,
Wm. B. Donald,
Stewart Granite Works.
Vavola & Co.,

Plate X.



Fletcher Granite Quarry, Woodbury.

ored so that in trade it is called white and in this it much resembles the "Barre White" but it is much harder and probably a better building stone. When polished it shows the numerous little dark blotches or spots caused by dark mica seen in any granite, though these are always very light, but when cut or carved it is very white though not pure white. It can be carved to almost any extent and when so treated is an exceedingly handsome stone.

As to that, it is handsome however treated and seems sure to be in great demand as a building stone since it has the hardness and durability of granite combined with the lightness of marble. The deposit has not yet been worked sufficiently to show how extensive it is, but no one can visit the locality and have any doubt that the supply is enormous. For the most part in both the quarries now opened the stone is in rather thin layers, that is, from 12 to 18 inches thick, though there are much thicker layers. The Ellis quarry is now uncovered over, I should judge, five or six acres. The surface soil is nowhere very thick and is easily removed. This quarry faces the south east while above on the other slope of a depression is the Woodbury Company's quarry, and still farther up there is on top of the hill a new quarry being opened by the Ellis Co. There certainly are many reasons for believing that Bethel is soon to become a large producer of granite.

Dummerston.—In the south eastern part of the State about four miles from Brattleboro in the town of Dummerston there is a large granite quarry worked by the George E. Lyon Company. Both light and dark stone is found in this quarry which is well equipped with all modern appliances. As the quarry is near the track of a branch line of the Central Vermont R. R., the stone is conveyed to the cars by an overhead trolley which can carry a load of twenty tons. The company owns two hundred and fifty acres of quarry land. There are a hundred men employed at this quarry.

Newport.—During the present year a company has been formed to operate a quarry in Derby with offices at Newport and Albany, N. Y. The work is being energetically started and good results may be expected. The firm name is Newport Granite Company.

WINDSOR.—What is known in trade as "Windsor Green Granite" is a syenite which is quarried on the eastern side of Ascutney Mountain. A considerable amount of stone has been taken out here at one time and another. The finest blocks are now in the Library of Columbia University where there are sixteen columns, each 3½ feet in diameter and 28 feet long. In the bank of Montreal, there have recently been placed thirty eight similar columns and in the new building of the Boston Journal much of this stone has been used, highly polished. In Bulletin No. 209 of the United States Geological Survey, which is on The Geology of Ascutney Mountain, I find the following statements which I quote somewhat at length as they are not only the latest, but the most valuable discussion of the rocks of the region ever published. The Bulletin is by Mr. R. A. Daly and is well worth careful study by any one who wishes a technical description of the Ascutney region. "The only quarry that has been worked in the Ascutney area is situated within a few hundred feet of the contact with the schists in the first of the phases of the main syenite. Various attempts have been made to use this stone for monuments and for ornamental purposes generally. The rock, as represented in the quarry, is a handsome dark green syenite, in this place characterized by medium to coarse grain and a typical eugranitic structure, elsewhere this phase grades into one possessing a trachytic structure. It is a syenite with variable amounts of free quartz and a low percentage of colored constituents. Primary veins or flow streaks are common; they are usually finer grained than the average rock and are even more poorly provided with bisilicates. In addition to the feldspars and accessory quartz, the list of minerals includes in order of their abundance, a hornblende, biotite, a pyroxene, allanite, titaniferous magnetite, apatite, pyrite, zircon, monazite, and a lime iron garnet.

The order of their crystallization seems to have been as fol-

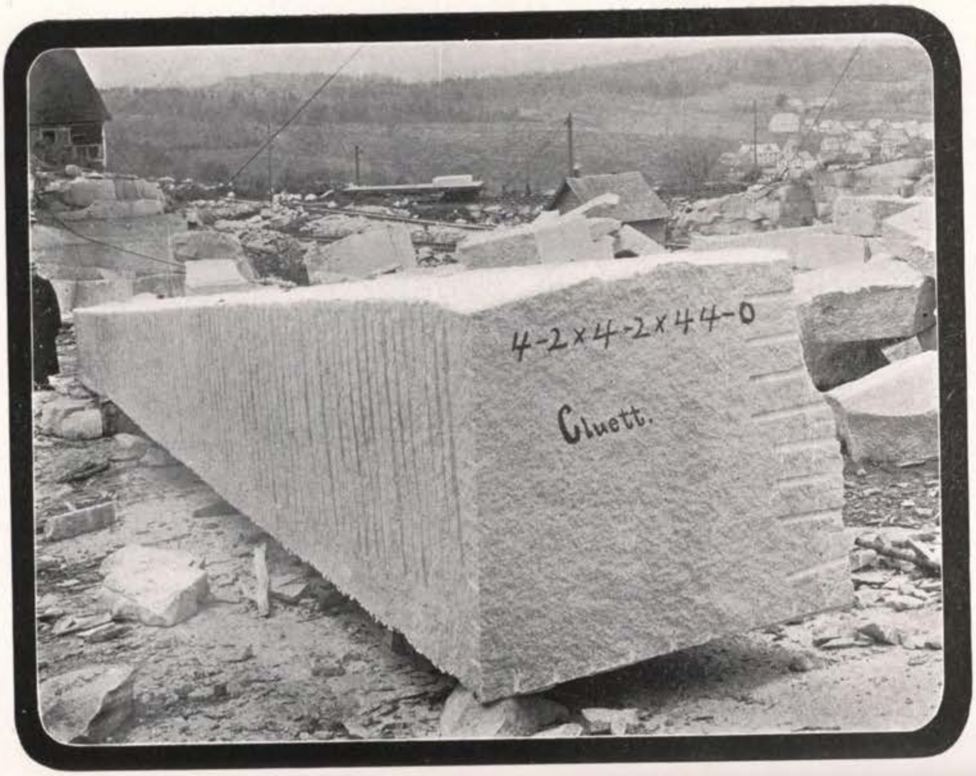
lows, apatite, zircon [magnetite, pyrite, garnet] [monazite and allanite] [augite, hornblende and biotite] oligoclase, alkaline feldspars, quartz.

THE FELDSPARS.—The constituents which determine the structure, texture and color of the syenite are the feldspars. Of these microperthite is by far the most abundant and with it are associated orthoclase, soda orthoclase, microcline, and a plagioclase. There is no observable difference in the microscopic habit of these feldspars, and it was only by a careful study of sections and rock powder that all the species could be determined. All of them are undoubtedly the product of primary crystalization. The microperthite is especially interesting on account of its typical development.

The pure potash feldspar is comparatively rare. It occurs as orthoclase and as microline, both contemporaneous with the microperthite in their period of crystallization. The plagioclase is no more than accessory. One of the most remarkable properties of this rock consists of the unstable character of its color. When broken out of the quarry a fresh specimen is uniformly, on the surface of the fracture, a light bluish gray. In the course of twenty four hours, under atmospheric conditions, this tint changes to one with a greenish tinge, and after exposure to the air for about thirty days it has become a deep brownish green. This green color is in its turn lost when the rock has suffered more pronounced weathering after many years exposure. The final change gives the familiar yellows and brown of a decomposed ferruginous rock. Examination quickly showed that the color change of the rock was conditioned by the feldspar and that it is altogether a superficial phenomenon, taking place only where the air has access to the mineral. The probable explanation of the color change is found in the oxidation of the ferrous oxide of the feldspars to the ferric, thus giving a yellow which in combination with the fundamental blue gray of the under layers of the crystal substance, affords the green of the altered surface.

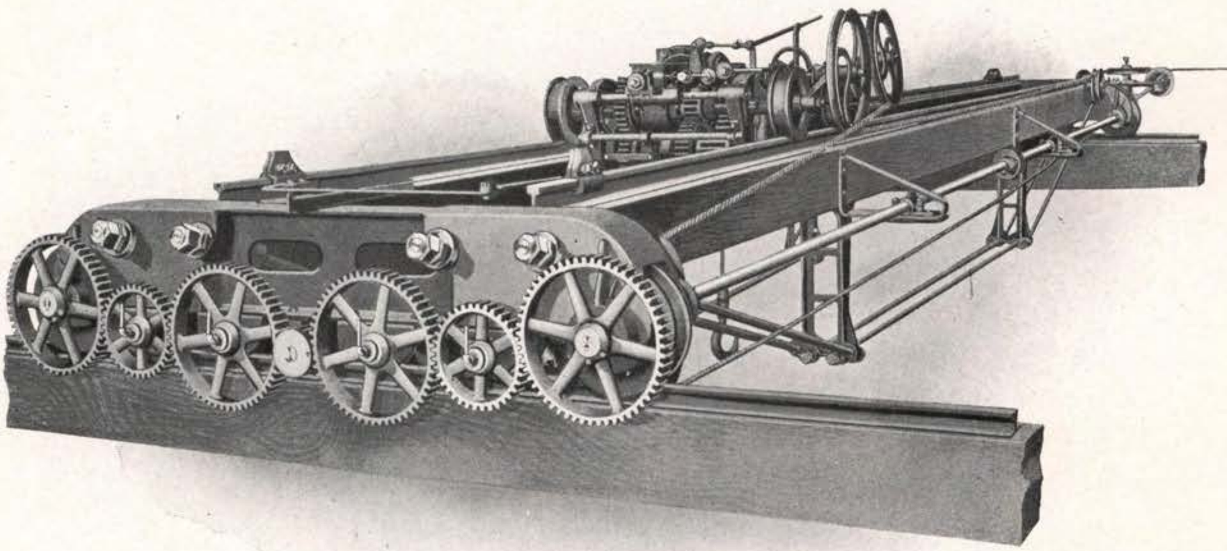
HORNBLENDE.—The next most important constituent of the

PLATE XII.



Block of Granite as Quarried for a Shaft.

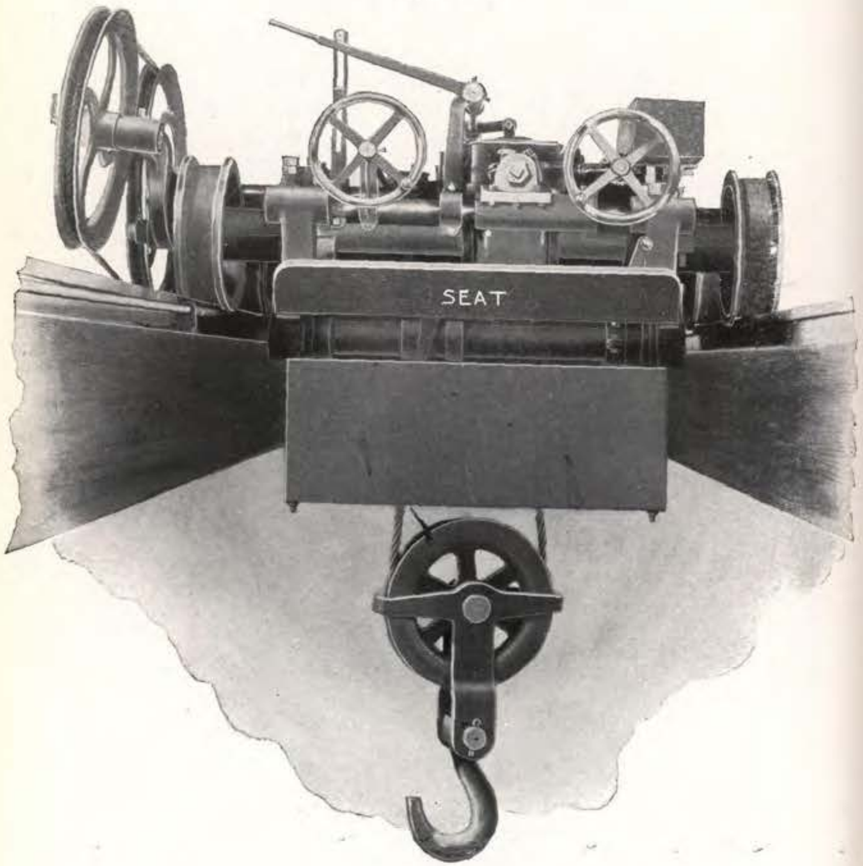
PLATE XIII.



General View of Gear End of Overhead Crane.

Lane Manufacturing Company.

PLATE XIV.



Overhead Crane—end view.

Lane Manufacturing Company.

Green Granite Co., but lately it has been managed by Norcross Brothers.

It should be added to what Mr. Daly has written as to the change of color to which the stone is liable that this should be understood as referring to pieces exposed to outside conditions. As a material for inside work it is not to be set aside since indoors it does not change, at least appreciably, and for some purposes it is very desirable as it is unlike other stone in color and takes a very fine polish.

Formerly granite has been quarried at Kirby where there is said to be a large mass of the stone, but at present no work is being done.

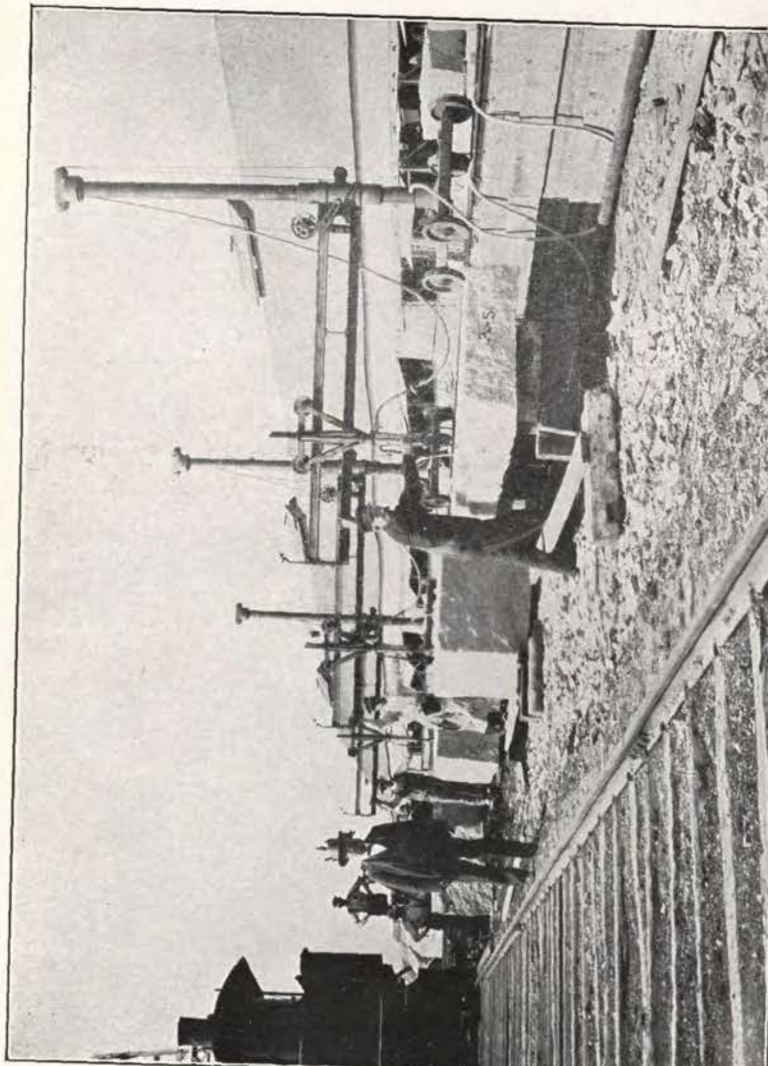
METHODS OF WORKING GRANITE.

Granite quarries and cutting plants usually called "sheds" are managed in a wholly different manner from that which prevailed a few years ago, and those who have not lately visited these plants have little idea of modern methods of treating the stone. The invention and introduction of pneumatic tools has revolutionized quarrying and all the various processes through which a finished piece of stone must pass. It is qiute a revelation to a novice to hear of sawing, turning, planing, or carving so hard a material as if it were wood. All this has very materially reduced the cost of production and made possible structures that formerly were unattainable.

In any important piece of work plans are drawn before the stone is disturbed in its original bed in the quarry. When it has been fully ascertained what sort and what size is wanted the block is quarried accordingly and at once numbered and by this number it is known until it reaches its final destination. Not only are drawings made, but if there is to be any carving or moulding, patterns of the exact shape and size needed are made and when the block reaches the cutting shed all is ready for each workman to go forward with his special part. In detaching the block, or slab, as the case may be, from the quarry the old hand drill may be used, but in a large up to date quarry the drilling will be done by compressed air or, less commonly, by steam. Plate XI shows pneumatic drills at work. Plate XII shows a block which is to be cut into a shaft as it is split from the quarry mass. Channelling machines are far less common in granite quarries than in marble, but they are sometimes used. The pneumatic drill is much lighter than that moved by steam and therefore preferable in most cases. Such a drill can sink a hole five eighths of an inch in diameter and a foot deep in about two minutes. Where possible the block is disengaged without blasting, by drilling a large number of small holes and driving in wedges. This is shown on Plate XI. When the block reaches the cutting shed it is taken from the car either by a derrick or by an overhead crane. The older granite sheds were built in a circular or polynodal form in order that a derrick in the center might be able to swing stone to one or another part as needed, but the overhead crane has changed this so that the new sheds are all built long and rectangular and a track runs on the ground for the railroad cars and another track overhead carries the crane. Plates XIII and XIV. It should be noticed, for the benefit of those who do not live in granite regions, that the term shed does not necessarily mean a mere open or partly open structure, but it is in the parlance of granite men any building in which the stone is worked. Most of these so called "sheds" are very substantial structures and some of the new very comfortable the year through. Plate XV shows the interior of a granite shed. This view gives a very good idea of a typical shed. The traveling crane is seen overhead just beyond the middle of the picture.

The quarried block having been transported from the quarry to the cutting establishment is there subjected to one or another process as it is to be used as a block or in thin slabs or in columns or whatever is desired. If it is to be used as a large piece it may be put under a McDonald stone dresser by which a very rough surface is rapidly made smooth. This is a very powerful machine, the cutting being done by two revolving series of bevelled discs of hard steel. By these the stone is cut down over a large surface ¾ of an inch at every stroke. More commonly a piece of stone is put under a "surfacer" which is less

PLATE XVI.



Pneumatic Surfacers at Work on Granite.

Courtesy of H. G. Kotten.

costly and, for all except large work, sufficient. A common form of this machine, for the illustration of which I am indebted to Mr. H. G. Kotten maker,is shown in Plate XVI. The power is compressed air and, as may be seen in the illustration,

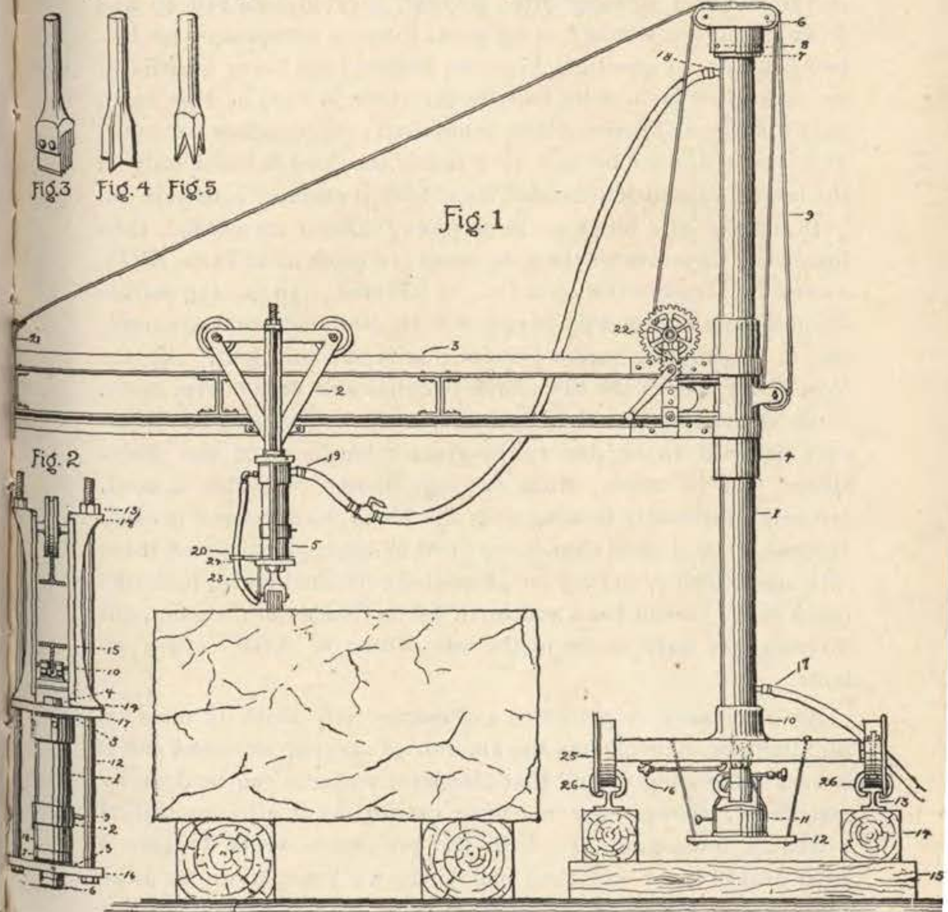


FIG. II.
Kotten Surfacing Machine. 3. 4, 5, Different forms of Chisels.

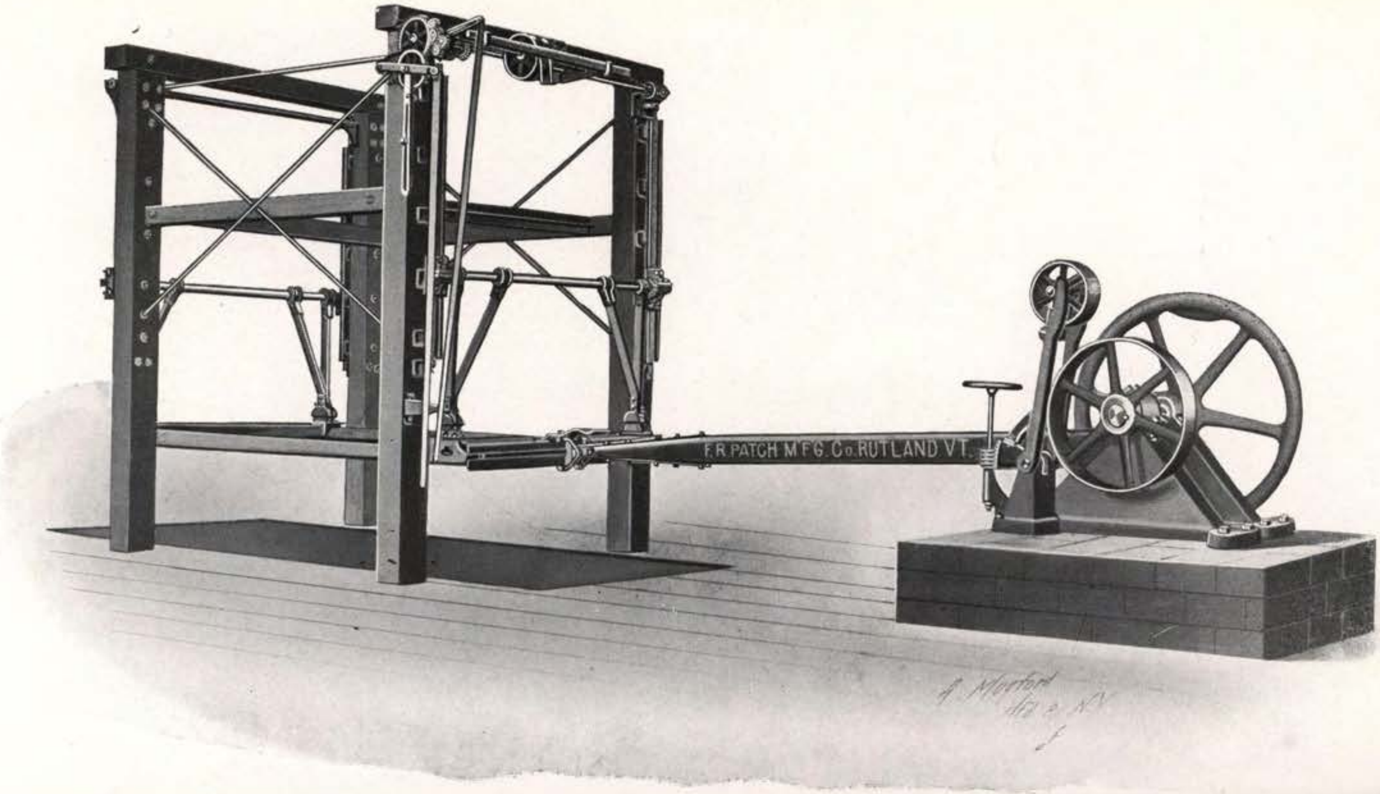
the machine is so made that it can be moved from block to block as needed. The text figure (Fig. II.) shows more in detail the structure of a surfacing machine.

It is claimed that one of these surfacing machines will do as much work in a day as could be accomplished by ten to fifteen men. The method by which the machine works may be understood by noticing the cylinder which the workman is directing. In this a chisel, or more often several, is rapidly moved up and down, the down stroke having great force, a pressure of 90 lbs. being used. A good machine can cut off from three fourths of an inch to an inch and a half, as the stone is hard or less hard, over a surface of from sixty to a hundred square inches per hour. The stone dresser being a very costly machine is used only in the largest establishments, but some sort of surfacer is used in all.

If instead of a block or thick piece, thinner are wanted, then instead of the surfacer the gang saws are used, as in Plate XVII, loaned by Messers. Patch & Co., of Rutland. In sawing marble smooth saws abundantly supplied with sand and water are used, but in sawing the harder granite this is not sufficient. At the Woodbury works the saws have peculiar and very coarse teeth, while at the Barre works I saw only smooth saws and the difference is said to be due to the greater hardness of the Barre stone. As in other stone sawing, plenty of water is used, streams continually flowing over the block, but no sand is used. Instead, chilled steel shot is supplied in large quantity and these little shot, which, as they are shovelled over the blocks, look like black sand, moved back and forth by the blades of the gang, cut through the hard stone at the rate of two or three inches an hour.

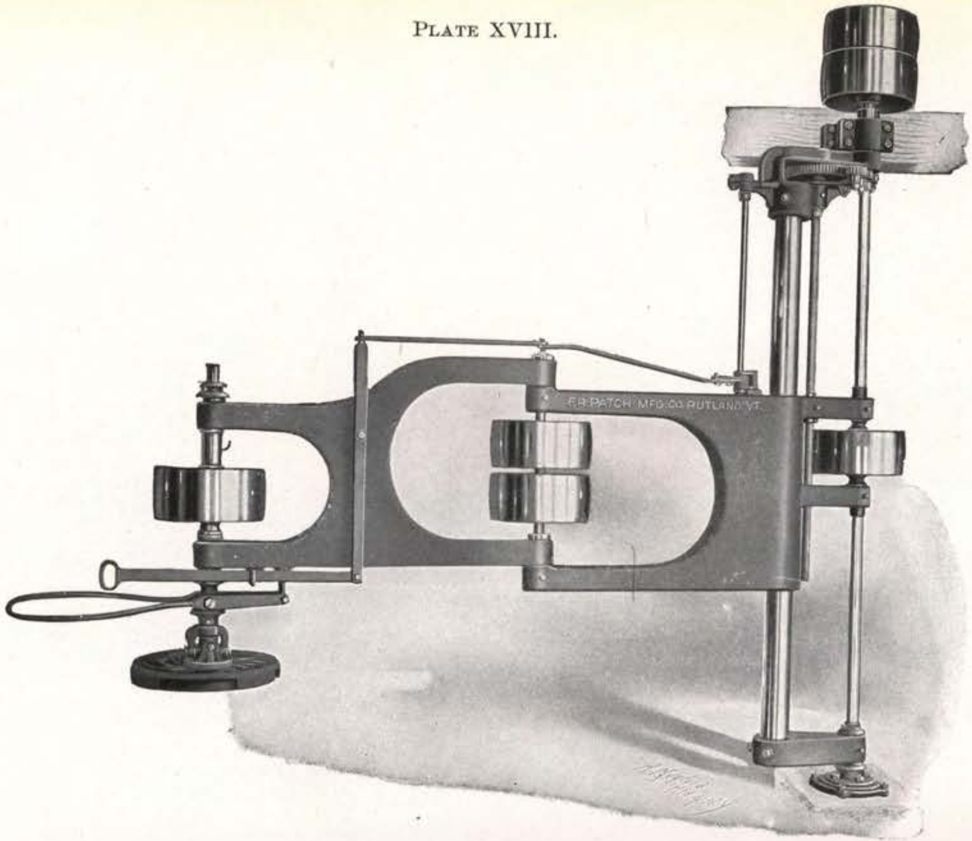
As machinery is perfected and more costly work is done on buildings or mausoleums the amount of carving increases and it is very interesting to find that elaborate patterns can be done by machinery, though the machine cannot do it all, the skilled workman must guide it. Still the pneumatic tools do save a great deal of labor and thus enable the workman to do far more and usually do it better, than if done wholly by hand. For any elaborate pattern the carver is furnished with a full sized model in staff. It will be seen that in all the pneumatic tools the workman does not strike any blows as formerly, but gives his whole attention to directing the cutting tool.

PLATE XVII.



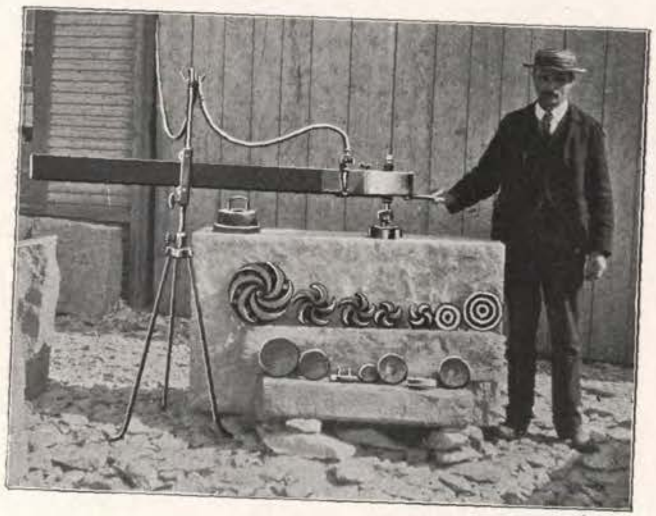
Patch Steel Frame Saw Gang. This is one of the best types of Modern Stone Sawing Machines.

PLATE XVIII.



Patch Stone Polishing Machine.

PLATE XIX.



Cavacchi Pneumatic Polishing Machine.

If a surface on block or slab is to be polished this is done, no longer, tediously, by hand, but some sort of polishing machine is used. Plate XVIII shows one form quite commonly used. The polishing is done by the disc at the left end of the figure and the whole is guided by the loop just above it. A pneumatic polisher has been invented by Mr. Cavacchi, of Barre, which is shown in Plate XIX which he has loaned. As may be seen, this machine uses no belting and is run by compressed air. Columns are worked out by hand in a rough form and then put into a lathe and turned. The lathes used are not unlike those used for turning wood, but the cutting tool is very different. Instead of a chisel a revolving steel disk with bevelled edge is used and the stone is partly cut and partly pressed off as the turnings are not fine powder, but quite large flakes, some of them as large as a silver fifty cent piece. The surface left however is smooth. Very large columns can thus be turned. I saw at the Woodbury Company's works a lathe which was turning one of twenty-two columns each a single piece, and each when finished to be twenty-nine feet long and three feet six inches in diameter and weighing twenty eight tons. The lathe on which these were being turned was one of the largest ever constructed and was capable of turning a column thirty two feet long and six feet in diameter.

The blacksmith shop is a part of a granite working establishment that is not usually thought of and yet it is absolutely essential. A moment's thought suffices to convince one that any tools that can be made must soon get so dull as to be useless when working on granite. And yet few realize how soon a tool is put out of use. On the average hand chisels can be used only from three to five minutes before they need resharpening. Hence each workman must be supplied with fifteen or twenty fresh tools each hour he works. Hammers, bushing tools and the like last somewhat longer, but sooner or later, and generally sooner, all tools must be made over. This means not merely grinding, but heating, forging and retempering, and finally in some cases grinding. Therefore there must be a force of skilled blacksmiths at hand in every stone working plant. As a rule one blacksmith can sharpen for fourteen men so that in the large works twenty or thirty men are constantly at work sharpening tools.

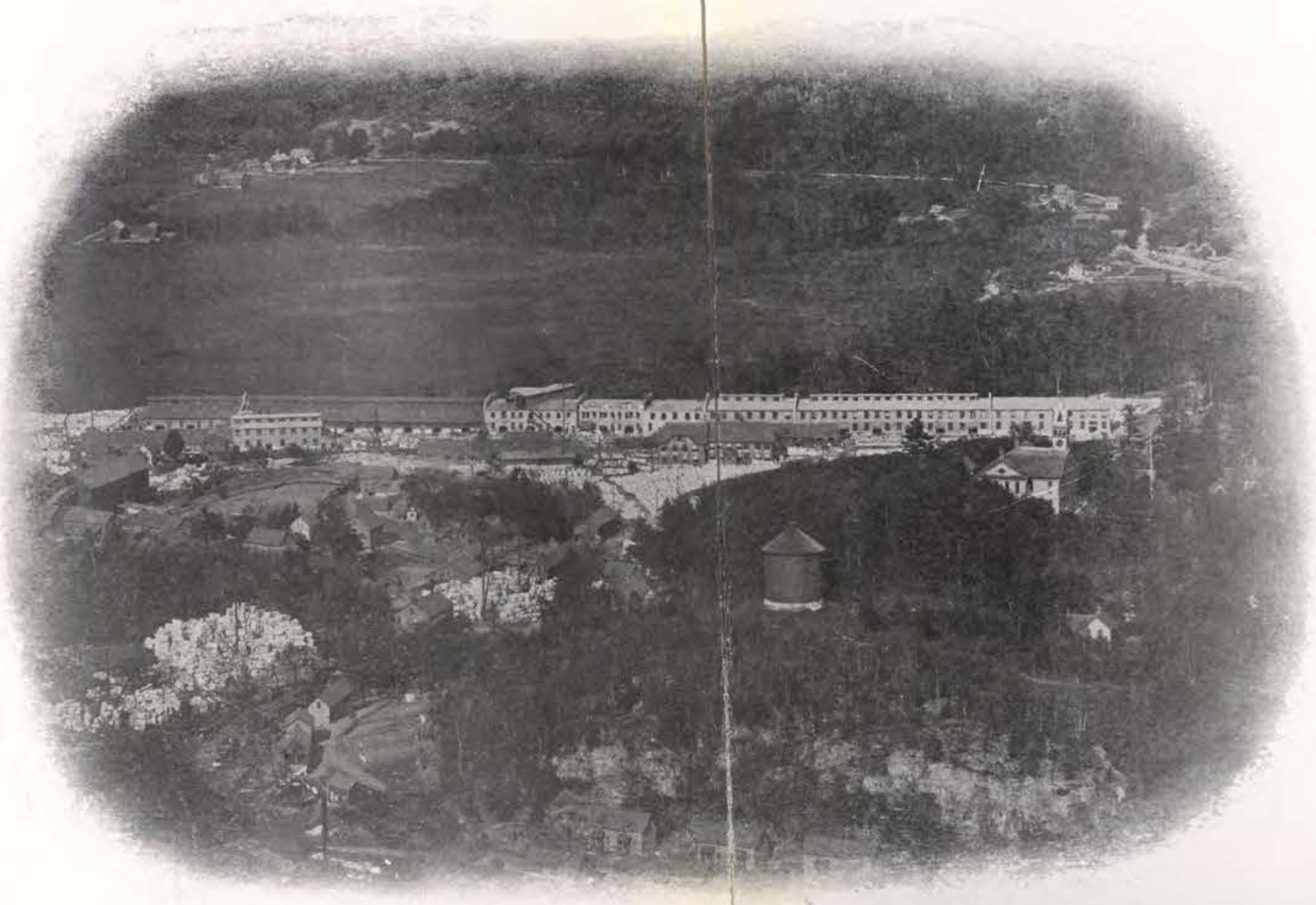
At the works of Barclay Brothers in Barre, I saw a very interesting machine, the second ever made, I believe, which did much of the work of the tool sharpener and with two attendants was able to do as much as five men could do. In this, the Pirie Tool Sharpening Machine, the tools are laid side by side, on a moving carrier which takes them slowly through an oil furnace where they are heated as desired, the degree of heat being regulated at will. As the tools emerge from the furnace they are passed one by one under a sort of triphammer die which shapes them and then if necessary they are ground between emery wheels and finally dropped into a brine tempering bath which is on another carrying belt and by this they are taken under a stream of cold water and finally dropped into a box ready for use. At the Barclay Works this machine has sharpened for seventy cutters and had an hour to spare in the day.

The above brief account of methods of granite working has been compiled from an inspection of the works of the Woodbury Granite Company, Barclay Brothers and Jones Brothers. For information as to different machines, I am indebted to Mr. J. I. Sargent of the first named works and to Mr. William Barclay, Jr.

As shown by the map, Plate II, the deposits of marble in Vermont are confined to a small area, which is mostly in Rutland county though extending a short distance north and south of it. Besides this area of true marble there is a narrow strip in northwestern Vermont which supplies the mottled Champlain marbles. It is quite remarkable that from so small an area should have come the stone which has made our State pre-eminent. While, as has been seen, granite is produced and worked by a large number of companies, marble is handled by only a few, and by far the larger part, by one. So far as I know, all the quarries are worked by companies having their own finishing plant. The following companies are now engaged in this business in Vermont.

List of Vermont Companies engaged in Quarrying or Manufacturing Marble:

PLATE XX.



Works of the Vermont Marble Company at Proctor.

PLATE XXI.

One of the Quarries of Vermont Marble Company, West Rutland.

Barney Marble Company, Swanton, now owned and managed by the Vermont Marble Company.

Brandon-Italian Marble Company, Quarries, Brandon, Mills, Middlebury.

Burlington Marble Company, Burlington.

Columbian Marble Quarrying Company, Quarry at Proctor, Mill at Rutland.

John Cullen Quarry Company, Danby.

Danby Marble Company, Danby.

Eastman Quarry Company, West Rutland.

J. K. Freedly & Sons, East Dorset.

Imperial Marble Company, Danby.

Norcross-West Marble Company, Quarries, Dorset, Mill, Manchester.

Orvillo Marble Company, West Rutland.

Raleigh Marble Company, Pittsford.

Rutland-Florence, West Rutland, Pittsford.

Sterling Marble Company, Pittsford, Beldens Falls.

Vermont Marble Company, Quarries, West Rutland, Proctor, Pittsford, Swanton, Mills, Proctor, West Rutland, Swanton.

White Stone Brook Quarrying Company, Danby.

Besides these The G. E. Royce Estate has Mill and Quarries, Pittsford. "Not worked pending settlement of the estate."

The Dorset Mountain Marble Company, Dorset. Not working.

Continental Marble Company, Dorset. Not working.

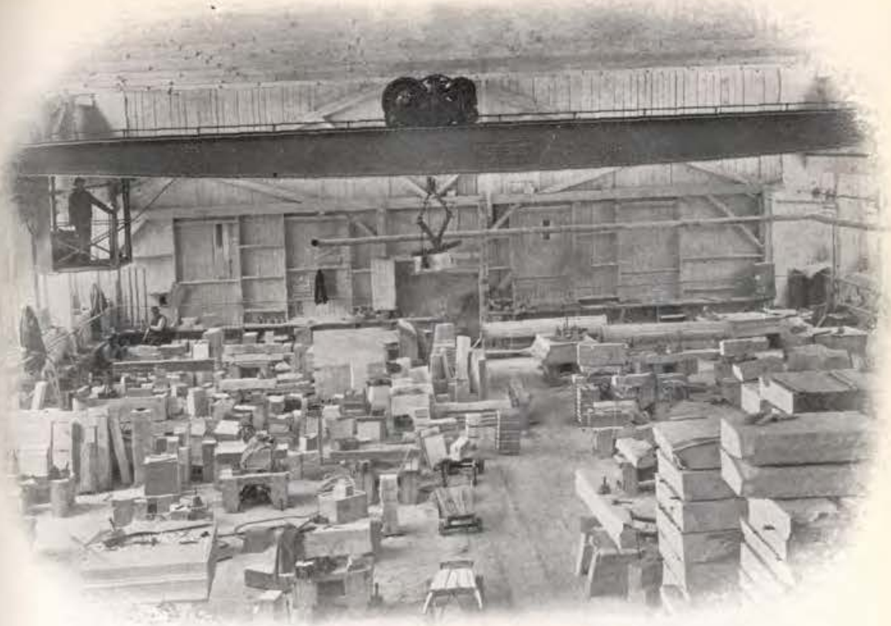
All of these companies are large and the Vermont Marble Company is probably much the largest in the world. The combined capital of these companies is about $8,000,000 and they employ 3,400 men, and their sales in 1903 amounted to considerably over $3,000,000. Within the past two years there has been a notable increase in the facilities for producing marble possessed by these companies. Several large mills have been built and equipped with improved machinery, new quarries have been opened or old ones long idle reopened, and in all directions increased activity, so that undoubtedly the sales for the present year, 1904, will largely exceed those of previous years.

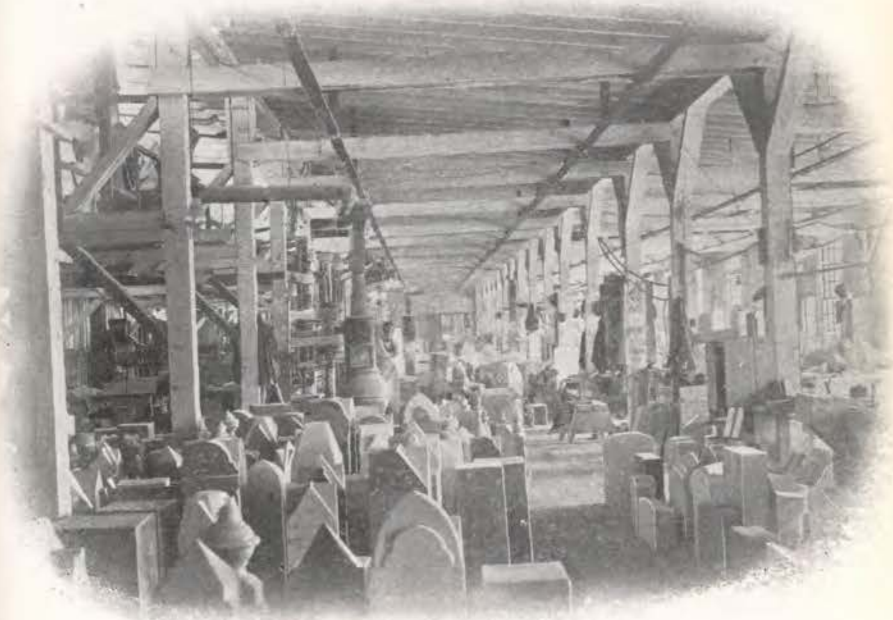
The Vermont Marble Company alone produce about one-half of all the marble sold in the United States and two-thirds of the finer grades. They have recently added the Beldens Falls property including the water power, and are about to expend several hundreds of thousands of dollars in installing electric power in their plant at Proctor, putting in three 100 horse power dynamos and other machinery. Plate XX shows the immense plant of this company at Proctor. Plate XXI shows a part of the series of quarries at West Rutland, and Plate XXII some interiors.

During 1903 this company got out 1,000,000 cubic feet of marble and expect to do more in 1904.

The Freedly quarry on Dorset Mountain has been worked for many years continuously, but the other numerous quarries on and about Dorset Mountain which formerly were in operation have been idle for a long time until within two or three years when the Norcross-West Company reopened one of the old and opened several new quarries, built a finely equipped mill at Manchester and a railroad six miles long from it to the quarries and are now doing a large business. The quarries and mill are fully provided with the best modern machinery, and the former can produce 60,000 feet of stone daily. Plates XXIII and XXIV show two of the quarries of this company. This company are now getting out 530,000 feet of marble for the New York City Library and 230,000 for the new medical buildings of Harvard University. The stone is light, more or less veined and clouded. It appears to be a very fine grade of marble especially for building purposes and it is very gratifying to those who are interested in the development of the resources of our State that the use of Vermont marble as a building stone has very largely increased during the last two or three years.

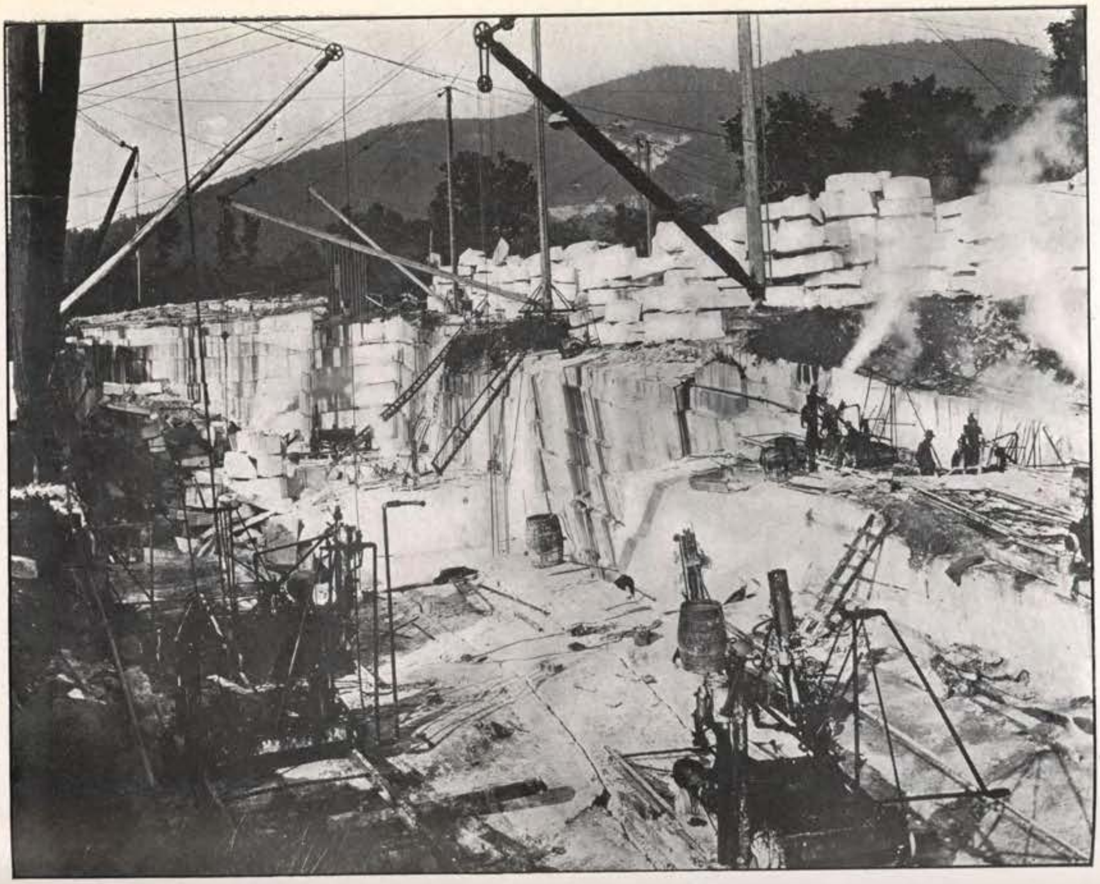
The Rutland-Florence Company is latest in age and is already a very strong concern. Their mill at Fowler is certainly not excelled, if it is equalled, by any other. It is framed with steel, very light and airy, furnished with electric traveling cranes, steel frame saw gangs and all that makes an efficient up to date mill. It is 430 by 100 feet. The policy at this mill is to do as much by machinery and as little by hand as possible. For instance, they have it so arranged that a block of marble may be placed by a derrick on a small car in the quarry and this is rolled on to a common platform car and thus carried to the mill where it may be rolled under a saw gang or placed conveniently for whatever work it is to receive carving, polishing, etc., and finally set in the store room





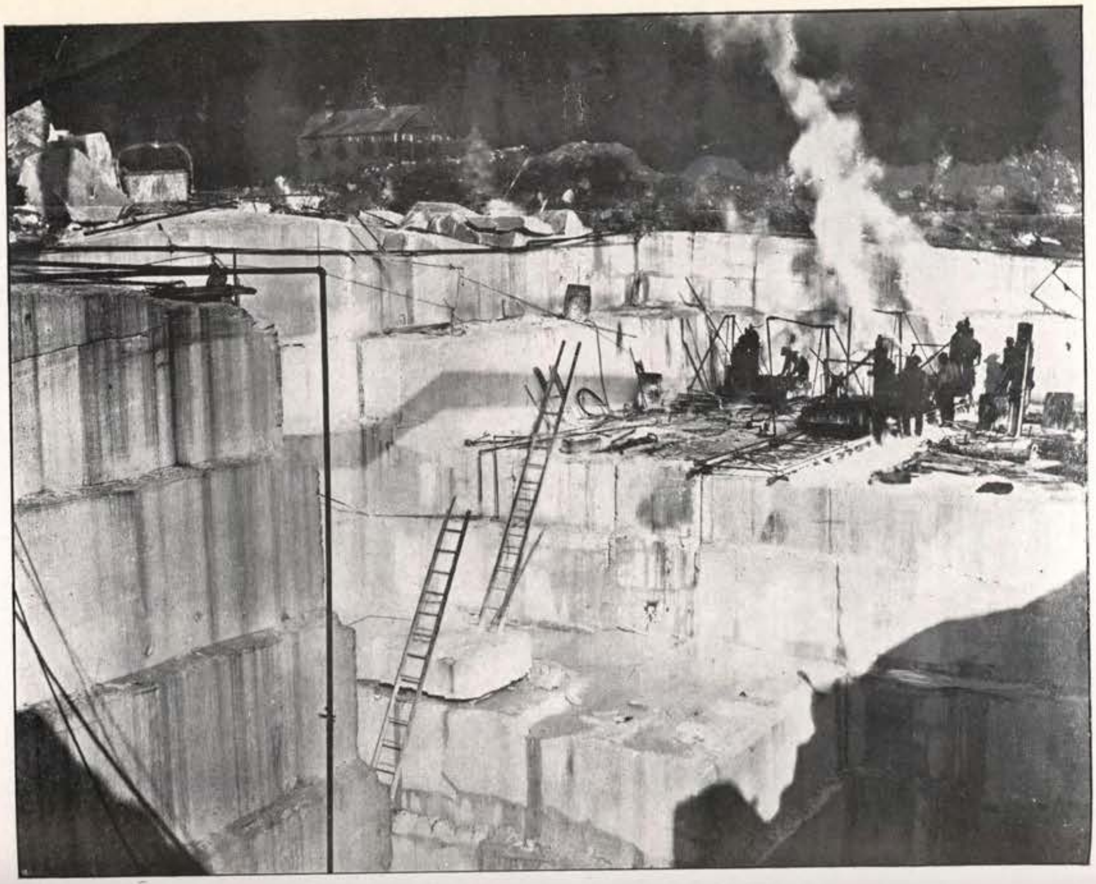
Interior of a part of the Vermont Marble Company Works at Proctor.

PLATE XXIII.



Marble Quarry, Norcross-West Co., Dorset. Main Quarry.

PLATE XXIV.



Marble Quarry, Norcross-West Co., Dorset. Pleateau Quarry.

ready for shipment on the car which brought it from the quarry. This company owns fourteen hundred acres of quarry land in Pittsford and Rutland. There is another steel mill at the True Blue quarry at West Rutland.

Nearly all the light colored marble of the State is located in Addison, Bennington and especially Rutland counties. The Brandon quarries on the north and those at Dorset on the south are at the limits. Besides light marbles there are the valuable beds of variegated red and white marbles of Franklin and Chittenden counties.

These marbles are mostly light colored, that is white variedly shaded with black, or less commonly brown, reddish, greenish or bluish bands, lines and blotches. The varieties are very numerous and many of them very elegant. Besides the veined marble, pure white, some of it fine enough to be used in the best statuary, is found.

Several sorts of limestone are used as marble and when sawn and polished make a jet black or gray stone. Most of this is obtained on Isle La Motte.

The limestone quarried at Swanton is usually used for making lime, and it is also sawed and polished to some extent, when it makes a very pretty dove colored marble.

A very valuable addition to the marbles named are the so-called Champlain and Roxbury marbles.

In the scientific sense these are not true marbles, but they are none the less fine, on that account, and are more elegant and costly than any of our ornamental stones. The Champlain marbles are hard, beautifully variegated in reds, browns, greens, olives and whites, no two slabs being exactly alike and none like any other stone ever seen. Still harder and more superb is the green, black and white verde antique of Roxbury, which is a kind of Serpentine.

During the past year, 1904, marble of various kinds has been extensively quarried in Swanton, Burlington, Brandon, Pittsford, Proctor, West Rutland, Rutland, Dorset and Roxbury.

SLATE.—Slate is quarried in two areas neither of them very large and each is a long narrow strip running from north to south. The best known and largest slate region is that in Rutland county west and a little south of the marble area. It is not more than half as long and perhaps twice as wide as the latter. It extends from West Castleton through the towns of Fair Haven, Poultney, Pawlet and ends in Rupert. In this area there are some thirty-four companies now operating and not far from a hundred quarries are now or recently have been worked. This area extends into New York and some of the largest firms owning numerous quarries in Vermont have their offices in New York at Granville and, as some of these companies also work quarries in the latter state, it is impossible to separate the slate business of the two states with entire accuracy. For a more full discussion of the slate industry of this region than can be given below, the reader is referred to the Report of 1900, and especially to the excellent paper by Prof. T. N. Dale, U. S. Geological Survey Report, Ninteenth Annual. Part III, pp. 153, 307, on the Slate Belt of Eastern New York and Western Vermont.

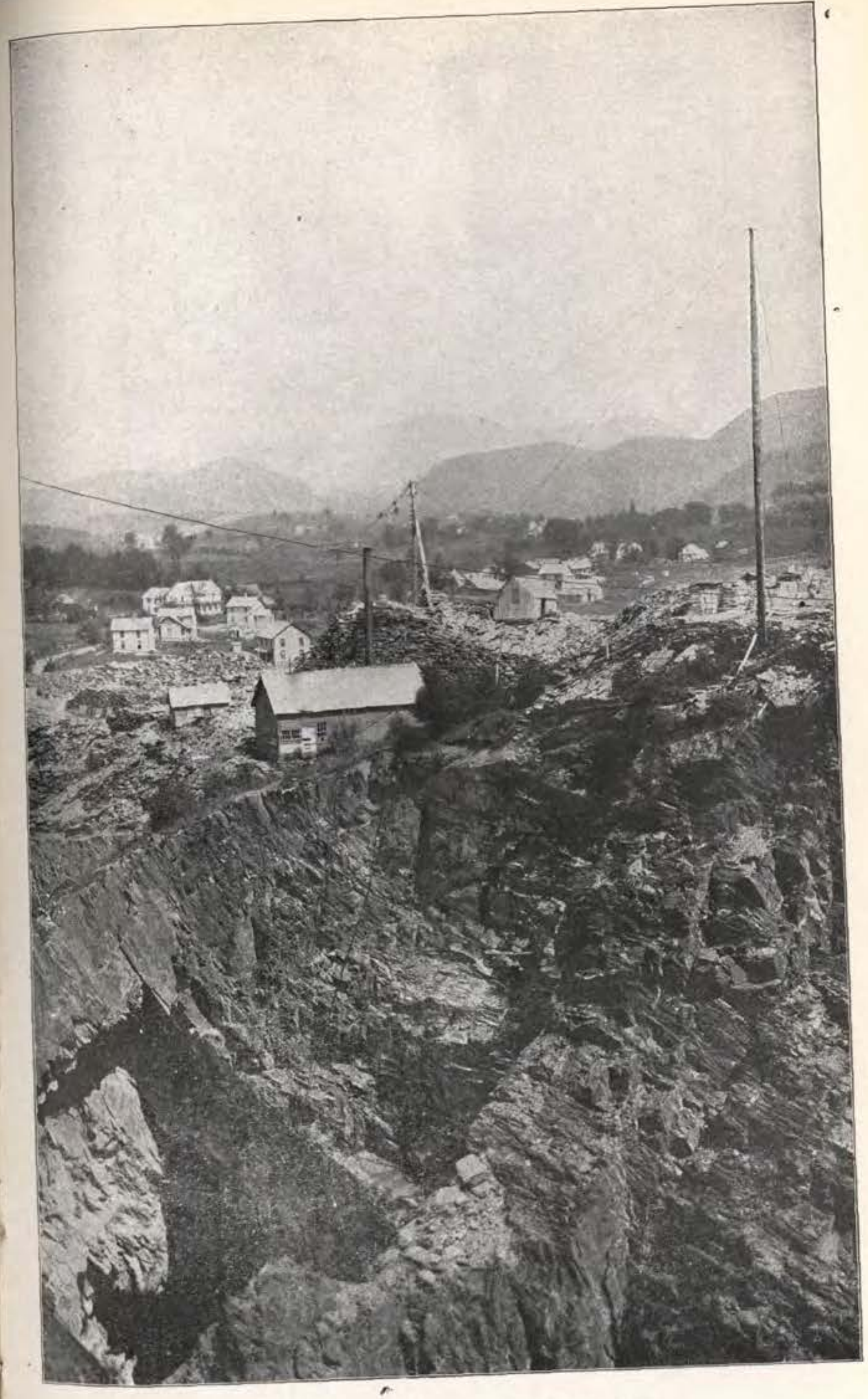
The other slate belt is mostly in Washington county, though it runs south into Orange for a short distance. Its present center is at Northfield where alone are quarries worked.

In both these regions there has been unusual activity during the past two years, new quarries having been opened, new companies formed and the production and sales has increased.

Taking up first, though necessarily with brevity, the great western slate belt, we find that all the firms which have reported are doing an increasingly large business. The following list, for the revision of which I am indebted especially to Messrs. Griffith and Nathanael, though others have also aided in making it full and accurate, is believed to contain all the companies at present engaged in the slate business either in quarrying or manufacturing or both. Most of the larger firms quarry their own stock, but some buy the stock and work it up for the market.

List of Companies engaged in the Slate Business in the Western Vermont Slate Belt:

Auld & Conger, Poultney, Bronson Slate Co., Hydeville,



Slate Quarries at West Pawlet, Looking Northeast.
The hills in the background are a portion of the Taconic Range.
By Courtesy of the U. S. G. S.

PLATE XXVI.

1

The Northfield Slate Range.

View east of the village of Northfield, and north of the dividing ravine. (1) Cottage of the Northfield Country Club. (2—3—4) Points where the outcropping slate may be seen.

Courtesy of Vermont Black Slate Company.

PLATE XXVII.

The Northfield Slate Range.

View east of the Village of Northfield, and south of the dividing ravine. (1) The "Union Quarry" and (2) the "Gov. Paine Quarry," properties of the Northfield Slate Company.

Buckmaster Slate Co., Poultney
Clayton & Burdick, West Pawlet
Eastern Slate Co., Poultney
Edwards Brothers & Jones, Pawlet
Edwards Slate Co., West Pawlet
Eureka Slate Co., Poultney
Flamings Slate Co., Castleton
Green Mountain Slate Co., Poultney
Griffith & Nathanael, Poultney
Thos. R. Griffith, West Pawlet
Hensbry Brothers, Hydeville
W. H. Hughes Slate Co., West Pawlet
Johnson & McCormick, Pawlet
Jones, Roberts & Rowland, Poultney
John J. Jones Slate Co., Castleton
Jones & Owens, Fairhaven
Lake Bomoseen Slate Co., Hydeville
R. E. Lloyd Slate Co., Poultney
Matthews Slate Co., Poultney
James Minogue, Castleton
Charles Morris Slate Co., Poultney
Nelson Brothers & Morrof, West Pawlet.
New York Consolidated Slate Co., Poultney
Norton Brothers, Granville, N. Y.
O'Brien Brothers, Wells
Parry, Jones & Owens, Poultney
Rice & Jones, Wells
Rising & Nelson Slate Co. West Pawlet
Griffith T. Roberts, West Pawlet
Rutland County Slate Co., Poultney
Scotch Hill Slate Co., Fair Haven
F. C. Sheldon, West Pawlet
R. J. Williams, Wells
D. J. Williams & Son, Poultney
Vermont Unfading Green Slate Co., Poultney.

As in the list of granite firms, several of the above have made no report so that it is not possible to give absolutely accurate statements as to the total slate business of the State but so far as can be ascertained, including the Northfield companies to be mentioned, there is invested in the business capital to the amount of $1,000,oco and over 1,000 men are employed, while the output for 1903 was nearly $1,300,000.

Plate XXV is introduced to show something of the character of the slate quarries. The slate of western Vermont is green, known in trade as "Sea Green" and "Unfading Green," "Purple" and "Variegated." There is here no red nor black slate. The former is found just across the line in New York and some of the companies that have quarries in Vermont also have red slate quarries in New York and on this account red slate is sometimes sold as from Vermont. Black slate, however, is found in abundance at the other slate belt shown on the map in Washington county. Formerly there was a good deal of activity in this region, but for some years nothing was done. Now, there are two companies busily engaged in getting out and selling this slate. It is a fine black stone, splits evenly and easily, does not fade and there does not appear to be any reason why the Northfield slate should not find a ready and increasing market. The two companies now operating in this region are the Northfield Slate Company and the Vermont Black Slate Company.

The Northfield Slate Company has furnished the illustrations given on Plates XXVI-XXX. Plates XXVI and XXVII are of general interest as they give, though less satisfactorily than could be wished, a general view of the whole slate area so far as it has been at all developed. Plates XXIX and XXX show the vertical position of the slate in the quarries. These quarries are remarkable for the firmness of the slate near the top where it would naturally be more or less decomposed through many years of weathering, but it is stated that, while of course not of the best quality near the surface, it is surprisingly sound.

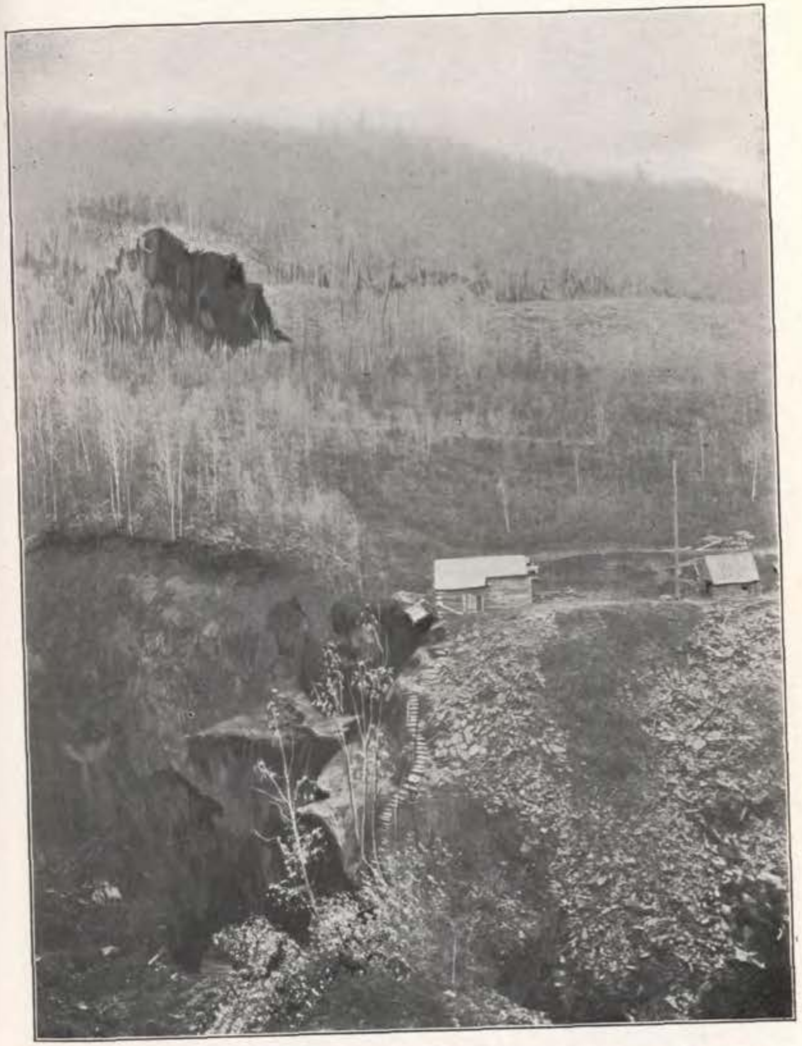
The Vermont Black Slate Company furnishes the illustrations given on Plates XXXI and XXXII. The company also sends the following

DESCRIPTION OF PROPERTY.

"This company owns 365 acres of land which is nearly all underlaid with black slate, 150 acres being more valuable for quarry purposes, it being accessible and the slate being easily moved by cable ways from the quarries to transportation. This slate as shown by Plate XXXI is workable from the top to an unknown depth. The vein is fully one-third of a mile wide, nearly all of workable quality, and passes directly through our property.

The company has three well developed quarries which cost a large amount of money to open. No. 1 is well equipped with cable ways, derricks and machinery for manufacturing roofing slate. It is our purpose at once to add modern machinery to this plant for manufacturing dimension stock. This machinery will have a capacity of 800 feet of dimension stock per day and give us one of the best slate manufacturing plants in the country.

Quarries Nos. 2 and 3 have no modern equipment. A very little amount of development will however produce large faces of workable slate, and new machinery will be supplied as needed.



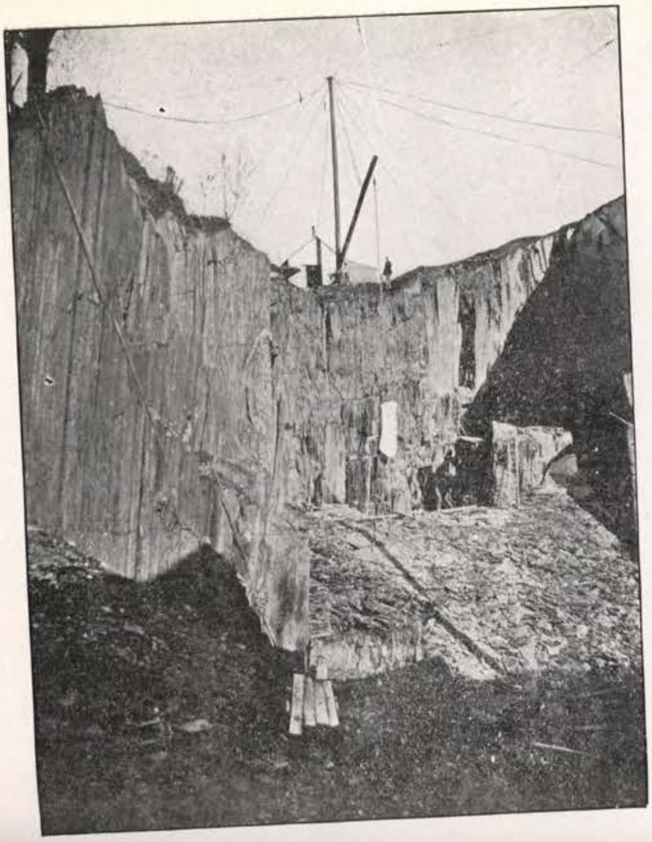
Union and Paine Quarries.

View of a portion of the Northfield Slate Company's property, showing the "pit" of the Union Quarry, together with engine and tool sheds, and, further up the hill, the "pit" of the Gov. Paine Quarry.

PLATE XXX.

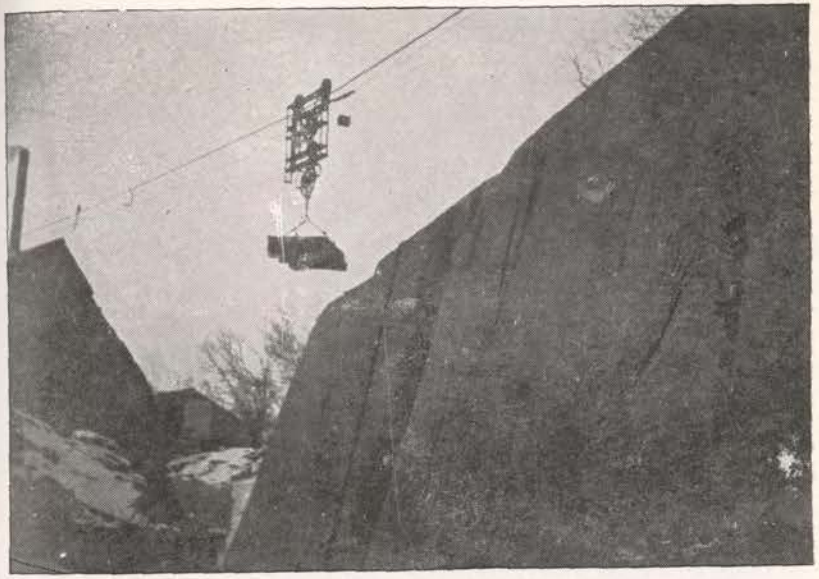
Face of Union Slate Quarry, Northfield.

PLATE XXXI.

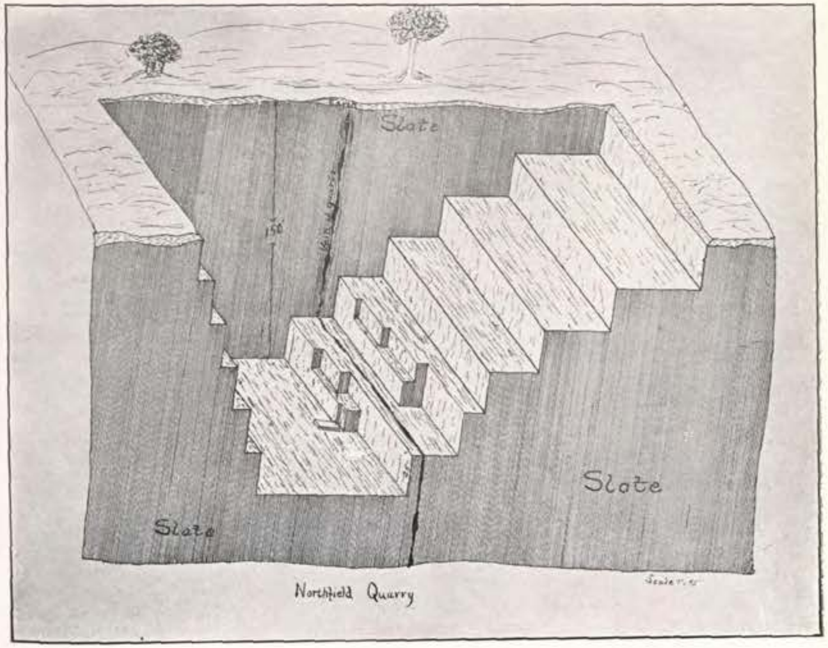


Quarry of Vermont Black Slate Company.

Shows two blocks of slate thrown out at one blast. Weighs 234 tons.
Value, $3,342.80.
Vermont Black Slate Company.



Shows face of quarry, incline and carriage lifting slate from the pit.



Position of Slate in Quarry. Vermont Black Slate Company's Quarry.

The company also owns 110 acres of land well adapted to the building of residences, and homes for the workmen, ample dumping grounds for all purposes for years to come, railway right of way and several dwelling houses now upon the property. The company has a lease at a nominal rent, from the Central Vermont Railway Co., of several acres of land near the railway station for the purpose of erecting a finishing mill and yard room for storing stock.

We have a complete survey of a railroad connecting our quarries with the main line of the Central Vermont Railway. This survey calls for only one-half mile of road and one twenty-five foot bridge. By this improvement we will be able to place all our stock, as it comes from the quarries by means of cable inclines, upon flat bottom cars for transportation to the different finishing departments and to the main line of the Central Vermont, taking in all our supplies in the same way, and avoiding all the danger and expense of hauling slate and heavy material by teams.

The great need of this slate region seems to have been sufficient capital to properly carry on the work."

LIMESTONE.—Limestone for building, curbing and macadamizing is extensively quarried on Isle La Motte at Fisk's and Fleury's quarries owned and worked by N. W. Fisk and E. S. Fleury. Limestone used chiefly for making lime is quarried by J. P. Rich at Swanton, W. B. Fonda at St. Albans, L. E. Felton at Highgate Springs, the Brandon Lime and Marble Company and the Leicester Marble-Lime Company at Leicester Junction. These firms sell several hundred thousand dollars worth of stone and lime annually. There are numerous small quarries located here and there over the State from which stone in relatively small quantity is taken for building and road material. South of Burlington there is a large quarry formerly known as Willard's Ledge but now worked under the name of Phelps Quarry. This furnishes sandstone for building, foundations and road material. The stone is very hard and durable and is of various shades and characters from nearly white quartzite to dark red; the latter, though hard, is less so than some of the very light. Most of it contains a small amount of lime. It is an excellent stone and when used in building presents a good appearance as anyone may see in the Cathedral, Court House, Methodist and College Street Churches and other buildings in Burlington.

SOAPSTONE. This material is quarried at Perkinsville and Chester and at both places there are mills in which it is sawed and ground.

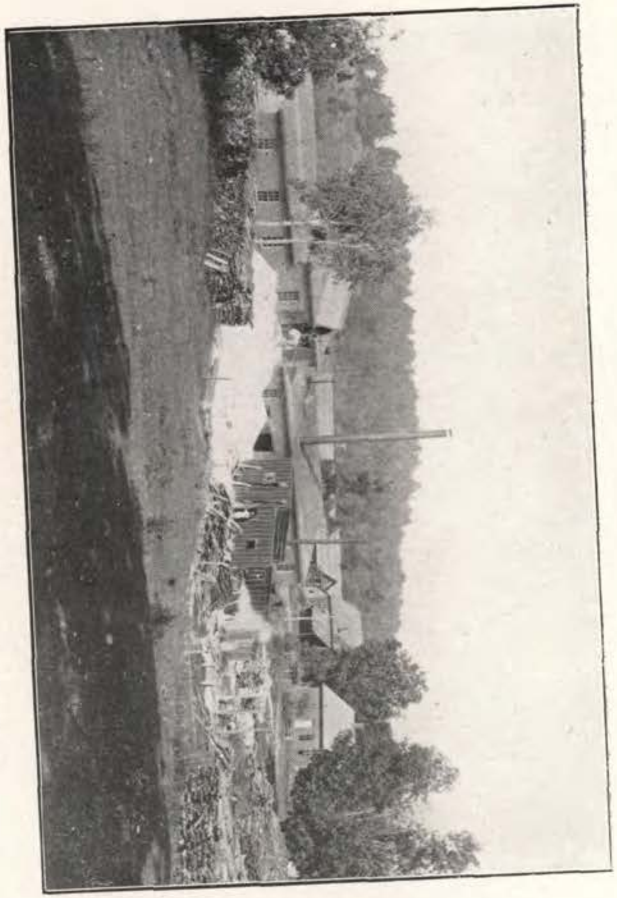
From an article in a recent number of *Rock Products* I take the following facts concerning the work at Chester Depot.

There are two companies working the stone at Chester. One of these, the Union Soapstone Company, works three quarries.

"The stone is quarried by using channelling machines and then splitting out the blocks with wedges. It splits easily and in regular blocks. These blocks are commonly six feet by four and of variable thickness. The soapstone lies in lenses from four to twenty feet thick and twenty to thirty feet wide. These lenses overlap each other so that the deposit is practically continuous and as they also occur one below another the depth of the whole may be considerable. The stone is so soft that it can be worked up more readily than other kinds and it is sawed, planed, tongued, grooved, turned, bored, etc., very much as wood might be treated. Water is not necessary except on the rubbing beds where the surface is made smooth. The American Soapstone Finish Company grind the stone to flour and make a good wall finish and for filling for some sorts of paper."

KAOLIN. From time to time the variously colored clays at Brandon, or rather Forestdale, two miles and a half east of Brandon, have been dug and used for various purposes, but for some years no systematic attempt has been made to utilize these deposits. In the chapter on the lignite and its fossils which follows in another part of this volume something of the geology of the region is given. Within the last two years, Messrs. Horn, Crockett & Company have sunk shafts into the white clays and built a very substantial and well equipped mill of which they have sent the view given on Plate XXXIII. This company dig only the pure

PLATE XXXIII.



Works of Crockett, Horn Company, Forestdale: near Brandon.

white clay. Formerly the red and brown clays were dug and ground and made into a coarse sort of paint. This industry, however, has not been carried on for several years and the old works are going to ruin. The new company have started energetically and produce ten or fifteen tons of refined white clay daily. When first brought from the shaft, the clay contains quite a per cent. of quartz sand. To remove this, the clay is mixed with water thoroughly and the thin mixture is run slowly through a labyrinth of narrow troughs and during its somewhat extended passage, the silica settles. From these channels the water carrying the clay is run off into huge tanks of concrete where the clay settles and from which it is pumped into "filter presses" where it is pressed into thick sheets. Finally it goes to the kilns where it is dried. The present depth from which it is dug is eighty feet, though the shaft has been sunk forty feet more.

The pure clay is used for making porcelain, giving body to paper, etc.

Mr. Horn sends the following analysis by Henry Carmichael of Boston.

Silica	48.91
Aluminum Oxide	39.99
Iron Oxide, FeO	0.33
Calcium Oxide	0.34
Loss on Ignition	8.92
Alkalies, etc. by difference	1.51
	100.00

Messrs. S. C. Lyon and Company of Shaftesbury also mine kaolin, ochre and china clay.

FIRE CLAY. The Rutland Fire Clay Company are working a deposit "Covering 225 acres and containing many grades of fine clay." This concern have a large capital, employ thirty men and sell a large amount of their product. They make a fire proof wall plaster, stove lining, etc.

TALC. In the last report the talc deposits of Moretown were merely mentioned. Since then there has been much work done at one point, and now The International Mineral Company are pushing the development vigorously. The accompanying views furnished by this company, Plates XXXIV and XXXV, show something of what is being done. The bed of talc in which they are workiug is very large and of excellent quality. The following analysis of this talc may be of interest. No. 1, average of three analyses made by C. H. Jones, chemist, at Vermont Experiment Station:

Water	5.15
Silica	57.08
Magnesia	27.16
Iron and Aluminum Oxides	8.40
Lime	1.72

Another sample taken from farther north analyzed:

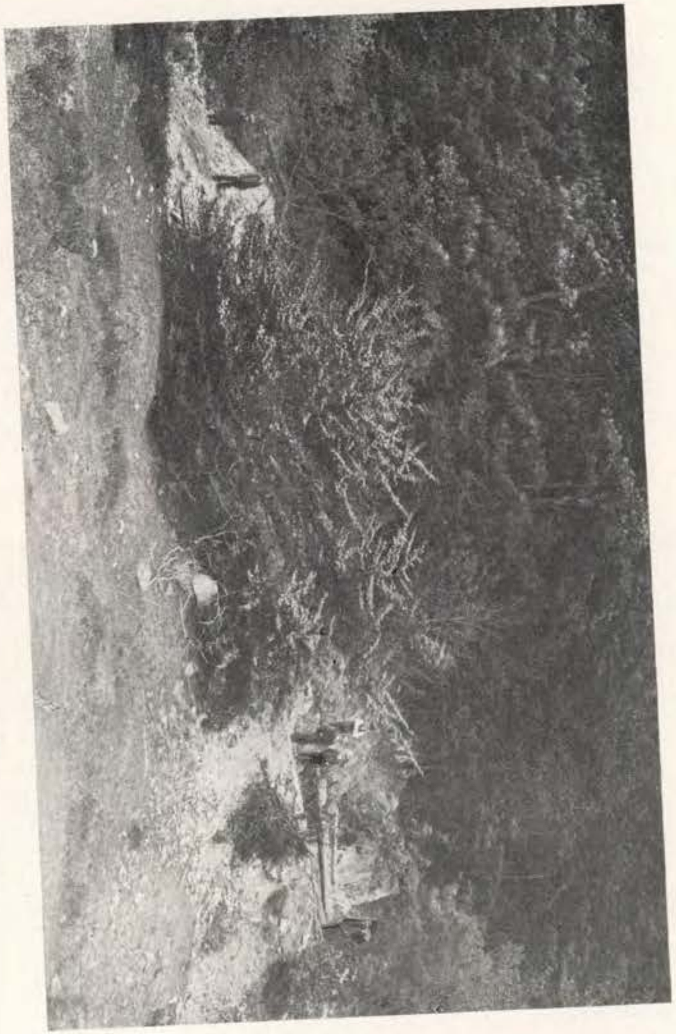
Water (H_2O)	4.50
Silica (SiO)	59.82
Magnesium Oxide. (MgO)	32.02
Ferric and Aluminic Oxides (Mostly Ferric)	3.52
Calcium Oxide (CaO)	none

ASBESTOS. Two or three years ago there was some activity in developing the asbestos deposits of the State, but at present all this has stopped. There is no doubt as to the presence of chrysotile asbestos in a number of localties and some of it is of very good quality, but whether it can be profitably worked under the present conditions is not certain. Openings have been made and more or less work done at Belvidere Mountain in Lowell and at South Duxbury. I am very glad to be able to include in this report an investigation of the asbestos region by Professor V. F. Marsters.

SCYTHESTONES. The Pike Manufacturing Company have at Evansville a plant where they quarry a "Fine grained quartose mica schist" and work it up into scythe stones employing some thirty-five men. This is a large company and they have several other factories in different parts of the country.

METALS. The only metals that have been mined in Vermont for many years are gold and copper. The former metal is found in small quantities in the quartz rock or sand in many localities

PLATE XXXIV.



Bed of Talc, 80 feet wide, Moretown. Property of the International Mineral Company.

PLATE XXXV.

Looking into the Cut in Talc Mass.

Interior of Cut in Talc Mass, Moretown.

and has first and last been the cause of much trouble and far greater financial loss than gain. With the possible exception of the Plymouth and Bridgewater regions, concerning which I have not sufficiently definite facts to warrant a sweeping statement, gold mining in Vermont has never paid. I do not intend to say, that no one has found gold in any amount, for, as is stated above, small quantities have been taken out of quartz or washed out of the sand of one and another stream, but in every case with which I am acquainted it has cost more to get the gold than it was worth, often far more.

It seems very strange that anyone can be so lacking in foresight as to expect to make money by mining, whether the mine contains much or little of the mineral sought and yet there are those who seem to think that any mine, especially if,it is on their own land, is necessarily profitable. As a matter of fact the greater number of mines are not a success. As in the last report I wish to call attention to the very common occurrence of little particles of yellow mica in the rocks of the state. In some specimens, these yellow sparkling bits of mica are easily mistaken for gold and many are deceived by them.

I do not wish to be understood as asserting that gold mining cannot, under any conditions, pay in Vermont. I do wish to say that it is extremely improbable that it ever will and, therefore, that the utmost caution should be exercised by anyone who undertakes to start a gold mine, or rather the caution should come before the undertaking is started. At present, so far as I have had reports, gold is mined only in Bridgewater though first and last a good many thousands of dollars have been spent and lost in mining in different places. In Bulletin 225 U. S. G. S. Contributions to Economic Geology, 1903, Mr. G. O. Smith has a very interesting summary of the subject of gold mining in this State from which I have quoted the following paragraphs. "In the town of Bridgewater gold was discovered fifty years ago, and within ten years of this discovery at least two quartz mills were built to treat the ore. The early work was characterized by extravagant expenditure and lack of reliable statements. It can safely be stated, however, that more money was expended in mill building than was secured from the ore treated. This kind of work has continued spasmodically, and even to-day the outlay in development work in progress appears out of proportion to the ore in sight.

The veins in Bridgewater have a north south trend, and apparently all belong to one general system which extends across the western part of the town. The southernmost productive locality is on Ottaquechee river immediately west of Bridgewater Corners. On the Ottaquechee property a small bunch of very rich ore was uncovered nine years ago, which is reported to have yielded between eight and nine hundred dollars in gold. Since the discovery of this pocket the property has produced very little and is not worked at the present time.

Next north on this veined zone is the Taggart vein, on which work has been done at various times, beginning with 1859. Ten tons of ore crushed and amalgamated are reported at one time to have yielded 374 pennyweights of gold. The Taggart vein is located on the old Thompson farm, one mile west of Bridgewater Center. It has been opened at several points, chiefly in the gulch of a small stream. These openings were visited at the upper exposure in the stream bed itself where the quartz vein has a width varying from eight to eighteen inches. The strike of the vein is 5° to 10° east of north and it dips to the east at an angle of 70°, being apparently parallel with the schistosity of the country rock. The quartz of this vein is white and barren in general appearance except for the small stringers of galena which it contains. The quartz is well cemented to the wall rock and there is no evidence of fracturing of the vein. Below the stream level at this point the vein thickens to nearly three feet and here the ore was taken out which was reported to yield $32 in gold to the ton. From a small pile of quartz and galena remaining at the edge of this opening a sample was taken which was assayed by Dr. Allen in the Survey laboratory with the following results :

Assay of a sample of quartz from the Taggart vein.

Gold	None.
Silver	1.27 ounces
Copper	6.19 per cent
Lead	6.26 per cent

This indicates a value of over $6, but the sample represents the richer part of a small ore body. The absence of gold is suggestive in view of the high gold value claimed for this vein.

Quartz has been mined from other parts of the Taggart vein, but it is said that whatever value it may have contained was lost in the process of milling. Four mills were constructed at various times in this vicinity for the purpose of separating the gold from the quartz.

Farther north in the same town is the Shatauguay group of claims. Little could be learned concerning this property, except that development activity was being confined to mill construction and road making.

A well equipped quartz mill was being built, but the openings that will furnish the ore were not shown by the manager of the property.

In Plymouth, the next town south of Bridgewater, mining interest extends back over forty-five years. At Plymouth Five Corners a mill pond was once drained and worked for placer gold. Sluice boxes and rockers were used and the result is variously reported at from $9,000 to $13,000. Some recent prospecting for quartz veins has been done and reports of success given out. At the localily itself, however, there is little faith in these reported discoveries. Near Tyson's Furnace in the southern part of Plymouth, the Rook Mining Company conducted operations twenty years ago on an ambitious scale, but, apparently, with no profit from the mine." (Bulletin U. S. G. S. 225, pp. 85-88.)

I have quoted the above at length since it is an account of the only locality in which there has been even an approach to success in gold mining, and here taking the entire experience into account, the cost has without doubt far exceeded the returns.

There can be no doubt that not a little money may be saved for better uses than paying for holes in the ground if those who have it to spend will consult competent persons as to the real value of the rock in which they plan to work. It is plain to anyone who knows the facts that some of the good people of Vermont have been greatly cheated by so called assayers.

Several instances of this have come under my own observation, but the worst case on record is that of a piece of grindstone sent from the south western part of the State which was reported to contain $25 gold to the ton. Not a little money has also been paid to honest assayers to no purpose because the samples contained only yellow mica, and this could easily have been known at no cost had the samples been first sent to the State Geologist who is always glad to examine and report upon any samples sent by citizens of the State and without charge. A full assay cannot be made without charge as the State does not make provision for this, but an examination which usually is sufficient to determine whether a complete assay is worth while is provided for and will always be made if requested.

SILVER. This metal has never been found in the State except in combination with other metals as seen in the analysis given above of the Plymouth rock. It occurs in some of the copper ores at South Strafford, but always in exceedingly small quantity, so that, so far as I know, there has never been any effort to get it out.

PLATINUM. It is not at all to be expected that this rare metal should occur in this State. I have had no opportunity to verify the statements quoted below, but I have thought it worth while to give them on the authority of the writer of the article which was published in "Expansion" for May, 1904, by Mr. W. L. Hinchman, B. Sc. of Rutland. Mr. Hinchman says:

"In April, 1901, while assaying some wall rock taken from next to a copper vein in the Plymouth gold district, to see how much copper sulphide it held, I accidentally discovered unmistakeable signs of metallic platinum. I kept on experimenting and in August of that year was sure that the gray sandstone or what some called 'flint' held one-quarter of an ounce of it to the ton, associated with pyrites, worth $5.25. Since then I have submitted samples to a leading chemist and also to a geologist of national reputation, both familiar with platinum, who have detected the metal. After such encouragement I have kept on striving to find a reliable cheap method for extracting the values profitably, and latterly with complete success.

"Now this sandstone lies in a broad belt, consisting of tilted cleavable layers, on the side of a 600 feet-high hill, several thousand feet long and 200 feet wide, showing veins of copper sulphides cutting across the grain of the layers or strata, the whole formation placed between walls of slaty shale cut by parallel fissure veins of quartz. Above this deposit, near the top of the ridge, there is a narrower ledge of black shale containing one-tenth of an ounce of platinum. Above this again is a large vein of platinum-bearing quartz. Across the valley, on the side of the opposite range of hills, lower than the sandstone, and about 1,500 feet away is a fissure quartz vein with one-tenth of an ounce of platinum and one-twentieth of an ounce of gold to the ton, altogether free milling ore. All these belts, ledges, and veins run parallel to the ridges of the hills and are located in a serpentine-asbestos-talc-soapstone district, with a dike of chromium oxide within three-quarters of a mile of the platinum, and several trap dikes in the near neighborhood. Some of the quartz veins running with the sandstone and in the slaty shale give $2.06 to the ton in gold, but no platinum. A dike of porphyritic rock some distance away gives three-tenths of an ounce of platinum to the ton with a value of $6.30.

"The gray sandstone when wet looks like the 'True Blue' marble, only darker gray and with very small, bright, iron-looking metallic specks scattered through it.

"The black shale when broken up or the dry 'mud' of the drill hole soils the fingers like black lead. This rock is filled with very small veinlets of quartz and the platinum seems in combination with the many small specks of bright iron pyrites.

"The quartz with platinum in it has the favorable look of iron-stained quartz containing gold, but the quartz is clearer and heavily spotted with a maple sugar colored brown. Sometimes there may be a 'powder flash' of light, goldy looking leaf metal in the seams of specimens of smaller grain and this is an alloy of platinum and gold. The porphyritic rock is pinkish in color throughout and crystalized so as to give almost the appearance of quartz and calcite, but it isn't when examined closely. This was pushed up from way down below in the earth and the platinum is associated with a small quantity of chromic oxide, showing greenish looking stains in the seams. You can detect a metallic point now and then on the surface in the sunlight.

"It is my opinion that the crystalline rocks like quartz and porphyry, possibly granulite, too, in which the chromic oxide occurs in thin micaceous sheets of glistening green, are the natural sources of platinum in Vermont; the black shale and sandstone having been enriched from solutions flowing through masses of disintegrated crystalline rocks and worked into these under pressure along with pyritous matter before they were baked."

In addition to the above, Mr. Hinchman has kindly sent me copies of letters from Torrey and Eaton, Assayers, New York, in which they say "No. 4 contains a small amount of platinum, probably not more than ¼ oz. per ton of the pulp sent and possibly a trace of gold." Mr. Hinchman says "The principal platinum prospect mentioned in the article in Expansion is located on the right hand side of the road from Plymouth Five Corners to Tyson and three-fourths of a mile from the former place. August 9th, 1904, Messrs. Torrey & Eaton, 30 Wall Street, New York, found a trace of platinum in grey gneissic rock from the Keyes farm at Readsboro, Southern Vermont."

It should be stated that the No. 4 mentioned above was a pulp obtained from "the crushed vein stuff mixed with quartz, found between the alternate cleavable layers of limestone, slate and sandstone rock."

"The crushed rock matter has been treated to a dead roast. No. 3 was taken out of a chlorine solution as a precipitate by using sal ammoniac and permanganate of potash as precipitants. No. 4 is the pulp then remaining."

COPPER.—A brief history of copper mining in Vermont was given in the Second Report, 1900, and need not be repeated here. A few of the more important facts may be summarized as follows: Copper ore has been dug with little interruption at one or another locality for more than a century, the ore at or near the Elizabeth mine in South Strafford having been dug for the manufacture of copperas in 1793. For many years after this copperas was thus obtained and then came the true copper mining when the chalcopyrite, which is the common ore, was dug, no longer for copperas

making, but for the copper it contained. This was not far from 1820. In time the production of copper had so increased that Vermont became the largest copper producer in the country and the copper mines were the most important mineral industry in the State. Then copper was discovered and mined in the now world famous Michigan copper belt, and the Vermont mines, though holding their own for a time, ere long began to be superseded and finally during the last ten years or so have been worked very little. There is an enormous amount of chalcopyrite in Corinth, South Strafford, Strafford and Copperfield. The percentage of copper is low and often there is much pyrite associated with the chalcopyrite. The low percentage of copper and the necessity of a haul of several miles to the railroad have been the great hindrances to successful working of these mines. If a cheaper method of extracting the copper is ever discovered there can be no doubt that these mines will again become important. The copper in these ores is from 1 per cent. to 30 per cent., but the latter percentage is by no means as common as the first. On the average, the proportion of copper may be stated at not far from 3 per cent. During the past two years more or less work has been done at the old Ely mine at Copperfield, at the Elizabeth mine at South Strafford and at the Union Mine in Corinth. At present there is not much work going on at any of these points, but it is possible that there is yet a future for the copper industry of our State. As will be seen later, there is a strong probability that newer and cheaper methods will soon be discovered, if they have not been already, and when this is accomplished the vast masses of low grade ore which are to be easily obtained in the localities mentioned will be in demand, and will, as in years long past, bring an important revenue to the State.

The large copper deposits of Vermont are all in the eastern part not far from the Connecticut river. There are smaller deposits elsewhere, but here are those that are likely to be of importance. The prevailing rock is mica or other schist, which has been called by Dr. Richardson "Bradford schist." In an article by Mr. Walter H. Weed published in Contributions to Economic Geology, Bulletin 225, 1903, U. S. G. Survey, there are sundry very interesting discussions of the copper area and from it I am glad to quote as follows: "The schistose rocks of the region, which underlie the glacial drift and frequently project through it, are prevailingly slate colored or gray, varying from coarse to fine in texture and foliation, the differences in color being due to varying proportions of biotite and silica. At the Elizabeth mine the foliation is very regular and the bands can be traced for long distances. At Copperfield the foliation is north and south, with a dip of 25° - 30° E; but the structure in general is that of a broad anticlinal fold, the detailed structure showing close folding and pushing of the softer more schistose beds, so that no single band can be followed for a long distance. The rocks when so folded contain many intercalated masses of quartz occupying the crests of the little anticlines and filling irregular, lenticular spaces along the flanks of the folds. Examination of thin sections of these rocks under the microscope shows them to consist of quartz, biotite, calcite, and magnetite. They thus appear to represent metamorphosed sedimentary rocks, probably impure sandstones, and siliceous shales."

"The deposits of the Vermont copper belt occur as lenticular masses in foliated micaceous schists. The ore forms lenses of varying horizontal extent and thickness, and these lenses overlap so that in going down a lens wedges out, but the tapering bottom of one lens overlies the upper end of another. The ore bodies sometimes show a clearly defined foot wall, but more commonly show transitions into the adjacent rock.

As a rule the foot wall is more regular than the hanging wall, the latter showing frequent undulations.

The horizontal extent of the ore lenses varies considerably at the different mines and, indeed, in the different lenses of the same mine. The ore body at the Elizabeth Mine has been extracted for seven hundred feet horizontally, and in the Ely Mine a lens over a hundred feet across has been mined. Along its strike an ore mass may either end in a blunt wedge sometimes showing a mere edge along the horizon, or the ore may fork into rapidly thinning wedges, or simply grade into country rock by an increasing amount of "slaty" material. The horizon of the Elizabeth ore body is traceable for nearly a mile, and another ore body, the Reynolds, is found on its continuation one and one-half miles northward.

The thickness varies at different localities. At the Elizabeth mine the ore was as much as 100 feet wide in the open cut workings, and on the 225 foot level is 35 feet between the walls. The ore has a maximum width of 12 feet at the Union and adjacent properties in Corinth and of 20 feet at the Copperfield property.

The depth to which these deposits extend is unknown. At the Ely mine the inclined shaft is 3,400 feet long.

The ore bodies are remarkably free from water. At a depth of 3,400 feet, the Ely ore body is very dry, the water of the mine being confined to a few hundred feet of the upper workings. The ore and encasing rock are very solid and practically no timbering is used.

The chemical composition of the ores is shown by the following average of a large number of analyses made of ore from the Elizabeth mine:

Copper	3.25
Iron	35.60
Silica	27.00
Lime	1.55
Sulphur	19.18
Magnesia	0.82
Alumnia	7.76
Zinc	1.07
Gold	trace to .02 oz. Silver .20 oz. per ton.

"The Ely ore carries about 15 per cent. more silica than the above, and the Corinth mines are of intermediate character." (Bulletin U. S. G. S. 225, pp. 190, 193.) I have already referred to the necessity for discovering a cheaper method of extracting the copper from these ores and just as I am writing this there comes from the author an account of a new method "The Wethereill Process Patent." The following extracts are quoted from the "Statement Respecting the Proposed Method of Working the Ore by Magnetic Separation," by J. N. Judson.

PROPOSED TREATMENT.

"Generally, the plan of the proposed treatment is as follows: The ore, as it comes from the mine, without sorting or selecting, will be crushed to, say, 10 mesh, or to whatever degree may be found most suitable, dried, sized and passed through magnetic separators for the removal of the bulk of the pyrrhotite. The residue, consisting of the bulk of the chalcopyrite and gangue minerals, will be roasted in some form of mechanical furnace, for the elimination of a portion of its sulphur and the partial oxidation of a certain portion of the iron in the sulphide minerals, and again passed through magnetic separators and the copper removed as good grade, self-fluxing product, amounting to perhaps 25 per cent. of the weight of the crude ore treated. The final non-magnetic tailings will consist of quartz, feldspar, muscovite mica, etc., which will be assumed as assaying 5 per cent. copper, whereas, it one may judge by the results of other places where Mr. Rowand's separators are employed on somewhat similar work, they should average much lower, probably not one-half of that figure.

While such is the general outline, the actual mill procedure may be varied somewhat in details.

As it is proposed to treat all of the ore mined without sorting or selection, it may be taken as having an average copper assay of 2.66 per cent., equivalent to 7.7 per cent. chalcopyrite. If, in addition, it contains 50 per cent. of pyrrhotite, with 3 per cent. of iron as oxide, its total iron contents will be 35.6 per cent., as given by Mr. Weed, and the only change from his figures will be in the percentage of sulphur, for the above stated amounts of chalcopyrite and pyrrhotite call for 22.44 per cent. of that element. With ore of the said composition and allowing that 50 per cent. of a pyrrhotite product of the assay given in the preceding paragraph is removed, the following table is of interest:

	Iron.	Copper.	Sulphur.
Ore, assays	35.6	2.66	22.44
Less 50% Pyrrhotite product	26.0	0.48	16.50
50% of Residue contains	9.6	2.18	5.94
Residue assays	19.2	4.36	11.88

So that out of the total sulphur in the ore some 74 per cent. will be mechanically removed in the magnetic product and at least saved from contaminating the atmosphere, even if it cannot readily be made a direct source of revenue."

"The magnetic process, as adapted for the Vermont ores, is not an expensive one, either in plant or operation. The crushing, sizing and drying of ore is practiced the world over, so it is not necessary to further allude to those steps. For the removal of the pyrrhotite, in most of the trials recorded, the crude ore was passed through a separator at the rate of 1 ton per hour. The magnet was excited by a current of 6 amperes at 115 volts, or with less than a horse-power of electrical energy. The later separation of the copper smelting products from the roasted residues could readily have been accomplished with a machine of the same power, so it may be said that the separations were effected by an expenditure of 2 horse-power in electrical energy at the rate of 20 tons of crude ore per day (*i. e.*, 20 hours). The separators had two fields, with working poles each 18 inches long, and the ore passed through both fields. As in most cases rather too much of the ore was removed in the pyrrhotite product, it was evident that a passage through one field would have been sufficient to have insured the removal of the bulk of the iron sulphide, so, with separators of a somewhat modified construction, the writer believes that fully twice the quantity of ore can be treated for the same expenditure of energy."

Mr. Judson and Mr. L. G. Rowand have leased the Elizabeth mine for two years and propose putting the method described to a thorough test in a large way at that place. Numerous preliminary tests with a small quantity of ore from all of the Vermont mines have already been made and the results were very encouraging. If this or any process can be found which will accomplish the results expected from this, copper mining in Vermont will unquestionably be speedily revived and brought back to its best days, for it is estimated as the result of many trials that the cost of producing copper in the new way will be less than half that of the best old method.

It is fortunate that two men who are not new in the business of handling ores and who have exceptional advantages for carrying out their plans should have taken hold of the Elizabeth mine. Every Vermonter will wish them success. Mr. Rowand is the inventor of the magnetic separators used in the new process and therefore will be especially competent to give them the best possible opportunity in working the Vermont ores.

Moreover, the process will not be used practically for the first time at the Elizabeth mine, for it has already been put to trial at some fifteen or more mines in this and other countries.

The following extract gives the belief of these gentlemen as to the future of their enterprise.

"The figures and estimates given are exceedingly conservative, and as there can be no question that the technical results arrived at in the experimental work on the Vermont ores can readily be obtained when operating in a commercial way, it is evident that the Elizabeth property can be made highly profitable, even when operated on what will be a very modest scale, pending the development of the property, as compared with the Tennessee Copper Company, and that without the creation of a nuisance to the community at large. The fact, as attested by Dr. Ledoux, that the mine contains a vast tonnage of ore of considerably greater value than 2.66 per cent. should not be overlooked, and, moreover, the possibilities lying in the future utilization of the pyrrhotite have not been taken into consideration."

Glaciation of the Green Mountain Range.

By C. H. Hitchcock.

In commencing to describe a prominent feature in the movement of the glacial ice over the higher mountains of Vermont, one is reminded of the view of the "drift" expounded in "The Geology of Vermont" prepared at the expense of the State under my father's direction and printed in 1861. It was there advocated that the various phenomena had been produced in connection with a deep oceanic submergence. Striae upon the summits of mountains were supposed to have been made by debris frozen into or moved in connection with floating masses of ice. That the highest points of land should have been scored by abrasions passing over them seemed to the older geologists better explained by floating than by glacial ice; for no one had then made clear how ice could move up hill to altitudes of thousands of feet. The ice of living glaciers moves down slopes: how then could the ancient ice have passed over the tops of the mountains unless the land itself had been so low that icebergs could have floated over them? The geologists had the credit of believing many strange stories, but even they hesitated to accept the doctrine that land ice could have been pushed over New England from the St. Lawrence valley. It is not the place here to show how the glacial theory gradually replaced the belief in icebergs and submergence. It is now accepted well nigh universally.

Briefly stated the following proposition may express the condition of things in the eastern part of our continent, so far as our territory was concerned. There was a glacier of continental dimensions, having its starting point in Labrador and sending out streams on every side. Part of it moved towards Newfoundland: more of it slid into the valley of the St. Lawrence, filled it to overflowing and discharged as readily as possible over the New England heights, the Champlain-Hudson valley and the Adirondack summits. Perhaps the greater portion followed the depressions of the Great Lakes towards the upper Mississippi. The Champlain-Hudson valley was the line of the least resistance, being at a low level and in the direct course, and, therefore, the ice seems to have followed it over a distance of eighty miles out at sea; while the excess pushed southeasterly over New England upon one side and southwesterly over the Adirondacks upon the other. So we may speak of the *Hudson River Lobe of the Labrador Glacier.*

Four mountainous areas exist within the territory named, all of which maintain intimate relations to this glacier. First, there is the inhospitable Labrador tract including the mountains to the far north and the watershed between Hudson's Bay and the St. Lawrence. Dr. R. Bell, (1), states that there are mountains about seventy miles back from Cape Chudleigh apparently from five to six thousand feet high, and the summits near the salt water lie above the influences of glaciation. Quite recently, I have seen the statement made that some of those mountains are fully 8,000 feet in altitude. If so, and the gathering ground is extensive, the problem is greatly simplified. The glacier started from a region capable of sending ice-streams over the valley near by and the distant mountains. Otherwise there has been a resort to two theories: either the land was higher than now in the Labrador district; or else the snow accumulated in such enormous masses that it was itself the high land. Whatever the high land may have been, there is no doubt of the movement of ice in the areas mentioned.

Second, there is the high land of eastern New England, in which lies the culminating point of the whole region—Mt. Washington, 6,293 feet. Its outpost is Mt. Katahdin, almost exactly a mile in height which proves to have been overridden by the ice sheet.

Third, the Green Mountains represent a line of summits trending a little east of north, and very greatly resemble the Blue Ridge of Virginia of which they are the continuation. They have been glaciated from Mt. Orford in Canada to Greylock in

Massachusetts. Connecticut river drains much of the eastern and Lake Champlain much of the western slope.

Fourth, the Adirondacks occupy the most of northern New York. They lie in parallel northeast ranges, with a culmination in Mt. Marcy 5,344 feet. The country is extensively forested, the soil inferior and the rocks granite much like those of Labrador.

Observations have been made of the glacial movements in all these areas, each one of which has its peculiarities. The White Mountain district has received the most attention, nearly all of its peaks having been examined for the signs of glacial occupation. All the higher summits have been abraded by the ice sheet. The Green Mountain area has been visited in part. All the higher peaks present the same phenomena, save that the greater altitude of the New Hampshire summits has been the occasion of a post-glacial accumulation of angular debris, leading the earlier observers to think they were never covered by the ice. The Adirondacks have been studied to a less degree than the Green mountains, and the Labrador country is known the least of all.

I will commence with a full account of all that is known of the Green Mountain region.

The Green Mountain Range.

The Green Mountains are spoken of as commencing in the Gaspe peninsula of Quebec, but for our purpose it will not be needful to speak of them east of the St. Francis river. The range is very low along this stream, from Sherbrooke to Richmond, 485 to 390 feet. The St. Francis rises near the Chaudiere, flows south-westerly till it turns abruptly and proceeds to the northwest, affording an easy grade for the Grand Trunk Railway. The stream is to be compared with the three rivers of northern Vermont which have cut through the range to its very base. The first important rise is to Mt. Orford, 2,860 feet. The line of the watershed descends next to Orford Lake, 961 feet. It rises again to mountains in the north part of Bolton, estimated to be 2,000-3,000 feet high.

The Bolton Gap, 711.

Sutton mountain, 3,000.

Glen Sutton station, Southeastern R. R. (C. P. R.), near the Missisco river, 526.

Irregular rise to Jay Peak, 4,018.

Descent to Hazen's Notch, 1,760.

High mountains in Lowell and Eden.

Descent to the Lamoille river, 541 feet at Johnson.

Sterling mountain, 3,700.

Mt. Mansfield, Chin, 4,348; 4,430 Guyot. The Nose, 4,094.

Winooski river, R.R. Station at Bolton, 345.

Camel's Hump, 4,088.

High peaks in Fayston, unmeasured.

Lincoln mountain or Potato Hill, 4,078.

Road from Warren to Lincoln, estimated at 2,000 feet.

Bread Loaf and Hat Crown.

Road from Hancock to Ripton, over 2,200 feet.

Mt. Horrid, Goshen.

Road from Rochester to Brandon.

High mountains in Chittenden, nearly 3,000 feet.

Commencing with the north line of the Rutland Quadrangle of theUnited States Geological Survey it is possible to follow the crest line of the Green mountains with great exactness through the Rutland, Wallingford, Londonderry, Equinox, Bennington and Greylock sheets to Greylock. I will mention only the more important points.

Road through Mendon, at the watershed, 1960.

Unnamed mountain, 2,856.

Road over the crest in Sherburne, 2,210.

Pico Peak, 3,960.

Mt. Killington, 4241. Given as 4,380 by H. Gannet, Bulletin 76, U. S. G. S.

Little Killington, 3,951.

Shrewsbury mountain, 3,737.

Saltash mountain, Plymouth, 3,278.

Mt. Holly summit on the railroad, 1,515.

South line of Mt. Holly, 2,824.

Highest peak in the east part of Mt. Tabor, 2,881.

Carriage road summit, Mt. Tabor, 2,140.

Highest peak in south part of Mt. Tabor, 2,961.

"Mt. Tabor" in N. W. corner of Peru, 3,586.

Styles Peak, Peru, 3,404.

Road over the range in Peru, 2,440.

Bromley mountain, Peru, 3,260.

Carriage road summit, Winhall turnpike, 2,040.

Mt. Stratton, 3,859.

Carriage road summit, Sunderland, 2,740.

Glastonbury mountain, 3,764.

Peak near south line of Glastonbury, 3,330.

Carriage road summit, Woodford, 2,389.

Mountains in Stamford, 3,063, 3,013.

Carriage road summit, Hartwellville to Stamford, 1,905.

Mountain South, 2,640.

Carriage road, Readsboro to Stamford, 2,400.

Hoosac range in Stamford, 3,014.

Hoosac range in Massachusetts, 2,800.

North Adams, Hoosac river, 704.

Greylock, 3,505.

The following features may be particularized: 1.—The Green Mountain range in Vermont is about 150 miles long, with a considerable uniformity for the higher summits. There is an absence of marked gaps for more than two thirds of the range at its southern end. 2.—There are four valleys crossing the range at its northern part; (a) St. Francis river in Canada; (b) Missisco river near the International Boundary; (c) Lamoille river just north of Mount Mansfield; (d) Winooski river at Bolton. The drainage is to the west or northwest in these four valleys, and the amount of erosion must have been fully 3,500 feet from the crest line down. Opposite the southern two thirds of the range, the drainage on the east is to the south, the Connecticut river. 3.—The lowest of the gaps higher than these river-cuts are near Mt. Orford, 961, in Bolton P. Q., 711; Hazen's Notch, Westfield, 1,760; Mt. Holly 1,515; Hartwellville 1,905. These are "wind gaps." 4.—The highest peak is

Mt. Mansfield 4,430, Guyot. Killington is put at 4,241 on the Rutland Quadrangle but at 4,380 by Henry Gannett in Bulletin 76, U. S. G. S. If the older figure for Mansfield at 4,348 were accepted, Killington would be a few feet higher, 4,380.

THE GLACIATION OF MT. ORFORD.

This summit rises quite abruptly to 2,860 feet, and being at the north end of the range one would imagine the ice current might have been deflected; though it be contrary to the analogy of the neighborhood to suppose it to have been a nunatak, rising above the ice. Thus R. Chalmers says: (4), "Orford Mountain, at the north end of Memphremagog Lake, was found to be glaciated to a height of 1,800 feet. The summit, 2,600 feet high, is bare rock, but no ice action was observed upon it. Owls Head, on the west side of Lake Memphremagog, 2,400 feet high, has not, according to Dr. Ells, been glaciated on the summit either. These and a number of other peaks in this range must have stood up above the surface of this ice sheet as "nunataks" [nunatakr] even during its maximum development."

I visited the summit of Mt. Orford in October, 1897, and reported the results of my observations to the American Association for the Advancement of Science, Boston meeting 1898, (5). Glacial striae were found at intervals to the very summit with a southeasterly direction. Boulders of the Laurentian gneiss from the north side of the St. Lawrence were recognized—a piece of one weighing perhaps fifteen pounds was sent to Professor F. D. Adams of Montreal for identification, and he wrote that the specimen must have come from the north side of the St. Lawrence. The glaciation at the very summit is remarkably well defined.

Our conclusion about the glaciation of this mountain has been confirmed by Principal Dresser, (6). After quoting Mr. Chalmers' statement, he says, "From these conclusions it is evident that the observations on which they are based did not include that dome shaped part of the summit of the mountain which is apparently its highest point. This, which is separated from the highest of the bare and exposed peaks along the front or

southern face of the mountain, by a deep ravine, shows most undoubted evidence of glaciation. Here, near the point where a flagstaff has stood for the past few years, the rock, a fine grained and much altered diabase, is distinctly striated, and the whole eminence has a generally smoothed and rounded appearance. Fragments of clay slate and pebbles of other rocks foreign to the mountain occur here, and boulders of serpentine, evidently from the western base of the mountain, are to be seen in other places near by. The rock appears to have suffered less from atmospheric erosion than at points of about equal height a hundred yards to the south, from which it seems reasonable to infer that it has been protected by a thin mantle of drift, of which the transported rock fragments mentioned above are remnants, which have not been removed by summer rains or forest fires. The direction of the glacial striae, as measured at the flagstaff by Mr. A. H. Honeyman of Knowlton, Que., and the writer, was found to be S. 25° E. magnetic, which fairly accords with the directions given by Mr. Chalmers for striae caused by the greater Laurentide glacier at the foot of the mountain. These range from S. 25° E. to S. 53° E. on the true meridian."

In regard to the glaciation of Owl's Head mentioned by Dr. Ells, I may say that I have examined the summit of this mountain and found no striae, because the rock has deteriorated and the glaciated surface destroyed. I did not, however, make the careful search for marks which may exist, first, because I was not aware of Dr. Ells' statement at the time of my visit and, second, because I found plenty of transported fragments about the summit, which are as good evidence of glaciation as striation.

Dr. Ells has spoken of the dispersion of boulders of the Laurentian gneiss over the whole of the region south of the St. Lawrence, (7), below the elevation of 1500 feet. They extend beyond the International Boundary and water shed into Maine, New Hampshire and Vermont; and have been dispersed by the Labrador glacier which both covered the lowland and swept over the heights.

Principal Dresser writes me that he has also discovered the marks of glaciation upon the summit of Sutton Mountain 3000 feet above the sea. This is the highest point in the Green Mountain range of Canada in the field of our inquiry. I found southeasterly striae upon the summit of the "Pinnacle" in Sutton in 1879.

THE HIGHER PEAKS IN VERMONT.

Jay Peak, 4,018 feet, is the first of the higher summits met with in proceeding southerly from Canada. It was explored by Prof. C. B. Adams, State Geologist of Vermont, who reports striae with the direction S. 40° E. on the summit, accompanied by furrows having the same direction.

The glaciation of the summit of Mount Mansfield is described in the Geology of Vermont, 1861, (9). I found striae measuring S. 10° E. with a rough stoss side upon certain ledges directed S. 40° W. on the Chin. This was in 1859. Mr. A.D. Hager later discovered striae running S. 45° E. between the Chin and the Nose, and presented an illustration of the same, adjacent to boulders, which seemed to him to have been the agent of erosion, (10). Prof. Edward Hungerford supplemented the observations of the Geological Report in 1868, (11), upon Mount Mansfield and elsewhere. He found very large transported boulders upon the ridge with striae bearing S. 25°-28° E.

I visited Camel's Hump in 1859 and found striae running about N. W. and S. E. "The summit illustrates beautifully stoss and lee sides," (12). Professor Hungerford found upon the summit of Camel's Hump fine lines of striation upon knobs of quartz with the directions S. 10° W., due W. and S. 35° E. About 700 feet below the summit, on the east side, he found striae bearing S. E. and S. S.E."

No one has reported upon the summit of Lincoln mountain. I have repeatedly crossed the range by the Warren-Lincoln carriage road and found no bare ledges upon the summit. Both flanks are covered deeply by till.

Professor Hungerford reports for Mount Killington a "well defined northern stoss side" and saw numerous small boulders

of foreign rock within 20 feet of the highest point. In 1896 I found there traces of the glacial smoothing from the north and N. 30° W. Boulders of the Georgia quartzite were plenty, also a two feet square block of a white quartz conglomerate, and diabase; all from the west side of the mountain.

The region north of Killington must have been extensively traversed by southeastward ice currents, since pebbles and blocks of the Burlington red sandstone are common in the till and modified drift at the lower end of White river and farther south. They are very abundant at the Quechee railroad summit and the Gulf.

In the east part of the Mount Holly gap striae are reported from S. 50°-60° E. In Ludlow and Plymouth there are several similar directions.

TRIP TO MOUNTS STRATTON AND HAYSTACK.

At the request of Prof. G. H. Perkins, State Geologist, I examined the summits of Mts. Stratton and Haystack in 1903, and he accompanied me to the summit of Mt. Stratton. These two mountains are the highest peaks in the southern part of the State, and therefore it was desirable to determine the course of the ice currents upon them.

We found Mt. Stratton completely covered by earth and forest growth. Fortunately a tree had been blown over on the summit laying bare a ledge having striae upon it pointing S. 18° E., magnetic. A quartz knob in another place showed glacial smoothing. Elsewhere several cobble stones of gneiss and quartzite made their appearance so that the evidence was decisive of the transportion of rock fragments over the summit in a direction east of south. There are signs of a local glacier down the valley of the North branch, as intimated in the report.

The summit of Haystack is a sharp cone 600 feet high, the total altitude being 3,462 feet. It is composed of a rough mica schist like that described from Searsburg, with many grooves and scratches running S. 20° E. magnetic. Being almost a bare rock no stones could remain upon it hence there can be no mention of erratics. Some of the grooves are a foot wide and several inches deep.

THE TACONIC MOUNTAINS.

Such Taconic mountains as Equinox and Eolus (Dorset) do not readily retain the drift markings, though a better search might reveal them. I have climbed only one of them in Vermont. Greylock is one of these summits, though in the line of the Green Mountains. There is nothing equivocal about the marks of the ice here. My father describes them in his report on the Geology of Massachusetts, (13), running east of south and I have verified his observations. More exactly, I found in 1892 striae S. 18° E. at the height of 2,400 feet. The same was found near the top and at the summit. I also found there many boulders of the Georgia quartzite. This is a very hard rock and therefore it is excellent material to illustrate the dispersal of the drift. The south east course in common on the Taconic peaks in Massachusetts, as along the whole western boundary of the State, upon Tom Ball in Alford, Lenox Mountain, etc. Upon Mounts Everett and Washington its course is S. 10° E. and S. 70° E. upon both sides of Hoosac mountain near the tunnel.

OTHER HIGH SUMMITS IN VERMONT.

A few examples of the courses away from the Green Mountains may be of interest. In Berkshire they run S. 8° E., S. 25° E. and S. 40° E. In Sheldon and Enosburg the course is S. 35° E. and S. 47° E. Upon the summit between Roxbury and Warren the striae run S. 31°-55° E. Zadock Thompson mentions several in Huntington from S. 26° to 68° E. Upon Mt. Pisgah 3,800 feet high on the east side of Willoughby Lake I found rather obscure striae S. 30° E. in 1892. Upon Mt. Pulaski in Newbury the course is S. 25° E. The highest land in Windham shows them running S. 20° E.

There are some lines running west of south, especially in the southeast corner of the state, as in Halifax, Wardsboro and Marlboro. At the interesting pot holes on the town line be-

tween Wardsboro and Dover 2,235 feet above the sea the striae run S. 30° W. It is in the col between higher mountains, and must have been the line of the discharge of a lobe of the great glacier. The westerly course is very marked down the Connecticut valley, particularly in Massachusetts and Connecticut and seem to represent an independent lobe of the ice sheet, probably after the ice had reached its maximum development.

Mt. Ascutney 3,186 feet high exhibits two sorts of glacial action. Upon the summit I observed the several directions of S. 20° W. S. and S. 70° E. One fourth of the way up S. 10° E. The rock is not a good one to retain the markings and some of these mentioned have since been obliterated by weather action. Two elements are to be noted. The first is the southeasterly movement common to the higher summits, and this is poorly shown by the striae, but very markedly by the rock fragments that strew the surface in Claremont and Newport, N. H., and elsewhere. The second element is that of the Connecticut valley lobe running south and slightly west of south. The mountain was a sort of measuring pole inserted in the midst of the Connecticut glacial lobe. As the southerly movement has been detected upon the summit, it is clear that Ascutney was not a nunatak but was entirely submerged in the ice-mass in the later period.

GLACIATION IN THE ADIRONDACKS.

In the older literature I find very little said about the evidences of ice action in the Adirondacks. The region lay chiefly in the Second District, reported upon by Professor E. Emmons. Several things were understood by him, (14). 1. The belt of drift along the western slope of the Green Mountains shows a predominance of Taconic rocks, with none of the so called primary crystallines. 2. The middle belt, including parts of the Champlain-Hudson valley and the Adirondacks, is characterized by boulders of hypersthene, gneiss and primary limestone. 3. The western belt, along the St. Lawrence valley, abounds in hypersthene and the granites of the far north. The striae are to the south in the Champlain valley and to the southwest in the St. Lawrence valley. The work is supposed to have been done mainly by icebergs; and he takes pains to mention his acquiescence in the views of Murchison.

The Third District, reported upon by Professor Lardner Vanuxem, lay to the southwest and south of the Adirondacks, just reaching into the crystalline area. He accepts as the more probable view the glacial origin of striae; and I understand him to teach that the distribution of the boulders in Northern New York was due to radial movements from the central upraised primary mass of the Adirondacks, (15). He assumed that the primary rock boulders of the St. Lawrence valley came from the Adirondacks rather than from the far north. In the description of the county geology he mentions the occurrence of the primary boulders in great abundance in the counties of Herkimer, Montgomery, Oneida, Otsego, Madison, Cortland, Tioga, and even into Pennsylvania. Thus the fact of the southwest movement from the Adirondacks is substantiated by the observations of Vanuxem.

Prof. T. C. Chamberlin presumes from the data in his possession, 1883, (16), that massive currents swept around these mountains both from the Champlain and St. Lawrence valleys, "while a further current, at the height of glaciation, probably passed over the Adirondacks, and gave to the whole a southerly trend."

Mr. Verplanck Colvin presents quite a satisfactory general statement about the glacial appearances of the higher summits. Mt. Marcy is said to be destitute of glacial drift; but its ledges have been rounded as if by ice, while the striae have been obliterated by weathering, (17). The other high peaks are more or less covered by the drift.

On attempting to gain further information, I found independent observations of striae by Prof. H. P. Cushing, upon the north flank of the Adirondacks, which were generally southwesterly. Prof. J. F. Kemp reported a similar direction as prevalent about Moriah, and elsewhere to the west of Lake Champlain. The striae in the Mohawk valley are described by Prof. A. P. Brigham as (18) flowing to the west.

Prof. J. D. Dana in the fourth edition of the manual of Geology, p. 952-4, 1895, presents an unusual generalization; due of course to the lack of precise information. "The ice of the Adirondack region flowed south, southeastward, over eastern Connecticut, into what might be called the realm of the White Mountains and it did this notwithstanding the obstructing Green Mountain range on the route; and this is evidence that the Adirondacks part of the plateau was the higher." "The facts prove that from all western New England the flow was from the northwestward, across the Taconic Range and the Green Mountains, and in a direction from the Adirondack region, or the more elevated Laurentide region beyond it."

Being desirous of obtaining satisfaction as to the actual movement of the ice over the higher Adirondacks, I visited Mt. Whiteface in 1896 and Mt. Marcy in 1898, and presented my conclusions in three brief papers, viz: "The eastern lobe of the Ice Sheet" in the American Geologist, July 1897. "The southern lobe of the Laurentide Ice Sheet," Proceedings of the Toronto meeting of the British Association for the Advancement of Science, 1897. The results of the trip to Mt. Marcy July 7, 1898, were stated orally the same evening to the Appalachian Club at St. Hubert's Inn, (19), and were included in the abstract of the third paper, "The Hudson River Lobe of the Laurentide Ice Sheet," August, 1898, published in the Proceedings A. A. A. S., Boston Meeting. It has been a matter of regret that this last abstract was so imperfect; but its purport did not differ from the first named paper. The discovery of the additional facts at Mt. Orford and the Adirondacks led to the change in the title.

The cone of Mt. Marcy rises abruptly for a thousand feet vertically. At its south base I noted a small esker, which certainly was once connected with a glacier. There seemed to be very little indication of disintegration in the rock of the cone. It is like one grand embossed ledge. Boulders estimated to weigh ten tons rest upon the surface besides many smaller ones and they have the usual shape of glaciated stones. No fragments of Potsdam sandstone were seen. If the boulders came through glacial transportation they could have come from a distance of more than twenty miles, since it is possible to travel that distance in a northeasterly direction on the same kind of anorthosite as is found on the summit. This peak has probably been glaciated.

The trip to Mt. Whiteface in 1896 proved the existence of southwest striae from Crown Point and Port Henry across to Jay and Wilmington. Mt. Whiteface, exceeding 4,000 feet in altitude, was found to be more or less covered by till carrying fragments of Potsdam Sandstone derived from the north east. Any mass of ice that came from the northeast and covered Mt. Whiteface must have covered also the whole Adirondack region, leading to the general conclusion that a lobe of the ice sheet moved southerly from the Laurentian highlands, naturally following the depression of the Champlain-Hudson valley. As in every glacial lobe there are radial movements to either side, so here the ice moved to the southeast over New England, and to the southwest over the Adirondacks.

The western limit of this lobe may have been at the angle in the terminal moraine near Salamanca, N. Y.; the eastern limit at Cape Cod, unless the land were elevated and the ice extended further to the east. It is probable, also, that the lobe continued down the submerged valley of Hudson River eighty miles beyond New York.

The facts about the glacial phenomena in the Adirondacks are brought out later by I. H. Ogilvie in the Journal of Geology, (20). He supplements the observations of Prof. H. P. Cushing in the northern counties, of Prof. J. F. Kemp in the eastern counties, and those of the Vermont Geological Report of 1861 for Lake Champlain. His conclusions are in accord with what have been already stated for the several districts named. All the striae known to the author are tabulated and presented graphically upon a map. "Not a single record," he says "has been found among the highest mountains. The map shows the three zones of striation: a zone along the Champlain valley where the striae are very numerous and variable in direction; a zone along the gneissic hills where they are less numerous and prevailingly [from the] northeast; and a zone among the high anorthosite peaks, where striae are entirely lacking, though the mountain tops here are conspicuously smooth." He further remarks; "upon the crystalline rocks of the Adirondacks the direction is uniformly southwest. No striae were observed in this region in other directions, except those which could be clearly shown to be influenced by some topographic variation of local character. There appears to be no change in direction with altitude. The approach to the high and rugged mountains is marked by a conspicuous decrease in the number of striae, which is what would be expected if the ice were stagnant in the valleys." * * * * "The summits, however, have been markedly smoothed; the abundant boulders of Potsdam sandstone on even the highest peaks give unquestionable evidence that the region was entirely buried, and by ice in vigorous motion. The conclusion reached is, therefore, that the ice entered the region from the northeast, flowing on in that direction where open valleys afforded opportunity, becoming stagnant in narrow valleys, and, finally, at the time of its greatest advance burying the region entirely, an upper southwestward moving current passing over the stagnant valley masses below."

PROFESSOR UPHAM'S PAPER.

In 1889 Prof. Warren Upham read a paper before the Appalachian Club, (21), upon the Glaciation of Mountains in New England and New York. All the facts known at that date respecting the marks of glaciers upon the higher summits of Maine, New Hampshire, Vermont and New York were summarized. The present report may be looked upon as the supplement to Professor Upham's very noteworthy contribution. Had it not been for the handicap of several nunataks proposed by the earlier geologists, Professor Upham would undoubtedly have presented the generalization suggested by my later paper.

He says that "New England presents three types of mountains in respect to glaciation, of which the least frequent is exemplified in this district only by Mts. Katahdin and Washington, with the neighboring peaks of the Presidential Range, where the surface has not been swept by the current of the ice-sheet, or, if it were at one time wholly ice- covered, as is demonstrated for Mt. Washington, the time of the glacial envelopment was very brief, not sufficing for the removal of the loose masses which have been fractured by frost from the underlying rock. The second and most common type is represented by Monadnock, where the moving ice-sheet has carried away all the rock fragments which before the Ice Age doubtless presented generally on all our mountain tops the same appearance as the present summits of Katahdin and Washington; instead of which, the surface is now left bare, and rounded in smooth low hummocks of rock on the stoss side." * * * * "A third and infrequent type is represented by the northwest side of Mt. Carrigain, where deposits of glacial drift, analagous to the till of lower areas, cover the bed rock."

It is of course natural to seek for symptoms of weak glacial action upon the highest mountain; especially as it has been held by many geologists in the past that all the higher summits were simply nunatakr, the first named type of Upham. My later studies of the Presidential Range, I think satisfactorily prove that the ice has moved vigorously over every Montalban summit. Except for the debris of later origin, were the levels two or three thousand feet lower, no one would consider the phenomena different from those common at lower altitudes. In the first place, a peak represents a very small area; transported material might happen to be very scant, and however abundant, to have been removed. The rain descending the slopes will wash out the clayey part of the till, and the stones thus liberated are liable to yield to the influence of gravity and descend. Mt. Washington has lost hundreds of the foreign stones carried there by the ice by the hands of Geologists anxious to possess themselves of such interesting glacial relics. The geologists of the year 1950 will not find a single one re-

maining, if the students of the next half century are as industrious as those of the past thirty years have been. Secondly, the angular debris of Washington and Katahdin is the product of conditions prevalent since the Ice Age. The exposure to freezing at the present time is excessive, and is adequate to account for the angular character of the fragments, as it has been no less intense ever since the glacial period. Preglacial disintegration cannot be proved. Third, striae and embossment are as plainly shown upon Mt. Washington as upon the average mountain of inferior altitude. The striae have been measured upon a ledge not fifteen feet lower than the apex, and are common upon fragments of quartz detached from the solid rock by freezing and gravity.

A word as to Katahdin. Quotations were taken from my report of 1861, in which I seemed to insist upon the absence of ice marks upon the summit. Later on I mentioned the fact of finding boulders that must have been carried over the very highest summit. It should be mentioned that I had had little experience in the unearthing of glacial indications at that time. The general rounding and smoothing of the summit is in favor of glaciation; and the inference that the fragments were angular, like those upon Mt. Washington, must have been based upon the account of the debris at the base of a precipice. The summit has no more angular debris upon it than can be seen upon any other New England peak of the same altitude, 5,215 feet, which is a thousand feet less than Mt. Washington's apex. Professor R. S. Tarr has since closed the discussion about the glaciation of Mt. Katahdin by his observations. He found glacial smoothing and transported fragments there.

It seems evident from a review of the facts that neither Mt. Katahdin, Mt. Washington nor Mt. Marcy are to be considered as nunatakr; and hence the first type of mountains, as urged by Professor Upham, must be merged with the second. All the New England and northern New York summits were swept over by the glacial current and the nunatakr must be sought for among the Catskills or some other highland comparatively near the ice-border just as they are in Greenland today.

A HISTORICAL STUDY.

It is quite interesting to recall how the facts have been gradually accumulated leading to the belief in the existence of the Hudson river lobe of the Labrador ice-sheet. First came the knowledge of the central current from the plain of the St. Lawrence directly south through Lake Champlain and Hudson river through the suggestion of E. Emmons and the measurements of C. B. Adams, in 1842 and 1846. The latter commenced observations upon the southeasterly courses of the striae up the three river valleys of northern Vermont and the single summit of Jay Peak. The Survey of 1861 afforded observations sufficient for a hasty generalization in the belief that the whole Green Mountain range had been thus swept over. This was followed by the conclusions that all the White Mountain summits and a large part of Maine had been glaciated in a similar manner 1861-1877-1892-1894. Meanwhile the Canadian geologists and others showed that the southwest movement along the Great Lakes and farther west covered more territory than the other courses. Prof. T. C. Chamberlin collated all observations previous to 1883 indicating the existence of lobes and the existence of two great forward movements of the ice. The latest part of the field to be explored is that of the Adirondacks, where the existence of the southwest movement is proved, though it was clearly suggested in 1842 by the discoveries of Vanuxem. All the workers in these several districts wrought independently of one another. Although surmised undoubtedly by many glacialists I am not aware that anyone showed the connection between the southeast movement in New England, the southern along the Champlain-Hudson valley and the southwest movement over the Adirondacks previous to my generalization of 1897 in the American Geologist. The existence of a glacial lobe starting in Labrador, flowing down into the valleys of the St. Lawrence, Lake Champlain and Hudson river, filling up these great valleys and then turning to the southeast and southwest over the elevated mountain districts is a grand conception which harmonizes all the observations made by geologists in the eastern part of North America.

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A Preliminary Report on a Portion of the Serpentine Belt of Lamoille and Orleans Counties.

By W. F. Marsters.

The occurrence of serpentine and associated minerals was early known to the pioneer geologists of Vermont. In the report prepared by Professor Edward Hitchcock and his co-workers, 1861, frequent mention is made of them and it is stated that in many instances more or less asbestos and talc in various varietal forms also appears. While considerable preliminary prospecting was carried on in the early seventies, no industry of any moment was established until a comparatively recent date.

According to the observations of Prof. Hitchcock, the serpentines are very largely confined to a broad band of talcose schists which enters the State on the north in Orleans County. The belt has a maximum width of some 15 miles and its eastern limit rests upon the western shore of Lake Memphremagog. This series of metamorphics is shown on his map as extending the entire length of the State and occupying portions of Orleans, Lamoille, Washington, Addison, Orange, Windsor and Windham counties and having a minimum width at the Southern boundary of the State of some two and a half miles. While some ten occurrences of serpentine are reported to exist in the southern half of this talcose belt, by far the largest of these deposits is located in Orleans and Lamoille Counties. What

may be the areal extent of the talcose schists and included serpentines beyond the Vermont border, has not yet been determined in detail by the Canadian Geological Survey.

AREA.

The small area under consideration in this report lies within the adjoining townships of Eden in Lamoille and

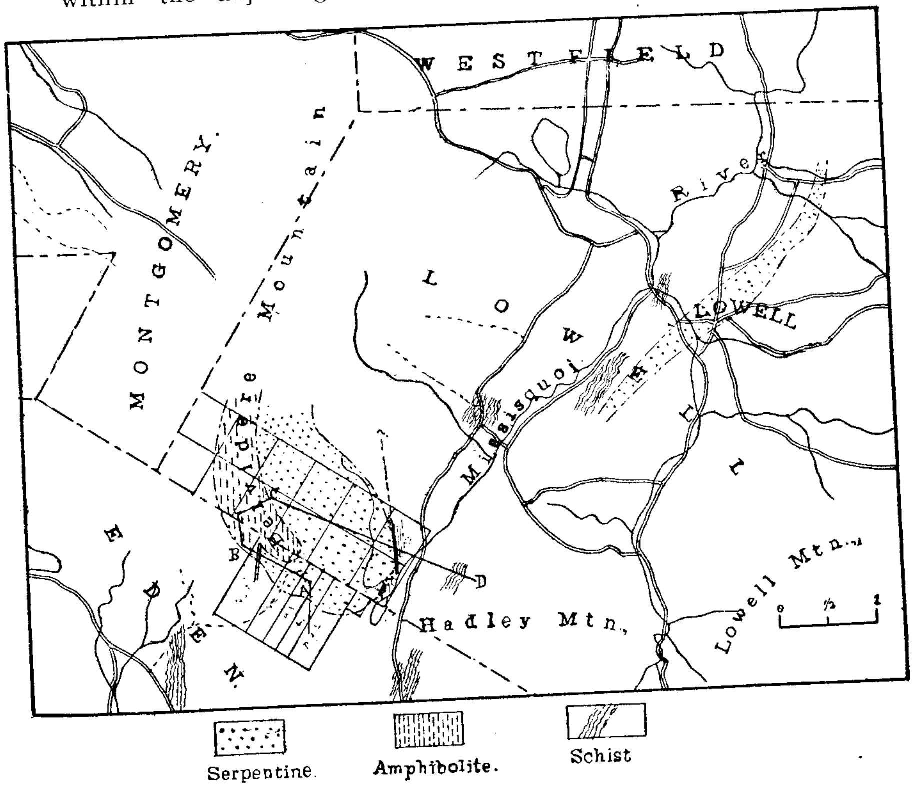

Fig. III. Map of Eden, Lowell, etc., showing Serpentine Area.
Drawn by W. F. Marsters.

Lowell in Orleans Counties. According to the Hitchcock map, the serpentine bands, of which there are two reported, terminate near the central part of Lowell township; the west one, however, is represented as extending a little south of the village of Lowell. In Eden township no serpentine is shown. There is, however, in Eden and continuing in Lowell, a most interesting area of these magnesian rocks forming the south slope of Belvidere Mountain, and a plateau-like projection to the southeast of its crest. This may be called the Belvidere area. Detailed study of the limits of this area force the conclusion that it is not connected with the belt passing through Lowell village.

Apart from the purely scientific interest in the origin and development of the serpentines they are, also, of special economic importance, inasmuch as considerable quantities of asbestos are known to occur within the limits of the region under consideration. Small lenses of talc, too, are not uncommon within the central part of the Belvidere area and also in the Lowell belt, but asbestos is by far the more abundant of the two and of greater economic importance. It should be added, however, that it does not follow that talc is always secondary in importance, in serpentine rocks; on the contrary, in the region of Moretown, Washington County, large talc deposits are being opened, and a mining plant is in process of construction. In this case, so far as can be determined from the preliminary prospecting, asbestos-like minerals are quite secondary to the development of talc. The talc appears to occur near the contact of serpentine with talcose and mica schists, or as small lenses within the serpentine. It is not at all improbable that careful prospecting within the limits of the Moretown area may bring to light a number of talc deposits of sufficient economic importance to form the basis of small but profitable enterprises.

TOPOGRAPHY.

Topographically, this region consists of a series of valleys and ridges having in general a north-east south-west trend. Near the western corner of Lowell lies Belvidere Mountain, a sharp-crested ridge with its highest point at its southern extremity and within a few rods of the Lowell-Eden township line. The Southern side of Belvidere Mountain is shown in Plate XXXVI. The altitude of the crest gradually decreases to

PLATE XXXVI.

View of Belvidere Mountain from the South.

the north and north-east. A steep-sloped valley locally known as Hazen's Notch in the south-west corner of Westfield separates Belvidere from the ridge on the north. Hadley Mountain is separated from Belvidere by the west branch of the Missisquoi River. From its northern flank a low spur extends to and beyond Lowell village where it is crossed by Johnson's branch, a tributary to the Missisquoi. A part of this spur is locally known as the Leland Hills. In the south-west corner of Lowell, are the so-called Lowell Mountains with the same general trend as Belvidere.

The greatest altitude of Belvidere is approximately 2100 feet above Eden Corners, and some 1200 feet above the office of the New England Mining Company. The upper half of the ridge presents exceedingly steep cliffs occasionally alternating with talus slopes and "slides" containing enormous blocks of rock, the *form* of these masses being due to the development of two well-defined systems of joints. To the north, however, the steepness of the slopes gradually decreases and a cover of waste extends well up the flanks. At the south end of Belvidere, a somewhat crescent shaped plateau rims the south and south-east sides. This topographic element is largely composed of serpentine rock, the level portion being comparatively free from drift or talus except along its upper edge, and again at its foot where it is in part covered up by sand or gravel deposits forming terraces on the bottom and along the lower part of the Missisquoi valley. The gradual extension of the glacial deposits up the slopes to the north and their coalition with debris from above, the whole being covered with a dense forest, renders the lithological relationships of the area between the plateau and Hazen's Notch very difficult to ascertain.

DISCOVERY OF ASBESTOS.

In the Belvidere and Lowell belts, asbestos was first discovered by Judge M. E. Tucker, November 9th, 1899. A considerable area lying along the township line as well as a portion of the belt passing through Lowell Village and to the north some two and a half miles, was prospected with considerable care.

In the vicinity of the Village and to the south, much prospecting has also been done but at a later date, by Mr. Silsbey. During the two succeeding years the Belvidere area attracted the attention of some of the prominent miners of asbestos in the United States and Canada. In 1900 Mr. B. B. Blake likewise discovered asbestos in ledges on the southeast slope of Belvidere, in Eden township. These discoveries finally led to the formation of a number of companies, but only one proceeded beyond the prospecting stage. In 1901 the New England Company erected a very elaborate plant equipped with the most modern machinery necessary for the treatment of asbestos rock. Active mining operations were begun in May, 1902, but in October of the same year, the plant closed its doors. No official statement has been obtained concerning the amount or the character of the fiber produced, or its adjudged value in the market of the country. The fiber, seen by the writer, which was said to have been the product of the New Enland Company, while too short for purposes requiring tensile strength, should fill all standard requirements in the manufacture of all classes of asbestos goods in which non-conductivity of heat is the only essential quality desired.

STRUCTURE AND ROCK TYPES.

Within the limits of the accompanying map, three well defined rock types were found; namely, *amphibolite*, in places assuming the appearance of a hornblendic gneiss; *serpentine*, massive, much crushed and sheared, the sheared belts being impregnated with fibrous and asbestiform minerals; talc, and lastly a large series of *talcose* and *micaceous schists*.

AMPHIBOLITE.

So far as has yet been learned, the amphibolites are confined to the crest of Belvidere Mountain. Their relation to the serpentine is shown in the accompanying cross section. They consist very largely of green hornblende; a smaller amount of a rod-like, colorless mineral, with optical properties similar to those of anthophyllite, an orthorhombic amphibole and a few

garnets now largely altered and accompanied by rims of secondary origin. Magnetite is common. Quartz and feldspar grains are comparatively rare. While there is considerable variation in the texture and relative amounts of the green and colorless amphiboles the persistence of the members of the amphibole family, and the general absence of both quartz and feldspar, except as secondary products, make the rock a fairly typical amphibolite. No attempt will be made in this paper to discuss, in detail, the microscopical characteristics and probable origin of this rock. The problem is a difficult one and will be reserved for later consideration and publication in a subsequent report of the State Survey.

SERPENTINE.

No sharp and well defined contact between the serpentine and the overlying amphibolite has been discovered. Such may not exist. Examination of thin sections points to the conclusion that a sharp line of contact does not occur here, but, on the contrary, the amphibolite has gradually altered to serpentine. The thin sections of the serpentine within a few feet of undoubted amphibolite show shreds and remnants of an amphibole surrounded by a felty mass of serpentine, often colorless, or very faint greenish yellow. It would thus seem very probable that the serpentine is a secondary product resulting from the decomposition of the amphibolite. The zone between typical amphibolite and undoubted serpentine is characterized by an abundance of garnet easily recognized by the unaided eye, but under the microscope it appears to have suffered considerable alteration with the development of rims of secondary origin. In a few cases the entire mass of the garnet has altered to a light green isotropic mass, probably serpentine.

The serpentine occurs in two areas, designated as the Belvidere and the Lowell. The Belvidere area constitutes the plateau-like projection at the south end of the range. Its areal extent, so far as known, is shown on the accompanying map. It is possible that a connection between it and the Lowell belt may exist beneath the till covering the floor and lower flanks of the Missisquoi valley. There are, however, certain structural phenomena which do not favor such a view. Near the foot of the plateau, at the asbestos opening made by Judge M. E. Tucker is a well defined fault with north and south strike and vertical dip; to the east of the fault-line, amphibolite, of the same general character as that forming the crest of Belvidere, forms the only rock in sight. Neither the area of the amphibolite nor the extent of the fault could be traced more than a few score of feet from the Tucker quarry. These structural facts would lend credence to the conclusion that the Belvidere occurrence is not continuous with that of Lowell. On the west side of the serpentine, a local fault occurs on the property of the National Company. It was first noted by Prof. J. F. Kemp, Columbia University, whose account of the serpentine and asbestos appears in the Mineral Industries, for 1900. The extent of the fault cannot be determined. It is not improbable that it may turn towards the west and skirt the west flank of Belvidere Mountain. Again, on the southern slope and to the southeast of the Tucker opening, there is a repetition of the same lithological changes recognized at the upper edge of the plateau. Thin sections show a considerable amount of fresh amphibole, but the series of abrupt ridges extending from the Tucker opening are very largely composed of fine grained felty serpentine. The facts, therefore, so far observed go to support the conclusion that the Belvidere is not a continuation of the Lowell belt. The accompanying Cross Section, Fig. IV, makes clear the conclusions here presented.

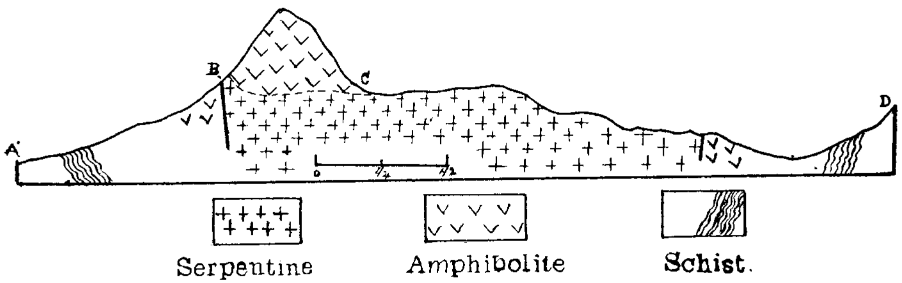

FIG. IV. Section through Belvidere Mountain.

The limits of the Lowell belt have only been approximately determined. An excellent section can be seen at the Village of Lowell, where considerable prospecting for asbestos has been done by Mr. Silsbey. No actual contacts of the serpentine with schists or amphibolite were found in this section. To the north some two or two and a half miles, the serpentine deposits form a narrow ridge overlooking the valley of the Missisquoi River on the west. Beyond the Perkins farm no serpentine was discovered. It is not improbable that it is pinched out at this point and recurs to the north as lenses at the various points reported by Hitchcock. To the south of Lowell, these magnesian rocks can be traced and have been prospected for a mile or more. Whether the deposit pinches out or continues into the slope of the spur of Hadley Mountain is not known.

Macroscopically the serpentine of the two belts is identical. It is an exceedingly tough, rather fine grained rock and light to dark green in color, but sometimes assuming a gray tint; in such cases the rock is generally minutely scaly in structure, and associated with talc-like bands of limited extent. In the Belvidere belt in particular the serpentines have been sheared and crushed to such an extent that minutely fractured bands may be traced for some distances. These are best shown at the Tucker openings along the lower limit of the belt and in the series of prospect holes extending from the Northwest corner of the National claim to and including those on the New England and the United States properties. The Fracturing and asbestos-like filling of the ruptures may be even microscopic in size. It is apparently along these lines of fracture that the fiber has developed. While it was exceedingly difficult to study in great detail the structure of the central portion of the Belvidere belt, such data as was obtained shows that the maximum amount of crushing and fracturing was produced near the upper and lower limits, and along lines of faulting. It is in these zones of greatest disturbance that the greatest amount of fiber is developed.

As seen under the microscope the serpentine presents a considerable range of variations both structurally and mineralogically. In its most typical phase it is a colorless or slightly yellow or yellowish green mass of grains, scales and fibrous bundles. The fibrous texture is scarcely apparent except in polarized light. The more massive phase is often nearly isotropic, while the fibrous presents a felty texture. When individual fibres could be examined they were found to behave in a manner similar to anthophyllite. In many sections there was an abundance of magnetite. A portion of this may be chromite and picotite. The arrangement of the ores is suggestive of the structure of the rock from which the serpentine was derived. Numerous illustrations could be sketched of the linear arrangement of the magnetite grains in parallel lines as if developed along cleavage partings. The green amphibole seen in the fresh amphibolite presents in certain sections an exact duplicate of the cleavage; in fact, it is believed that a more detailed study of sections, now in course of preparation, will show various stages of decomposition and final passage into massive and fibrous phases of serpentine, with the magnetite as a secondary product.

It should be stated that such a mode of origin has already been recognized by Professor B. K. Emerson* in his investigations of "The Geology of Old Hampshire County, Mass." In a belt extending from Zoar to North Blandford, he has recognized, in addition to the association and undoubted derivation of serpentine from hornblendic schists (amphibolite), similar relationships of serpentine with olivine, enstatite and sahlite. With these mixtures are associated large beds of crystalline limestone, dolomite and tremolitic schists. Concerning the whole series, Prof. Emerson says "The presence of dolomite as an original constituent, both as inclusions in the unchanged enstatite and in the interstices of the enstatite rock, as well as in great beds, indicates the derivation of the whole series from large beds of dolomitic limestones."

The asbestos occurs in two distinct forms, usually designated as "slip fiber" and "vein fiber." Such examination as has been

*Geology of Old Hampshire County, Mass., Mon. XXIV. U. S. G. S., pp. 115, 116.

made of the slip fiber shows it to be a fibrous form of amphibole; the vein fiber, on the other hand, is probably true chrysotile. Both kinds are found in the Belvidere as well as the Lowell belt, and are best developed either in the immediate vicinity of the faults or near the upper and lower contacts of the serpentine with the amphibolites. A very good showing of the vein fiber was discovered near the northeast line of the New England property, some on the United States, but by far the best showing can be easily seen on the Tucker properties along the lower contact. Both slip and vein fiber occur at the Perkins farm and again in the ledges within the limits of Lowell village on property owned by Mr. Silsbey. At some of these points the showing of fiber is so promising that it is confidently believed that careful prospecting and the economic management of modest plants will establish profitable enterprises in the manufacture of asbestos fiber of second and third grades. Fiber fulfilling the demands of fair grades of paper stock, asbestos board, etc., has already been made from the ore from the Tucker, National and United States properties. No statistics, however, of the production per ton of ore, have been obtained.

Schists.—The talcose and mica schists are well exposed on the south and southwest of Belvidere. Towards the east and along the slopes of the Missisquoi Valley, in the vicinity of Lowell, very excellent exposures may be seen. The entire series, so far as seen, maintains a general northeast-southwest strike and nearly vertical dip, although to the southwest of Belvidere it swerves towards the north.

While this most puzzling formation presents structural features and to some extent a mineral constitution, which would suggest a sedimentary origin, a detailed microscopic study of the entire terrane may reveal a mass of data which would necessitate a change of view based upon macroscopic characters.

Origin of Serpentine.—Serpentine was early recognized as occuring in large masses as rock, and also in crystalline form as a mineral. As early as 1835 Quenstedt* discovered crystals of

*Poggendorf's Annalen fur Physik und Chemie. Vol. XXXVI. p. 370.

serpentine, in the region of Snarum, Norway. From a careful investigation of this material he was able to demonstrate that it had been produced by the alteration of olivine. Although his conclusions met with vigorous opposition, the additional observations and studies of Rose, Volger and, later, Roth, substantiated the views of Quenstedt. In his classic memoir, J. Roth* discusses this problem in its entirety. In "British Petrography" Teall gives a condensed statement of the views of Roth. He says; "In this memoir, the author points out that the ordinary agents of weathering-water, carbonic acid and oxygen—are powerless to remove alumina; and he draws the general conclusion that if a non-aluminous silicate rock occurs as an alteration product, it must arise from the modification of an original rock free of alumina. Powerful chemical agents such as sulphuric acid, which may arise from the oxidation of pyrites, capable of removing alumina, would of course also remove the other bases including the magnesia necessary for the formation of serpentine. Now the rock serpentine is practically non-aluminous, and it is also in most, if not in all, cases, unquestionably an alteration product. It becomes important, therefore, to consider what common rock-forming minerals are capable of yielding serpentine. The above considerations point to the conclusion that these minerals are olivine, the rhombic pyroxenes, diallage, and non-aluminous hornblende and augite. According to the author the process of making serpentine commences by the taking up of water and by the oxidation of the iron if infiltrating water contains free oxygen. It proceeds by the removal of the bases, especially lime if present, mainly as carbonates; and a portion of the precipitated and therefore soluble silica. If we take the case of olivine, then assuming that no change of volume occurs, from 5 molecules $= 10\,MgO + 5\,SiO_2$
by removing $4\,MgO + 1\,SiO_2$
and adding $4\,H_2O$ we have $6\,MgO + 4\,SiO_2 + 4\,H_2O$
or in other words two molecules of serpentine."

In a like manner Roth has also established the derivation of serpentine by the alteration of monoclinic pyroxenes.

*Uber den Serpentin und die genetischen Beziehungen desselben. Abh. d. k. Akad d. Wiss. Berlin, 1869.

The well known close association of some serpentines with dolomitic rocks and ophicalcites has given some ground for the belief that these magnesian rocks may have been produced by the alteration of a mass high in magnesian carbonate. This process, however, is not regarded with favor, either by Roth or Teall, who are inclined to accept the view that such serpentine masses as may be associated with crystalline limestones and dolomitic rocks, may have been derived from malacolite, tremolite, etc., which develop in these rock masses by processes of metamorphism.

Some observers have also maintained that serpentine has been produced by the alteration of members of the feldspar family. Supposed cases of this sort have been described by Heddle,* and Bischof† has worked a series of chemical reactions purporting to explain the succession of chemical changes. Careful examination has shown, however, that the final alteration product investigated by Heddle was not true serpentine, but pennine (pseudophite).

ASBESTOS. VARIETIES AND COMPOSITION.—Considered from the standpoint of the mineralogist, the term asbestos appears to be a general one, which has no well defined generic or specific value. As used by Dana, the term is made to include fibrous forms of four distinct mineral compounds. In a careful study of the asbestos series in the geological department of the National Museum, Dr. C. P. Merrill discovered that the commercial asbestos included fibrous forms of (1) monoclinic amphibole (tremolite), (2) serpentine (amianthus), (3) anthophyllite, and (4) crocidolite (blue asbestos). Concerning these species Dr. Merrill says: "Of these, tremolite and serpentine have long been recognized in fibrous forms, and are as a rule readily distinguishable from one another by the silky fiber and greater flexibility of the last named.

"Asbestiform crocidolite is well known to most mineralogists, though so far as the present writer is aware, the South African locality is the only source of the mineral in commercial quantities. That the fibrous form of anthophyllite is also sufficiently common to be commercially used as asbestos, seems not to be so well

*Heddle, Trans. Royal Soc. Edin. 1879. Vol. XXVIII p. 544.
†Bischof Chemical and Physical Geology, Eng. Edit., Vol. II., pp. 66 and 67.

understood, though the leading text-books on the subject all mention the mineral as sometimes occurring in fibrous forms resembling asbestos. That a lack of discrimination between fibrous and thophyllite and the true tremolite asbestos should exist is not strange, since to the unaided eye they are often in every way alike, and it is only by microscopic or chemical means that the true nature of the mineral can be made out." The best grade of asbestos, Italian and Canadian, *very* finely fibrous with *silky lustre* and usually occurring in veins with the fiber normal to the vein-walls, is a fibrous form of *serpentine*, and properly called chrysotile, both by the mineralogist and the tradesman. Under this term Dana includes much of the silky amianthus associated with serpentine rocks and popularly regarded as asbestos. The term *Bostonite*, too, has been applied by the trade to the Canadian chrysotile. The second and third grades may be regarded as fibrous forms of the non-aluminus members of the amphibole family. Considered as a group, the color is light to deep green or bluish green; the fiber may be fine and wooly in texture and easily separated, but it differs from the chrysotile, in that it is often harsh, flexible to a limited degree and waxy or dull in luster. These grades lack any marked degree of tensile strength and hence are not suitable for the manufacture of articles requiring a high degree of flexibility and strength, such as cloth, rope, etc., but is all that can be desired for uses wherein non-conductivity of heat is the only essential quality desired.

Asbestos is essentially a hydrated silicate of magnesia, with a small but variable amount of the oxides of iron and alumina present. Analyses of Italian and Canadian Chrysotile made under the direction of Mr. J. T. Donald yielded the following results:

CHRYSOTILE.

	I.	II.	III.
(1) SiO_2	40.30	40.57	40.52
(4) Mg O	43.37	41.50	42.05
(3) Fe O	.87	2.81	1.97
(2) Al_2O_3	2.27	.90	2.10
(5) H_2O	13.72	13.55	13.46

I. Italian as found in commerce. II. Canadian, best grade, Thetford-Black Lake district. III. Templeton, Ottawa district.

A comparison of these analyses with those of the amphibole variety appended below, reveals certain differences of much value to the prospector.

ASBESTOS, AMPHIBOLE VARIETIES.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
(1) SiO_2 ...	55.87	55.48	57.69	57.12	57.73	59.00	52.11	53.28
(2) Al_2O_3 ..	.....	2.01	.....	0.75	.72	.91	1.01	.....
(3) Fe_2O_3 ..	.....	.....	.....	.....	.....	.....	20.62	.....
(4) FeO ...	4.31	.....	2.46	6.36	8.61	6.09	16.75	.....
(7) MnO ..	1.12	.....	0.13	.....	.....	.....	.....	.....
(6) MgO...	20.33	17.23	23.68	29.44	28.77	29.90	1.75	22.87
(5) CaO....	17.76	10.35	13.39	.....	0.08	.45	none.	.....
(10) Ign....	.....	1.47	0.17	5.74	2.52	2.35	1.58	19.53
(9) Na_2O ..	.....	1.54	3.14	.....	0.57	.68	6.16	.....
(8) K_2O ...	.....	.....	.....	.....	0.14	.43	....	.....

I. From Zillerthal. II. From Mexico. III. From Frankenstein.

IV. Anthophyllite. Sall Mountain, Ga., R. L. Packard.

V. do. Nacoochee Ga., R. L. Packard.

VI. do. Mitchell Co., N. C., anal. by R. L. Packard.

VII. Crocidolite, South Africa, Dana, p. 400.

VIII. Crocidolite, Idaho, G. P. Merrill: Notes on asbestos and asbestiform minerals. Proc. U. S. Nat'l Mus. Vol. XVIII, pp. 281-292.

It will be seen that the latter contains from 15 to 17 per cent. more SiO_2 but only half the amount of MgO. This deficiency is apparently made up by the substitution of 10 to 17 per cent. CaO. The two groups may be therefore easily determined by proving the presence or absence of calcium and water. The chrysotile yields an abundance of water but fuses with great difficulty on the edges of the fiber. F = 6. The amphibole and pyroxene varieties, however, fuse easily and yield little or no water in the closed tube.

(8) PRODUCTION.—An inspection of the tabulated data dealing with the production of asbestos in the United States, during the past ten years, reveals the unexpected fact that the annual output was considerably less than 1,000 short tons, this mark being exceeded in 1900 by an additional 54 tons, and again in 1902, by 5 tons. In 1882, the output reached some 1,200 tons with an estimated value of $36,000. In 1901 the total production fell to 747 tons, with an estimated value of $13,498, but in the following year again increased nearly 50 per cent. and was valued at $16,200. A comparison of values and amount of production shows that the increase in output has been accompanied by a corresponding fall in prices. During the past two years, however, the growing demand for all grades of the crude product, has increased the values, especially of the better grades, where strength of fibre is an essential quality.

While asbestos is known to occur in many localities in the United States, the most productive field during 1902 was the Sall Mountain, White County, Ga. It is operated by the "Sall Mountain Asbestos Co."

ANNUAL PRODUCTION OF ASBESTOS IN THE UNITED STATES, 1890-1902.

YEAR	QUANTITY SHORT TONS	VALUE
1890	71	$ 4,560
1891	66	3,960
1892	104	6,416
1893	50	2,500
1894	325	4,463
1895	795	13,525
1896	504	6,100
1897	580	6,450
1898	605	10,300
1899	681	11,740
1900	1,054	16,310
1901	747	13,498
1902	1,005	16,200

VALUE OF IMPORTED ASBESTOS 1890-1902.

YEAR ENDING	UNMANUFACTURED.	MANUFACTURED	TOTAL
1890	$ 252,557	$ 5,342	$257,899
1891	353,589	4,892	358,461
1892	262,433	7,209	269,642
1893	175,602	9,403	185,005
1894	240,029	15,989	256,018
1895	225,147	19,731	244,878
1896	229,084	5,773	234,857
1897	263,640	4,624	268,264
1898	287,636	12,897	300,533
1899	303,119	8,949	312,068
1900	331,796	24,155	355,951
1901	667,087	24,741	691,828
1902	729,421	33,011	762,432

ANNUAL PRODUCTION OF ASBESTOS IN CANADA, 1890-1902.

YEAR	QUANTITY SHORT TONS	VALUE
1890	9,860	$ 1,260,240
1891	9,279	999,978
1892	6,042	388,472
1893	6,473	313,806
1894	7,630	420,825
1895	8,756	368,175
1896	12,250	429,856
1897	a30,442	445,368
1898	a23,785	486,227
1899	a25,536	485,849
1900	a30,641	763,431
1901	a38,079	1,186,434
1902	b40,416	1,148,319

a Including asbestic. b Including 10,197 tons of asbestic.

PRODUCTION OF ASBESTOS IN THE WORLD IN METRIC TONS*.

Year	Canada.		Cape Colony (c)		Italy		Russia		United States	
	Tons	Value	Tons	Value	Tons	Value	Tons	Value	Tons	Value
1898	21,577	$ 486,227	161	$ 10,185	131	$ 9,000	1666	$ 60,000	803	$ 13,425
1899	22,938	483,299	[b]	....	81	7,264	2693	97,342	827	13,860
1900	27,797	748,431	157	12,785	[b]	....	[d]	....	998	16,500
1901	36,475	1,259,759	89	7,165	[b]	....	[d]	....	678	13,498
1902	36,668	1,203,452	[d]	....	[d]	....	[d]	......	916	12,400

[a] From official reports of the respective countries.
[b] Not stated in the reports.
[c] Exports.
[d] Statistics not yet available.
[*] The Mineral Industries, its Statistics Technology and Treas. for 1902, Vol. XI.

Statistics show, also, that the value of the total imports, manufactured and unmanufactured, for the year 1902, is $762,-432. Nine-tenths of this is obtained from the Canadian mines. According to the statistics gathered by Henry Fischer on the world production of asbestos, Canada produced during the calendar year, 1902, 36,668 metric tons valued at $1,203,452. It follows from these facts that the United States have imported more than half the value of total production of Canada. Under these conditions it is evident that the demand for this product ought to foster careful and detailed investigations of all the most promising areas within our own borders. Vermont should receive her share of attention and careful study. There is surely sufficient evidence of the existence of fibre in large quantities within the Belvidere and Lowell areas to warrant much additional careful and prudent prospecting and detailed study.

REPORT

OF THE

STATE GEOLOGIST

ON THE

Mineral Industries and Geology

of Certain Areas

OF

VERMONT.

1903-1904.

FOURTH OF THIS SERIES.

GEORGE H. PERKINS, Ph. D.

State Geologist and Professor of Geology, University of Vermont.

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ARGUS AND PATRIOT PRINTING HOUSE.
1904.

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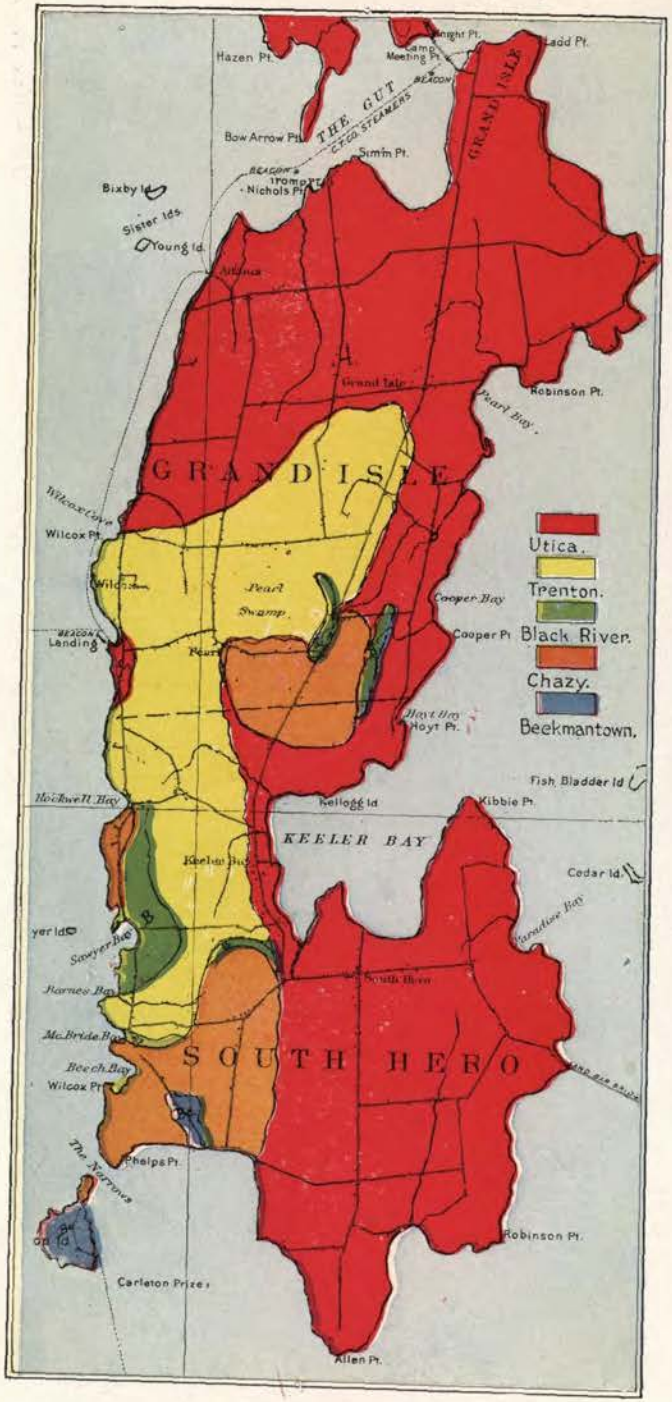


Geology of Grand Isle County.

In the Report immediately preceding this there may be found a somewhat detailed account of the geology of Grand Isle with a map of the area studied. The work there begun was continued through the seasons of 1903 and 1904 and extended over the whole county, that is over North Hero, Isle La Motte, and the peninsula of Alburg. Although the whole area to be described has been carefully gone over, some of it several times, nevertheless, the present account is to be regarded as far from final. There yet remains much work and very interesting work. Many parts of the region abound in fossils which await careful collecting and subsequent study, and I have no doubt that such study would be amply rewarded in the discovery of new forms and would furnish material for new conclusions. The whole region is a most charming one and nowhere is geologizing more delightfúl and interesting.

Grand Isle County is composed of a large peninsula, Alburg, and a group of large islands which nearly fill the northern part of Lake Champlain. These islands are; Grand Isle, thirteen miles long and on the average three miles wide, embracing 19,000 acres; North Hero, thirteen miles long and, on the average, a mile and a half wide and containing 6,272 acres; Isle La Motte, nearly six miles long and a mile and a third in average width, containing 4,670 acres and several small and not permanently occupied islands, as Providence, Cloak, Sawyers, etc.

Were it not for its peculiar physical features the county would be a difficult region geologically because over most of its area there are no bold outcrops of the underlying rock, only low exposures where the surface drift has been washed off and these not always where they are most needed. But because the county is so largely made up of islands with their great extent of shore line and consequent exposure of rocks it is for the most part not difficult.

The whole county is underlaid by Ordovician* rocks which are to a large extent covered by Champlain clays and to a much less extent by sands and gravels. The whole county includes about eighty-two square miles, or 52,480 acres. The surface is less rugged and uneven than is that of the State in general and there are nowhere elevations of more than 380 feet above sea level or 280 above the Lake. Indeed elevations approximating this altitude are not common and most of the surface is much lower.

On Grand Isle there are elevations on the east side south of Sandbar bridge, others west of Keeler Bay, also near the south end of the island, and north of Keeler Bay. In all these places the rocks have been thrown up to a height of 100 feet or more. I did not find on North Hero any elevation greater than 60 feet above the Lake and most of this island is much lower than this. Isle La Motte is more diversified than the rest of the region in its wide lowlands and abrupt upheavals. At the Head, which is the extreme southern part of this island, the rocks, mostly Chazy, rise quite steeply to a height of 140 feet above the Lake or 240 feet above sea level. North of this there is a large swamp which almost cuts the island in two and north of this is another abrupt rise of the ledges of Trenton limestone which at the highest are 220 feet above sea level. Yet farther north on the west side below the light-house is another rise nearly as high.

On Alburg peninsula there are numerous elevations and numerous large swamps. The elevations here are mostly quite inconsiderable, 20 feet to 40 feet in the southern part, while through the wide northern part the levels are all low, and much of the surface swampy. Naturally, because of its insular character, the county has a very great extent of shore line. I do not find any measurements of the whole of it, but as nearly as I could measure it, and as shown by the U. S. Coast Survey and U. S. G. S. Topographical maps, there is in all 127 miles, that is, 14½ miles on Isle La Motte, 31 miles on Alburg, 42 on North Hero, and 40 on

*In my previous Report I have used the term Champlainian for these beds and I prefer this term, or that of the New York geologists, Champlainic. I believe that the term Ordovician is open to serious objections. Notwithstanding this, I use this term, under protest, as it seems to be almost universally adopted by geologists and the use of either of the others under the circumstances can only tend towards confusion.

PLATE XXXVIII.

Dike near Robinson's Point. The Dike Rock is twenty inches wide, and projects from two to eight feet beyond the shale. It is of a brownish color, while the shale each side is black, so that it is less conspicuous in the picture than it should be.

shown later, this is true to a still greater degree of the rest of the county.

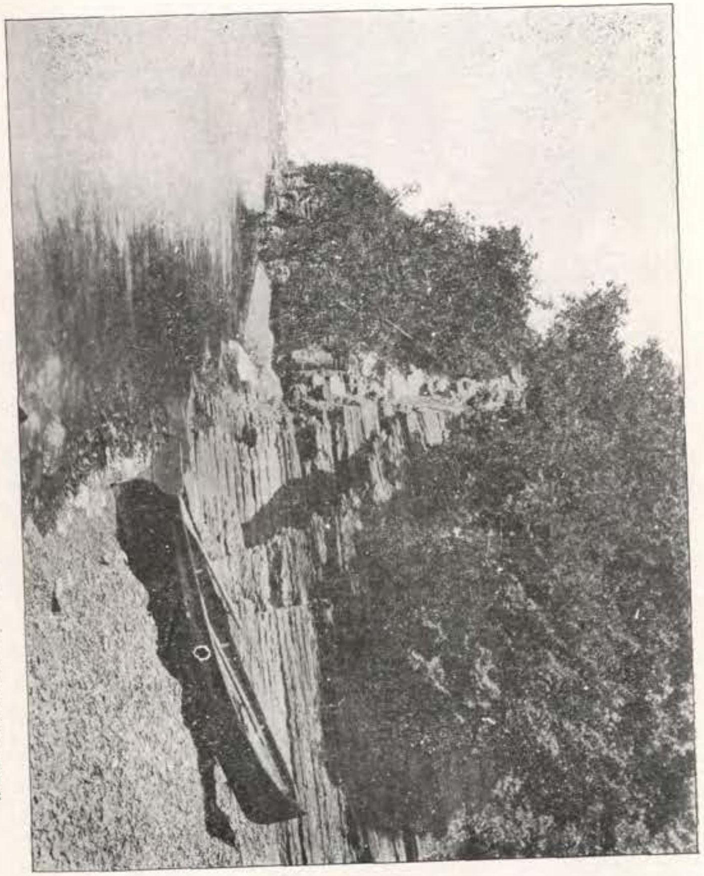
The Utica here, as everywhere, is for the most part a brittle, thin bedded, rather soft rock, but in places it grades into limestone so like the Trenton both in texture and fossils that it cannot be distinguished from it, so that there is a very gradual transition from Trenton to Utica.

Generally, the color of the shale is black or nearly so, but in some places it is banded with gray or light brown. Sometimes, as in the great cliff south of Sandbar Bridge, these bands are very numerous and several inches wide. Plate XL shows one of the typical Utica exposures as seen on the shores of the Lake and Plate XLI shows one of the highest and most disturbed of these. Veins of white calcite are very common in the shale and in a few places on both Grand Isle and North Hero it is penetrated by layers of white quartz. Elsewhere, as on Kibbe Point, there are ferruginous siliceous layers which become rust brown on exposure to the air as the iron oxidizes. The Utica beds for the most part contain very few fossils. As has been noticed the Utica beds show greater disturbance than those of any other formation found in the region and, as more fully described in the last Report, the cliffs south of Sandbar bridge are not only upheaved, but folded and crumpled to an extent rarely seen, as plate XLII shows. This plate also represents the banding mentioned above.

Not only are the Utica beds on the island barren of fossils, but where these do occur, the number of distinct species is small so far as has yet been discovered. The following have been found and in a few places some of them are fairly common: *Triarthrus beckii*, *Diplograptus pristis*, *Climacograptus bicornis*, *Schizocrania filosa*, *Orthoceras coraliferum*.

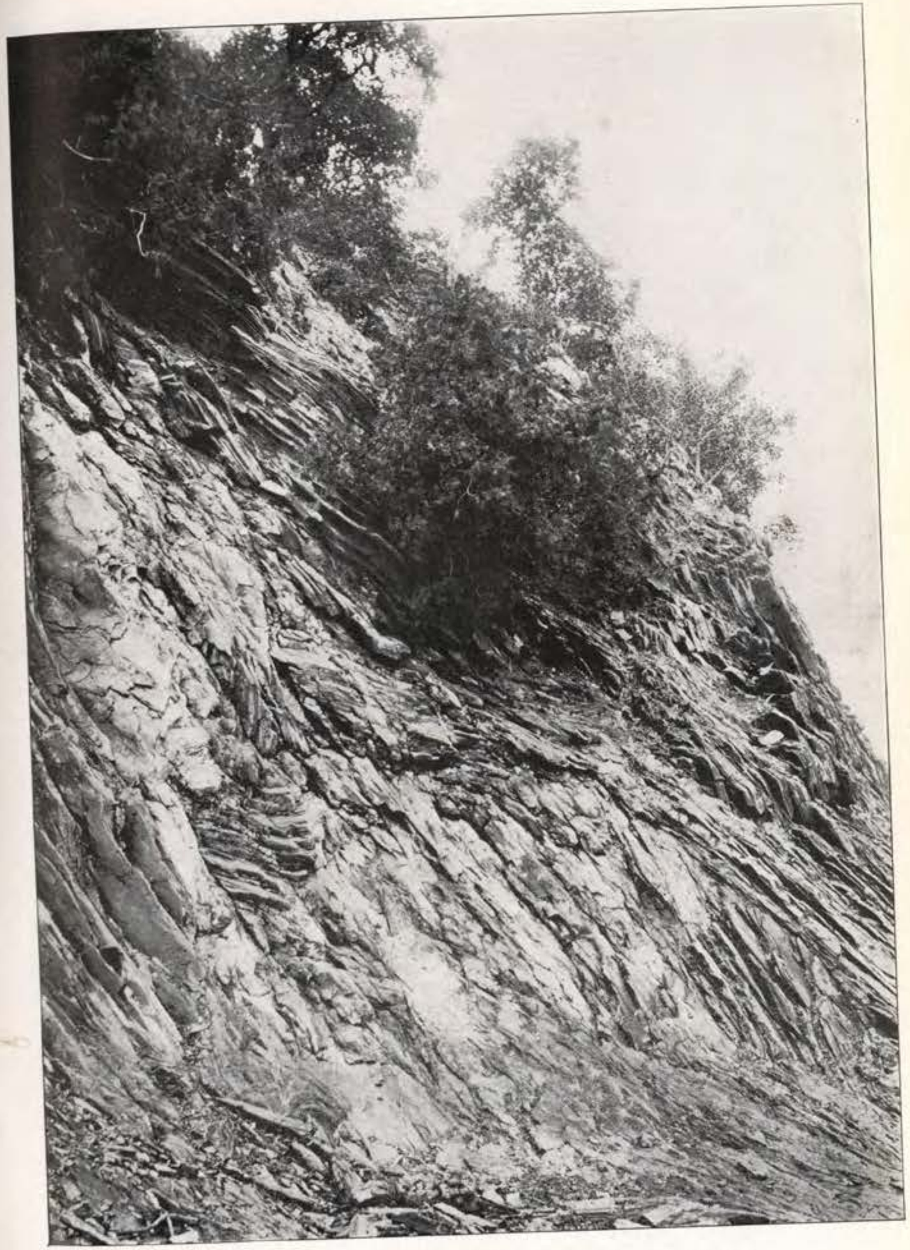
As the yellow area on the geological map of the island shows, there is a large portion of the middle occupied by Trenton rocks. These begin on the north, just south of the cross road which runs from Pearl Bay west through the village of Grand Isle and extend south for somewhat more than six miles to McBride Bay where they come against the BlackRiver.

Most of the beds are black, compact, not greatly disturbed and



Utica Shale, Corbin Beach, West Shore, Grand Isle. A Characteristic Shale Bluff.

Plate XL.



Cliff, Utica Shale. South of Sandbar Bridge. Eastern Portion.

Cliff, Utica. Central Portion showing Great Disturbance. South of Sandbar Bridge.

often, as in Plate XLIII, very regular and horizontal. Plate XLIV shows an ordinary outcrop of Trenton on shore. Although usually black, there are beds of various shades of gray, some of them closely resembling Chazy rock. They are mostly, if not wholly, Middle Trenton, though there are some beds of Upper Trenton.

On the west shore north of Gordon Landing the typical Trenton limestone becomes shaly and gradually passes into the Utica, *Diplograptus pristis* and *Asaphus gigas* occuring on the same bit of stone. Elsewhere in the same shaly rock *Trinucleus concentricus*, *Orthis testudinaria* and *Calymene callicephala* are found together. We have here, therefore, what may be considered as Utica shale with only Utica fossils, an intermediate shale with both Trenton and Utica fossils, and Trenton shale with only Trenton fossils, there being no discernible division between them. These conditions are not of common occurrence, but they do exist. On the other hand there are Trenton layers which can be distinguished only with difficulty from the Chazy by the lithological character. These beds are not very fossiliferous but when fossils are found they soon decide the age of the rock. The more common Trenton fossils found on Grand Isle are as follows: *Asaphus gigas*, *Calymene callicephala*, *Trinucleus concentricus*, *Leptaena sericea*, *Rafinesquina alternata*, *Platystrophia biforata*, *Orthis lynx*, *Zygospia exigua*, *Z. recurvirostra*, *Conradella compressa*, *Bucania punctifrons*, *Bellerophon bilobatus*, *Holopea paludiniformis* *Endoceras proteiforme*, *Orthoceras junceum*, *O. olorus*, *O. amplicameratum*, *O. strigatum*, *Monticulipora lycoperdon*, etc. etc.

There is, in addition to the area shown, a Trenton outcrop too small to be indicated on the map. It is a little knob of undoubted Trenton, as it affords typical fossils, located in the south part of the island a little north of the letter o in the word South on the map and just below the angle made by the fork in the road in the midst of the Chazy area.

THE BLACK RIVER LIMESTONE.—As the green areas on the map show, the rocks of this age do not occupy a large space on the island. There are in all six exposures. Five are seen on the map and one, too small to be shown, is found crossing the road at a point that may be indicated by the first letter o in the name South Hero as it runs close to the eastern edge of the letter and the outcrop almost touches, or would if shown, the top of the same letter. This formation is found on the shore only at Sawyer Bay and a short distance south and at McBride Bay for a few rods. It is everywhere a compact, hard, brittle rock breaking with the smooth fracture that is typical of this limestone. It is mostly black, but in some of the exposures it is grayish or drab.

The most typical Black River is found along the Lake as shown in Plate XLV. The masses farther inland are lighter in color and often filled with veins of white calcite as seen in Plate XLVI. Many of the older houses on the island were built of blocks of this limestone, which could be used as broken from the main mass without much, if any, shaping. It is greatly to be regretted that many of these substantial and picturesque buildings have fallen to ruin and disappeared.

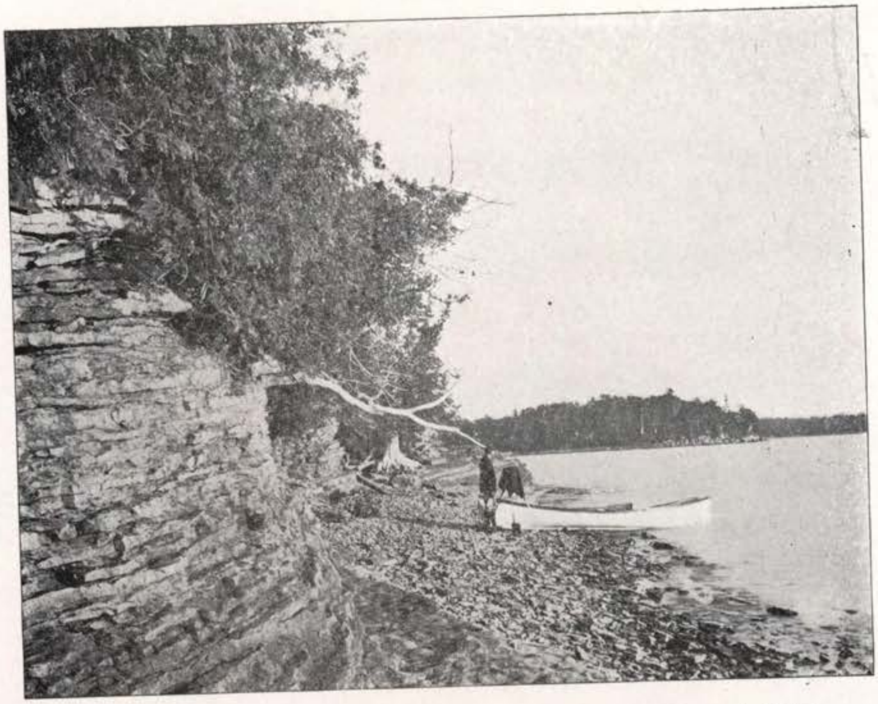
The more common Black River fossils, *Columnaria alveolata*, *Maclurea Logani*, *Stromatocerium rugosum*, *Tetradium fibratum*, *Rafinesquina alternata* etc., are found in some layers, but for the most part this stone as found here is nearly destitute of fossils. The large Maclurea, which I have, though with much question, called Logani, is abundant in some layers near McBride Bay and also great masses of Columnaria, twelve to eighteen inches in diameter are occasionally found. Plate XLVII shows one of the best exposures of this rock and, incidentally, one of the typical semicircular bays of the islands.

THE CHAZY. Although not as extensively distributed over Grand Isle as either the Utica or Trenton, the Chazy is perhaps the most interesting formation found on the island inasmuch as it presents a much greater variety in its beds and their contained fossils. The three areas, colored orange, are sufficiently well shown on the map. In no case has the Chazy been greatly disturbed, the dip being only a few degrees. The very great variety in the different beds and the number of beds is shown in the lists given in the last Report. Most of these

PLATE XLIII.

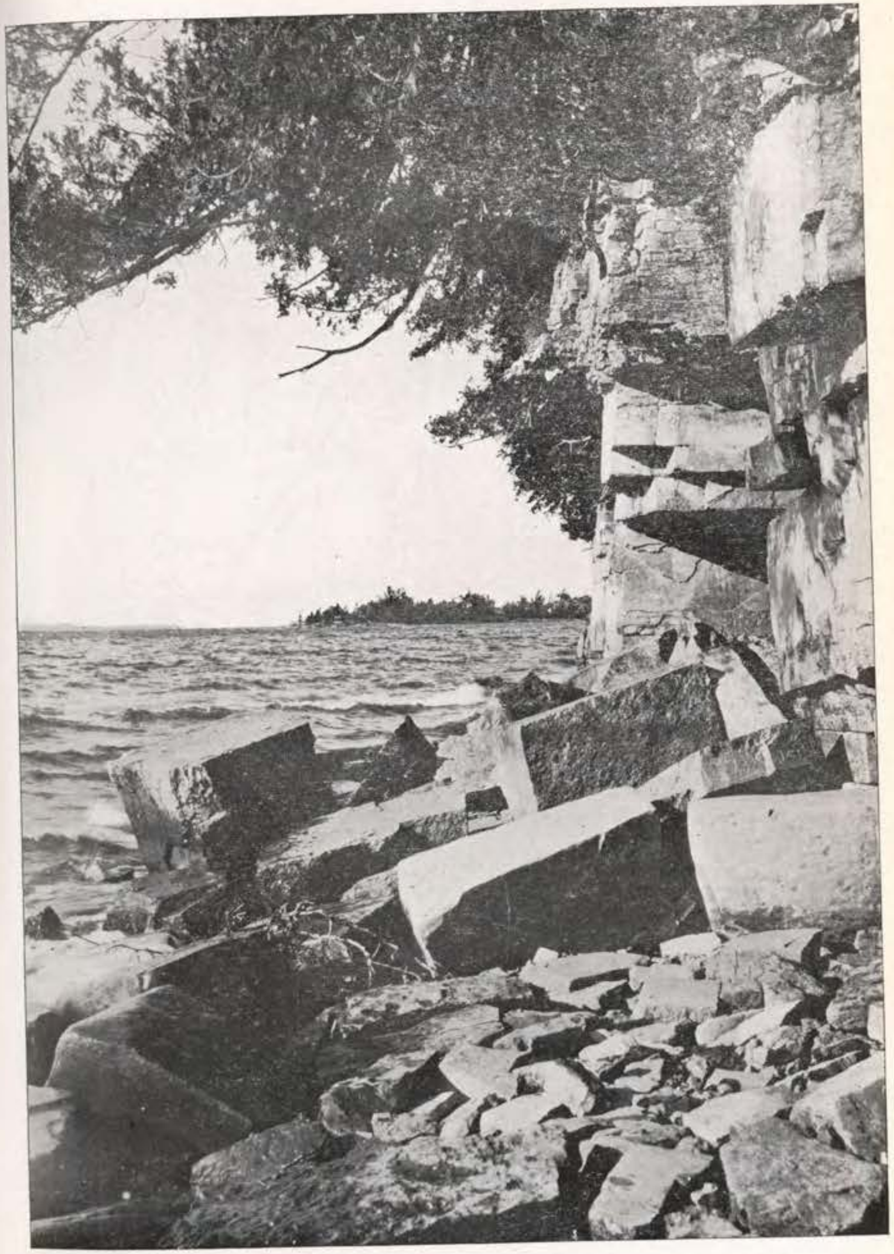
Nearly Horizontal Trenton Beds, North of Rockwell Bay, Grand Isle.

PLATE XLIV.

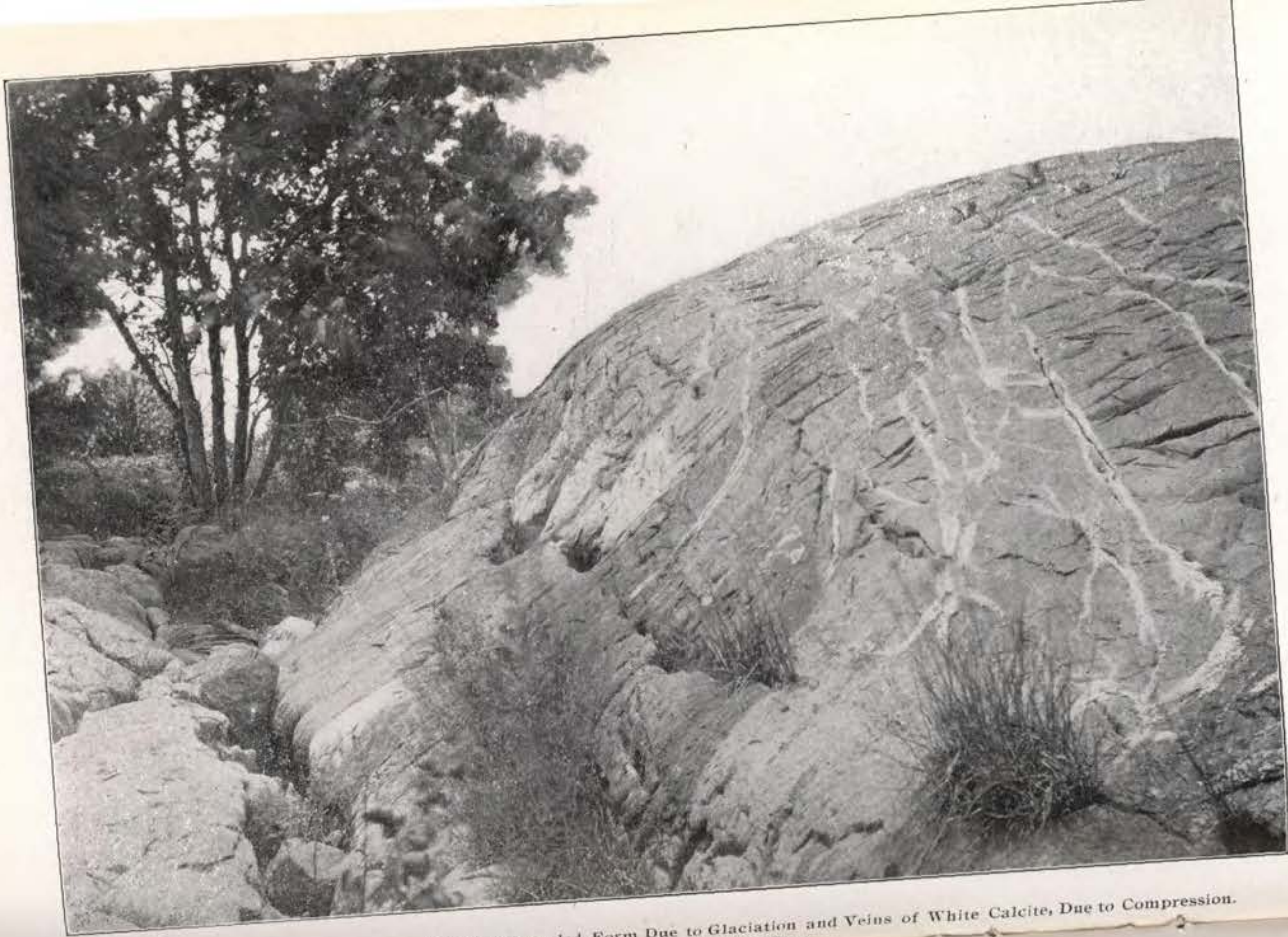


Hero.

Trenton Bluff at McBride Bay, looking South. The Shore in the Distance is Chazy.



Chippen Point, looking North, Black River Limestone.
Showing the regular jointing, characteristic of this limestone.



Outcrop of Black River Limestone, Showing Rounded Form Due to Glaciation and Veins of White Calcite, Due to Compression.
East of Road Near Taby Bay.

beds are quite thin as would be expected, and as is necessarily the case, since the number of beds is so considerable and the total thickness of the formation not great. Most of them abound in fossils and some of the Rhynchonella beds and those containing Strephochetus are almost wholly made up of these fossils. Corals, Sponges and Brachiopods are usually very abundant. Yet there are some beds which are very barren. While, as has been noticed, most of the beds are thin, only a few inches or at most three or four feet thick, there is one bed which exceeds any that I have seen elsewhere. This is the great bed exposed by the quarrying at Phelps Point shown in Plate XLIX. A typical Chazy exposure on the shore of the Lake is seen in Plate XLVIII. The beds belong mostly to the upper Chazy, though the middle is not by any means lacking; and there is a small exposure of the lower.

Most of the common Chazy fossils occur, and, as has been stated, some of them in immense quantity. In the last Report (pp. 151, 116, Plates LVI, LIX) Prof. H. M. Seely has described some new species of Chazy sponges from these rocks. Plate L shows one of these in place in the rock as taken from the quarry and it also shows how nearly the fossil composes the whole mass.

THE BEEKMANTOWN. (Calciferous.) Only a very small area, colored blue on the map, of rock of this age is exposed on Grand Isle, none at all on North Hero and Alburg and only a narrow strip, at the southern end, on Isle La Motte.

On Grand Isle it appears near Phelps Point in the position shown by the blue space on the map. It is located in the upper part of the Beekmantown and is a hard, very siliceous stone containing few fossils, and those inconspicuous, such as *Isochilina*, *Bathyurus*, *Asaphus*, etc.

The Beekmantown appears in fine exposure on Providence Island a few rods south-west of Phelps Point, the entire island, except a narrow tongue of Chazy at the north end, being composed of this rock.

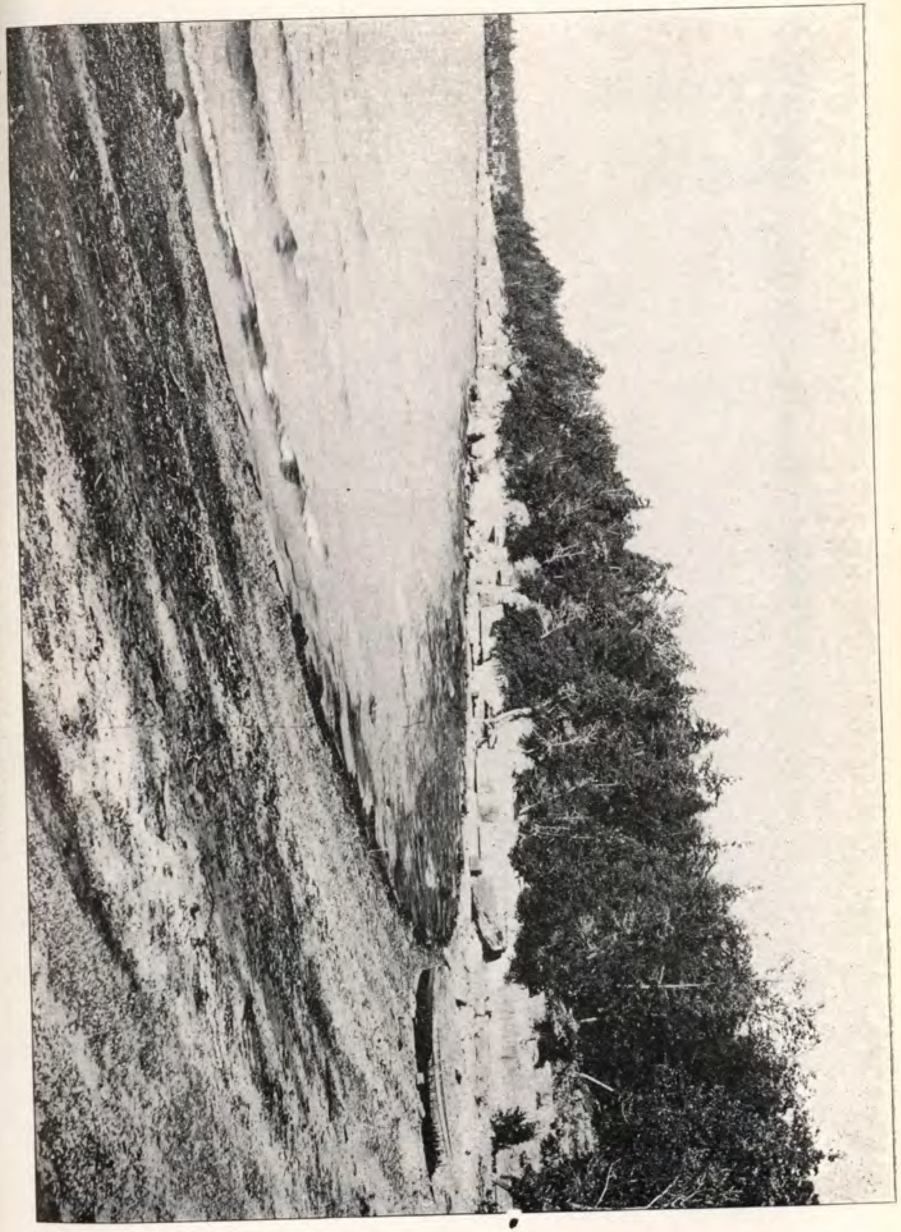
NORTH HERO.

The peculiar form of this island is evidently largely due to erosion. It will be readily suggested to anyone looking at a map of this region and especially if it be a Coast Survey chart on which the soundings are given, that originally Grand Isle county was a single mass of land out of which the present land bodies have been carved by the waves of Lake Champlain. For the most part, the water in the spaces between the various bodies of land is shallow. Between the north end of Grand Isle and North Hero the depth is very slight. Between the two bridges it is not over 5 feet on the average, though outside of the bridges it is more, even reaching 20 feet. In the Alburg Pass, only the southern part of which is shown on the map, we find the depth somewhat greater. In one place near the Tongue the soundings give 60 feet, but this is very exceptional. Between Blockhouse Point and Fee Fee Point the channel is from 25 to 30 feet deep, while north of Fee Fee Point to the Canada line the average depth is not far from 12 feet. Between Jordan Point on Alburg and Reynold Point on Isle La Motte, the depth is from 19 to 38 feet in the deepest part of the channel, growing less towards the north as in the passage on the other side of Alburg.

As the map, Plate LI, shows, North Hero is nearly separated into two parts which are not far from equal in size. Here at the "Carrying Place" the connecting land is at high water several feet under water and at extreme low water it is only a narrow strip of rock just about wide enough for the wagon road which runs through it.

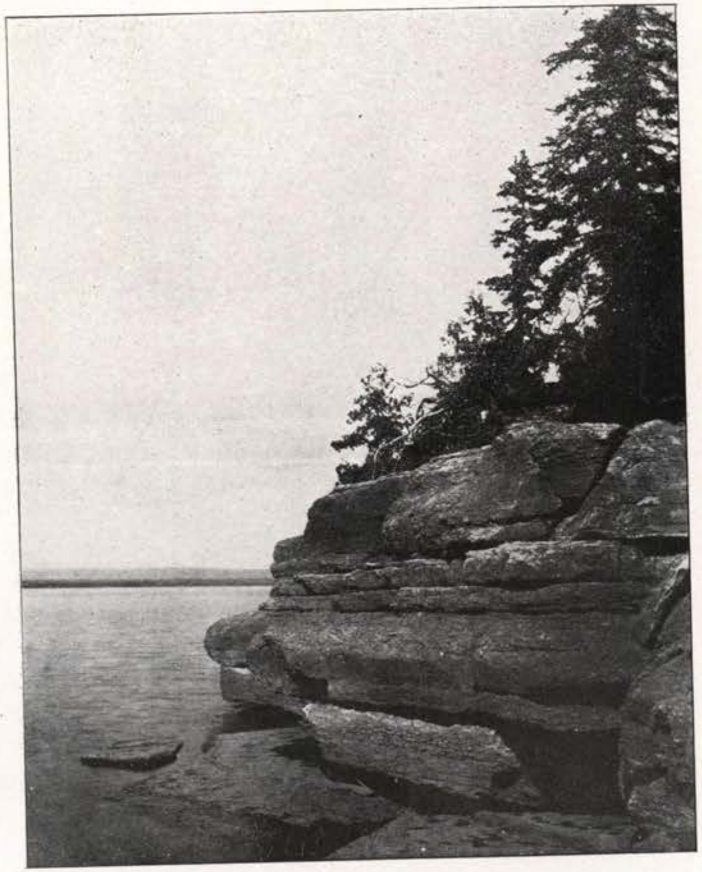
The extreme length of the island from north to south is not far from 13 miles and, as nearly as so very irregular a strip can be estimated, its average width is 1½ miles. The widest part is near the north end where it is over two miles. The area is given as 6,272 acres and the length of the shore line is 42 miles. The whole island is a mass of Utica shale and its irregular outline is due to the softness of this rock. The strata are for the most part little inclined.

The shale is usually thin bedded and brittle so that it is easily worn away by the waves of the Lake and it is still being more or less rapidly eroded during storms. Like the shale in other parts

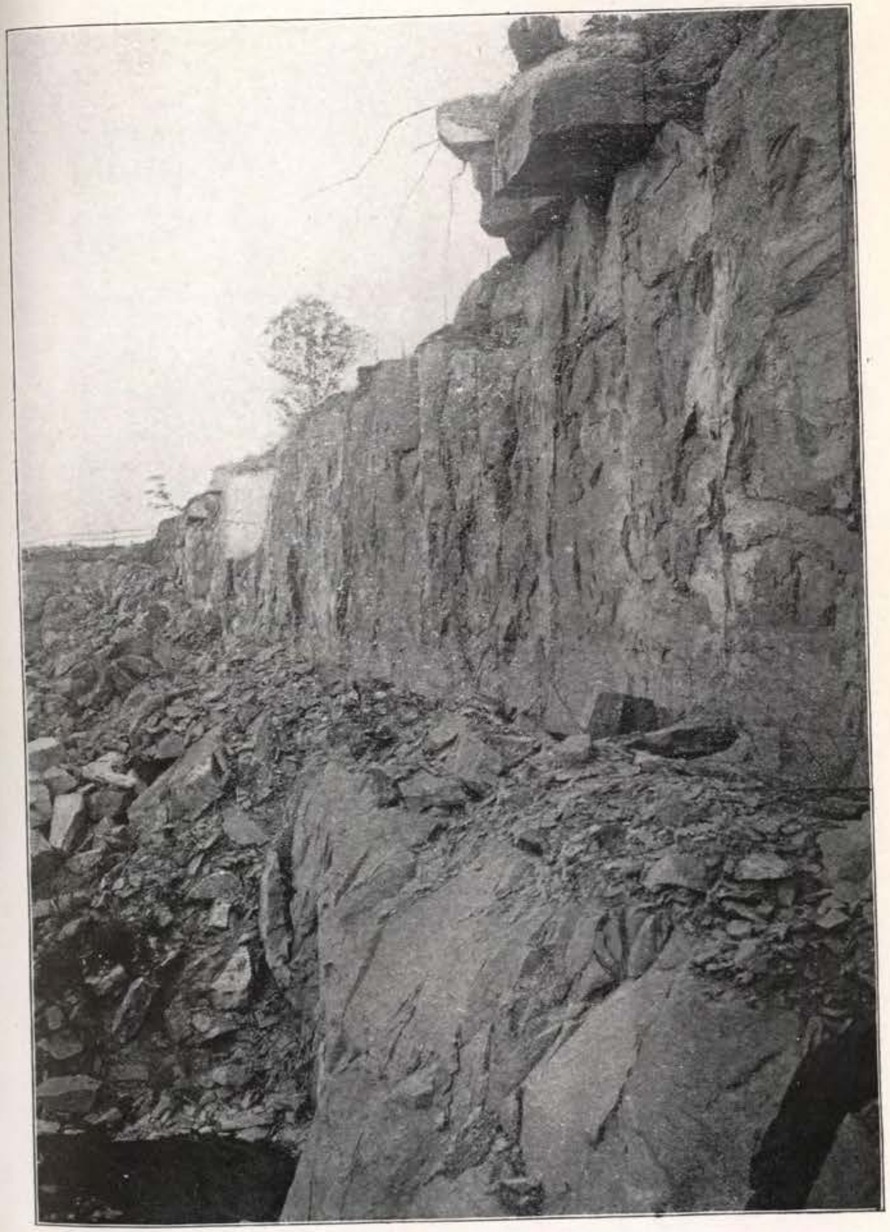


Chippen Bay, Looking North. Black River Limestone.

PLATE XLVIII.



Typical Chazy Cliffs, Wilcox Point, Grand Isle.



Thick Bedding of Chazy at Quarry on Phelps Point. (The upper layer is over twenty feet in thickness.)

PLATE L.

Photographed from a Layer almost wholly compossed of Strephochetus ocellatus, Seely. Upper Quarry at Phelps Point.

of this region, this is mostly poor in fossils, but in places *Triarthus* and *Diplograptus* are common.

The surface of North Hero is level there being no elevations higher than 60 feet above the Lake and these are few, by far the greater part of such elevated land as there is being less than 40 feet above the Lake.

The total thickness of the shale was not made out, but it is not less than 200 feet, and is probably more. A well sunk to a depth of 120 feet near the Creamery did not go through the shale and there are many feet above this. Except boulders, no other rock except Utica shale appears on this island. Most of the rock is covered by glacial clays and often below this is a very similar clay which is the result of the decomposition of the shale. Just how much of the soil of the island is due to deposition of glacial material and how much is due to the decomposition of the shale it is very difficult to determine for the one very closely resembles the other. So gradually and quietly has the change of shale to clay gone on that often when a section has been made through the soil and down into the solid shale, it is impossible to decide definitely where the clay ends and the rock begins. This is well seen in several of the cuts of the Rutland R. R. Even the lamination of the shale may be as distinct as ever in the clay and not until one undertakes to move a mass does he discover that it is clay and not shale. However it has been formed, the clay of one sort or the other, and usually of both kinds, covers a very large part of the rock. Along the shore of the Lake, of course, there is a good exposure, though even here the rock is often interrupted by sand for a greater or less distance, where it has been carried out. The surface soil varies greatly in thickness. The depth is not usually great, sometimes only a few inches, elsewhere a few feet.

There are several low areas occupied by swamps and it is quite probable that some or all of these were formerly water ways and the present island was therefore not one, but several. This, if ever, must have been after the channels had been cut through the shale making islands from what had been the mainland. That is, there were at first no islands. But after the

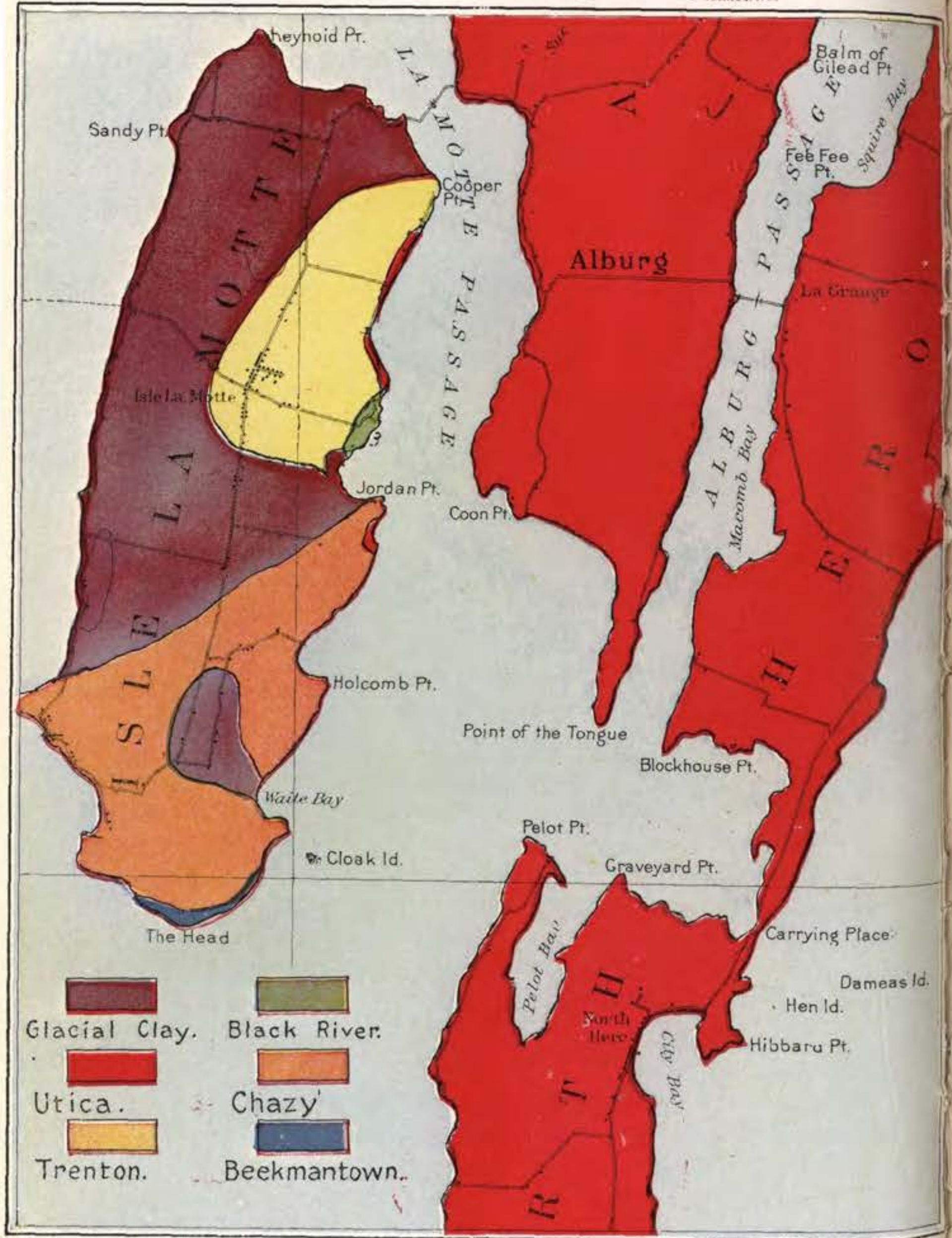
Utica had been deposited as a muddy mass under the sea of which the Champlain region was part, and after this mud was consolidated into shale and the whole had been somewhat elevated and become dry land, then the waves, or currents, or both, washed channels through the land here and there, a process which probably required centuries for its completion. Thus, finally, a small archipelago was formed out of what had been one land area. Then some of the shallower and smaller channels, either through filling or elevation of the bottom, ceased to be occupied by water and either became dry land or remained swampy, while the deeper channels still separate one island from another or from the mainland.

On North Hero the principal partly submerged areas are as follows. One extends from Pelot Bay south-west for about a mile to the Lake. A second runs from just west of the Carrying Place to City Bay. A third cuts off the south-west part of the island ending at Hazen Point. It is not probable that, geologically speaking, the time since these were covered with water is very long.

The following running account of the disposition of the rocks along the shore of North Hero may not be uninteresting to those who may wish definite knowledge as to the make up of the island.

Beginning at the Carrying Place and proceeding south along the east shore we find a low, shaly, slightly sloping shore from which the land rises towards the west, that is inland, and forms a ridge about 20 feet high, beyond which is the marsh mentioned above. Farther on towards Hibbard Point, the shale near the water gives place to sand. Then the shale again appears, and at the Point it rises in a cliff 20 feet high and this increases soon to 40 feet. At Hibbard Point the shale is quite variable in character. In some places it is compact and thin bedded, elsewhere it is thin and friable.

Everywhere *Triarthrus* and *Diplograptus* occur and nearly or quite entire specimens of the trilobite are unusually common. The shale at this point dips, 4°-5° E. 20° S. ordinarily, but in places the dip increases to 20° and becomes nearly due east.



The shore is for the most part shingle and there are no boulders north of the Point. But not far south of it boulders begin to appear in abundance.

Continuing southward along the edge of City Bay, Plate LII, there are numerous small boulders and, occasionally, outcrops of shale where the wash of the Lake has carried off the covering soil. At the southern part of City Bay the shale comes to the water or near it,and soon forms a cliff 20 feet high and from this point south for more than three miles to Knight Point where the bridge crosses to Grand Isle the rock is nearly continuous, there being only a few small breaks where clay comes to the water. Throughout this distance the Utica shale appears in a series of low cliffs not far from 20 feet high with little variation until within half a mile of the bridge. The shale here is not as regularly bedded and not as perfectly jointed as that on Grand Isle, but it is everywhere irregular, although there is little upheaval and no dikes. Throughout, the dip varies but little from 10°-14° E. 20° S. though occasionally it is somewhat more, bnt never over 20°. In this part of the island the underlying shale does not seem to have decomposed to form soil similar to the glacial clays as noticed elsewhere, but the line of demarkation is usually distinct. In places there are numerous small masses of pyrite in the shale.

It would hardly be anticipated that glacial striae would be noticeable on so soft and easily weathered a rock as the shale and they have altogether disappeared except where the wash of high water has recently uncovered new rock. In such places the striae are sometimes very fresh. It chanced that in the spring of 1903 when I did most work in the region, the water of the Lake was unusually high and there were high winds by means of which more than ordinarily the banks were washed and a much larger area of fresh rock was uncovered along the shore. The first place where markings were observed was about a mile south of City Bay where these were beautifully clear. These striae varied considerably in size and direction. Most commonly they were S 20°-25° W. but there were many lines which did not take at all this direction. For example on the

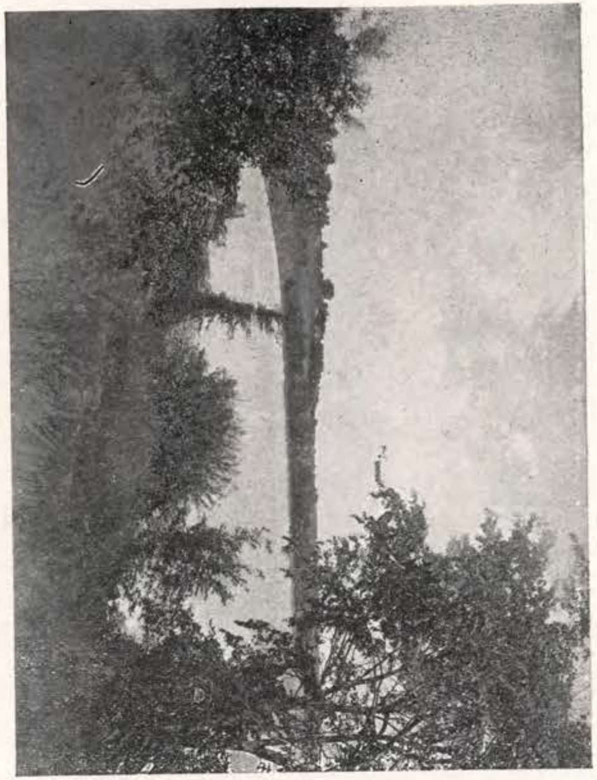
9

surface of one ledge I found the following: S.40° E. S.60° E. S.20° W. S.40° W. S.65° W. S.20° N. Curious curved striae were also noticed here and other unusual marks, possibly made by pebbles rolling under the ice.

After leaving City Bay with its shore strewn with little boulders, none appear for more than a mile. Then they again occur and of far greater size. Some are very large. There was a group of five large masses of the Swanton marble, the mottled red and white, which were far larger than any others in the region. The largest was 7 feet wide, 12 feet long, 7 feet high. The other four were smaller, but still large. These huge masses are the more noticeable because most of the boulders are much smaller, not usually more than 2-4 feet in diameter and they are from more remote localities, being mostly Canadian rocks.

From Knight Point on by Camp Meeting Point and around Hibbard Bay the shore is low and sandy no rock appearing at any part though a little back from the water it can readily be met. On the south-west side of Hibbard Bay there is a shale mass some 40 feet high which forms a rounded knoll and beyond this is a singular remnant of what was formerly a much larger strip of land. This is Bow and Arrow Point, a beautiful strip of shore, as Plate LIII, which I am able to give through the courtesy of the Rutland R. R., shows. Between Bow and Arrow Point and Hazen Point the shore is marshy or sandy, as Plate LIV shows, but there is an exposure of shale arising out of the marsh just before Hazen Point is reached. From Hazen Point northward the shale is to be seen with little interruption along the shore for about five miles, Plate LV. Along most of the west shore the shale cliffs are from 20 to 40 feet high and generally are near or quite at the water's edge even in midsummer. As one goes north from Hazen Point the shaly layers are at first nearly horizontal, but after some three fourths of a mile, they are disturbed and there is an anticline and the layers dip from 25°-40°. Here for several rods the compact shale forms a solid, sharply sloping shore from which all shingle or fragments have been washed. Yet farther north there are abundant evidences of disturbance in the folded, crumpled and broken strata.

PLATE LII.



City Bay, North Hero.

Courtesy of Rutland R R.

Bow and Arrow Point, North Hero.

Courtesy of Rutland R. R.

On the west side of Pelot Point the cliffs of compact shale rise almost perpendicularly from the water to a height of 40 or 50 feet. This long, narrow point is the highest land of so large extent on the island. There are knobs or small areas elsewhere as high, but none of them are nearly as large in extent as this. This elevated space was probably at one time a small island by itself. It is a mile and three fourths long and only a quarter of a mile wide for the most part, and the widest part is not over three eighths of a mile wide. On the east side, the shale is capped by one of the heaviest beds of clay. Yet here and there, the shale reaches the surface. Near the end of the Point there is an excavation from which the railroad company have taken out a large quantity of shale for ballast and to help fill the embankment through the Lake to Alburg. The east shore of Pelot Bay is low and there are only a few places where rock appears. The shale on the west shore is much broken and tilted and there are several small anticlines. As a rule, however, the dip is not more than 20°-30°, for the most part S. E. From Graveyard Point at the eastern terminus of Pelot Bay eastward to the Carrying Place, the shore is low and swampy.

Following the west shore, still north beyond the Carry, there are low shale outcrops followed by a low sandy beach succeeded by shale near the turn of the shore line to the west. From this point on to Blockhouse Point the shore is again low and sandy except at one place where the shale crops out in a low exposure. At Blockhouse Point there is a much stronger outcrop of rock and it is more compact than usual. It is also peculiarly banded. A section taken on the west shore a little north of Blockhouse Point gives the following layers:

Clay surface soil	3-4 feet
Much decomposed shale	2 feet
White and gray Quartz	12 in.
Shale, greatly broken	6 in.
Quartz	2-4 in.
Shale crumpled and broken	3 feet
Shale	7 in.
Siliceous layer weathering rust color	8 in.
Shale	8-20 in.

North of this section the bands of quartz occur for a short distance there being sometimes one and sometimes two.

In the last Report there were noticed some interesting siliceous layers in the Utica at Kibbe Point. I have seen such nowhere else except in the same shale a little north of Blockhouse Point, but they are much less numerous at the latter place. These layers are very conspicuous since they weather to a light rust color, though when freshly broken the stone is steel gray. Farther north the banks along the Lake grow higher and a peculiar slaty cleavage appears in some of the layers of shale. The shale beds here reach a height of 50 or 60 feet and reach north to within a half mile of Macomb Bay. Beyond this bay north to Stevenson Point at the end of the island, the shore is low, sandy or muddy and often thinly strewn with small boulders. The only bit of shale that appears on the west shore between Macomb Bay and Stevenson Point is at FeeFee Point where there is a small exposure which hardly rises above the low shore. Passing around Stevenson Point and down the east shore, we find a low, sandy beach strewn with small boulders for about half a mile when shale is again found and from here on there are frequent outcrops of sharply tilted rock which nowhere form cliffs. The dip is in the main E. 20°-30° S. In places it is as great as 45°, but not more. As seen, south of City Bay there are small areas where the soil has recently been washed off and here glaciation is displayed. Many of the scratches run nearly due north and south, others S.20° E. but the most common direction is S. E.

About three miles north of the Carry the shores are 10-15 feet high. The shale is heavily capped with clay soil. South of Long Point there are more boulders than anywhere else on the island. At Parker Bay is perhaps the best and most gradually sloping sand beach on the island, and the sandy shores continue for some two miles south of Long Point no shale appearing, and as a whole there is more sand than shale on the east shore, while the reverse is true of the west shore.

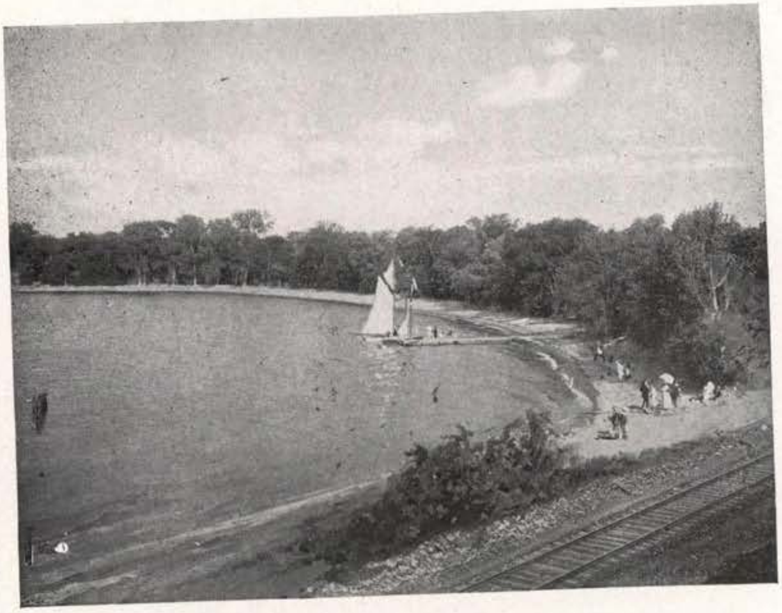
ALBURG.

This peninsula is a long tongue of land reaching south-

PLATE LIV.

Shore of North Hero. Low, Utica Bluffs.
Courtesy of Rutland R. R.

PLATE LV.



North, From Bow and Arrow Point. Low Sandy Shore.
Courtesy of Rutland R. R.

ward from the Canada line for 11 miles. From Alburg Center south the width is nowhere more than 2½ miles and for the most part less, while north of the Center the width rapidly increases until at the boundary it is six miles. The entire area is considerably greater than that of either Isle La Motte or North Hero, being 23,040 acres. The surface is more varied and irregular than that of the rest of the county. Only the southern part of Alburg is shown on the map, Plate LI. If one looks at the United States Geological Survey topographical map, he will see that not a small part of the peninsula is covered by marshes. Two of these are very large, while several are of small area. Between the swamps, the land rises in hillocks and ridges, the highest being 100 feet above the Lake though most of the surface is much lower.

The only rock on Alburg is Utica shale and, as on the islands, this forms cliffs usually not more than 20 or 30 feet high along the shore, interrupted by stretches of sand and marsh.

ISLE LA MOTTE.

Though not as large as the islands thus far considered, Isle La Motte is nearly 6 miles long from Reynold Point on the north to the southern part of the "Head." The greatest width is across from Fisk Point to Holcomb Point, 2 miles, and the average width is not far from a mile and three-quarters. It contains 4,670 acres. As the map plainly shows, its shores are less cut into by bays than those of either of the other islands. Indeed there is no deep bay anywhere along the shore for the three identations, all on the east side, which cut into the shore line enough to be recognizable as bays are not extensive. Geologically, Isle LaMotte is more like Grand Isle than either Alburgh or North Hero, but in many respects it is unlike any of the adjacent land.

The surface is irregular by reason of hills and valleys, though there is a wide extent of level prairie like land near the middle. The boulder drift, which is almost wholly wanting in other parts of the county, is conspicuous here. Some portions of the island are completely covered with small boulders, and enor-

PLATE LVII.

Section through an Old Sea Beach. Isle La Motte.

In some places, however, the rock for a few rods has been carried out and the shore is sandy. Elsewhere, even at lowest water, the cliffs come to the water so that there is no passage on land. Thus there is a marked difference between the eastern and western shores. Near the western border of the north half of the island there are some very interesting sea beaches. The road which runs north from the Chazy ferry follows the western edge of one of these old beaches and the cross road from the ferry to the Corners passes by a cut through one of the largest. Plate LVII shows a bit of one side of this cut. In places this beach material is very distinctly and regularly stratified and contains numerous shells, *Macoma*, *Mytillus* and *Saxicava*. *Mytillus edulis* is usually not common in the Champlain clays, though the other species often are, but here it is the most abundant species. The shells occur in layers an inch or two thick. This beach is the highest on the island and is from 60-80 feet above the lake. It extends from about a quarter of a mile south of the road north nearly to the end of the island.

There is a succession of beaches which rise like terraces one above another from the west towards the east. As has been noticed, the immediate shore on the west side is low and sandy, but north of the cross road to the ferry it is, even in summer, only a narrow strip from 10 to 50 feet wide and is only slightly sloping. Then the steep bank rises abruptly 10-30 feet. This is the first of the beaches. It contains *Mya arenaria* and *Macoma fusca* and a few small boulders. The carriage road to the lighthouse runs along the top of this beach. Not far east of the road there is a second beach and east of this a third and finally a fourth. They are all within half a mile of the Lake.

South of this system of beaches there is a wide, almost entirely level region over a mile wide on the west, but growing narrower towards the east. This reaches across the island. The surface is only a few feet above the ordinary level of the Lake and most probably at one time the whole was covered by water and, of course, in this case there were two islands.

As will be seen later, it seems likely that this whole area is underlaid by either Trenton or Upper Chazy as suggested by

Brainerd and Seely in their paper on Calciferous Formation in the Champlain Valley. Bull. Am. Mus. Nat. Hist. Vol. VIII, p. 312. "Away from the shore the strike and dip of the Trenton are uniform and identical with the strike and dip of the Chazy to the south of the marsh, we may, therefore, suppose that the concealed strata are the uppermost beds of Chazy, which at Chazy village six miles to the west, and at Valcour and Grand Isle, consists largely of *Rynchonella plena*. In fact boulders of these sitata are found on the shore of Isle La Motte to the south of the marsh."

As may be seen on the map, the marsh mentioned above divides the island into a southern and a northern portion each being approximately equal to the other. Undoubtedly, the rock masses which formerly filled the marshy area have been carried away.

North of the marsh which extends from just north of Jordan Point nearly across the island the rock is mostly Trenton, flanked by a very narrow Utica area on the east and a small patch of Black River north of Clark Bay.

With the exception of the small exposure of Utica just south of Jordan Point and the narrow strip of Beekmantown at the Head, all of the island south of the marsh is Chazy, Upper, Middle and Lower.

There is no Trenton south of the marsh nor any Chazy north of it.

In the north-east part of the island, there is an upthrust of the Trenton which at the highest is 100 feet above the Lake and extends over quite an area, within which is a much smaller space where the elevation is 120 feet or more. In the southern half there is also an uplift. Here at the southern part of the Head the highest rocks are 140 feet above the Lake from which the cliffs rise very rapidly to their full height and then slope to the northward much more gradually.

Thus, beginning at the southern end, we have the following terranes on Isle La Motte. First, forming a part of the shore of the Head, a narrow edge of upper Beekmantown, (blue on the map). Above and north of this is a full exposure of all the in turn followed by a second shaly layer 12 inches thick. Still lower comes a bed which is very compact and solid when not exposed to weathering, but breaking up curiously into shaly material when acted upon by frost. This bed is 30 inches thick. Below this comes another more firm and solid bed 30 inches thick and then one similar 28 inches thick. These beds are mostly dark bluish gray when freshly broken and some of them retain this color. Below these beds are two thinner, one a shaly layer 16 inches thick and finally a solid one 10 inches thick.

The lower beds mentioned could only be examined at low water as even then they soon run under the water.

CHAZY. As the map shows, this formation (colored orange on the map) is well developed on the island. It can easily be supposed that it underlies the area running west from Waite Bay and therefore forms the whole south part of the island, except the small area of Beekmantown just considered. The early Vermont geologists were so impressed by the mass of Chazy here that they called it "The Isle La Motte Limestone." This name was first used by C. B. Adams in his Second Annual Report, 1846, Page 164. On page 162 of this Report he uses this term for that part of the Chazy found in the section through Snake Mountain. The name Chazy Limestone was given to the major part of Adams' Isle La Motte Limestone by Hall and Emmons after the fine exposure of this rock at Chazy village, N. Y. The area marked on the map as covered by Chazy rocks is seen in very numerous outcrops. In some places, as in Fleury's pasture, the thin surface soil has been largely washed away leaving large areas of rock wholly bare. Along the shore of the Lake these rocks are well exposed for several miles in a practically continuous ledge, for where the Beekmantown comes to the water, the Chazy is only a short distance back and easily seen. So that from Jordan Point on the east, south and around the Head and then north to Fisk Point one can anywhere find plenty of Chazy rock. The Beekmantown forms the shore for about a mile at the Head dipping only at a low angle and appearing in successive outcrops as one goes east.

With this exception the shore is Chazy for over six miles. Inshore over fields and pastures and cut into by several quarries, there is an area some two miles from east to west and more from north to south where the Chazy beds are everywhere exposed. According to Brainerd and Seely there are in all 640 feet of this rock and further: "The upper portion of the Chazy at Isle La Motte is abraded and covered by a marsh, north of which the Black River and Trenton appear. The dip and strike are the same on both sides of the marsh. If we take this to be the dip and strike of the concealed strata, the total thickness of the Chazy at Isle La Motte would be 640 feet."*

Most of the beds are Lower and Middle Chazy, but in the northern part of the area are some of the upper beds. In some places we found great difficulty in separating the Upper Chazy from the Middle and in some instances we failed to find a dividing line. In Bulletin Am. Museum Nat. Hist. Vol. VIII, p. 310, Brainerd and Seely give the results of their investigations on this island, as follows:

"The strata appear on the south half of the island with a somewhat sinuous strike and dipping northward at an angle of from 3° to 5°. After 60 feet of Calciferous rock we have the following measures of the Chazy in ascending order:

Group A (Lower Chazy).

1.	Layers of sandstone and slate containing *Lingula* and *Orthis*,	23 ft.
2.	Silicious limestone with seams of tough slate containing *Camerella breviplicata* Bill., *Orthis porcia* Bill., *Strophomena aurora* Bill., *Strophomena camerata* Con., *Zygospira acutirostra* Hall, *Asaphus canalis* Con., *Cheirurus vulcanus* Bill., *Illæneus crassicauda* Wahl. (?), *Remipleuride Schlotheimi* Bill.	55 "
3.	Massive beds crowded with *Orthis costalis* Hall	75 "
4.	Crinoidal beds containing univalves and the layer of red-spotted marble; *Columnaria parva* Bill. occurs near the top,	70 "
	Total exposure of *A*	223 ft.

* The Chazy Formation in the Champlain Valley, Bull. Geol. Society America, Vol. 2, p. 298, March, 1891.

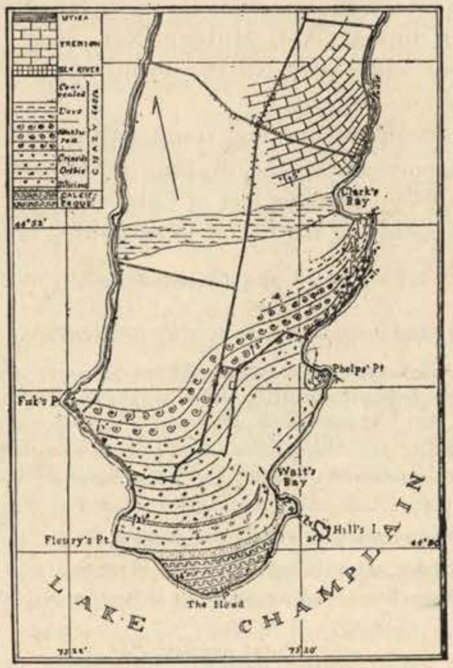
Group B (Middle Chazy).

Bluish-black, massive limestone like *B*, 3, at Valcour Island, containing *Maclurea magna* in abundance, and strata largely filled with *Stromatocerium*. The gray oolitic bed is found here at the base of the group, and the strata at the top are unusually massive, about .... 150 ft.

Group C (Upper Chazy.)

1. Pure, fine-grained, dove-colored limestone with intercalated beds of silicious and dolomitic, iron-gray limestone, containing *Cyrtoceras boycii* Whitf., *Orthoceras titan* Hall, *Placoparia multicostata* Hall, *Lichas champlainensis* Whitf., and undescribed species of *Illænus* and *Bucania* .... 120 ft.
2. Concealed .... 150 ft.

Total thickness of Chazy at Isle La Motte .... 643 ft.



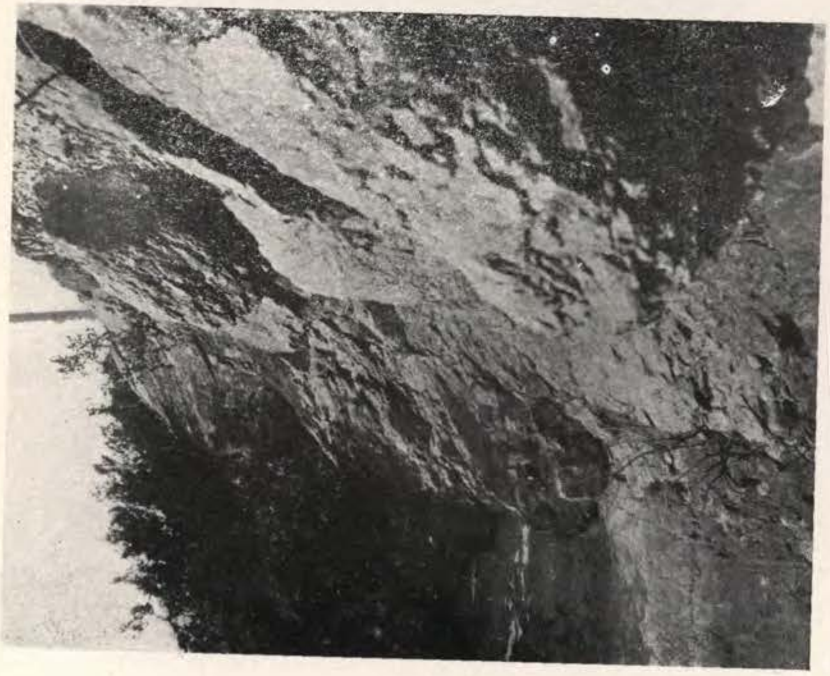
ISLE LA MOTTE, VT

FIG. V.

The above figure gives a reduced copy of Brainerd and

PLATE LIX.

Brecciated Limestone, Near View.



Brecciated Limestone. Bushed up against regularly bedded Chazy layers.

Seely's map of Isle La Motte and will be a useful addition to the colored map. As to the use of the map the authors call attention to the fact that "in using the map for field work it should be remembered that the shading indicates the position of the strata on a horizontal plane at the level of the lake. Because of the small dip the exposures of these various strata at *elevated* points should be looked for farther south than indicated on the map."

If we follow the Chazy from the north, it first appears at Jordan Point on the south side of Clark Bay. This bay is not named on the colored map, but it is the small bay north of Jordan Point. On the south side of this bay there is a low glaciated outcrop of limestone which is the first of the Chazy. This is only about 30 feet across, then there is a short stretch of sand and we come to the point. Jordan Point is a sharp upthrust of rock, somewhat over 20 feet high, the strata dipping to the north. Most of this limestone is compact and hard, but there is a shaly layer near the water.

From Jordan Point south, following the lake shore, the Chazy beds form low but massive cliffs with no shore. These beds continue for several hundred feet without break and then there is a little bay only 200 feet around its shore. Beyond this the solid beds again appear and can be followed for several miles. Indeed, with the interruption of two or three small bays they are, as before noticed, practically continuous as far as Fisk Point, some six miles or more. About forty-five rods south of Jordan Point there is a curious brecciated limestone which is thrust up against the more regular Chazy beds. There has probably been some faulting here and more or less disturbance. The breccia is a very dark mass including fragments, generally angular, of a compact, fine grained, bluish limestone. The inclusions are very numerous, are usually small, that is, not larger than a hen's egg and many much smaller, some no larger than peas, but occasionally, a piece will be seen that is 6 or 8 inches long and half as wide. Plate LIX shows the mass of this singular rock as it lies thrust up against the regular beds in the background and also the rock itself taken at short range.

At its first appearance this brecciated mass appears for 175 feet along the shore and is from a few inches to 4 feet in thickness. Evidently it is only a remnant of a larger mass; near the southern end of this there is an upthrust of Utica. This shale is much crumpled and has been violently thrust up against the breccia.

Evidently, there has been faulting between the shale and the breccia and between the breccia and the regularly bedded limestone.

As to the age of this breccia, I cannot speak positively. Longer examination of the inclusions would, doubtless, reveal fossils which would decide the matter. So far as I could discover, most of the included bits of limestone contained no fossils. But in one of the larger pieces Illænus was found and in another case Maclurea was obtained so that it seems pretty certain that the included fragments are Middle Chazy and of course it follows that the rock itself is later, perhaps, upper Chazy. The Utica mentioned above extends for 500 feet south and forms the shore at the water edge for this distance, but this rock is confined to a narrow strip not going inland from the immediate shore. After the shale, the brecciated layer again appears for about 50 feet and then for nearly a quarter of a mile, the solid Chazy beds form the shore. A little bay north of Goodsell's quarry makes a break in the rocks for a few rods. The strata nowhere dip more than a few degrees, at most 20° or 30° S. W., and usually much less. Just north of Goodsell's quarry there is a fault and 30 feet of the rock has gone out. At Goodsell's the rock is Middle Chazy. There is, naturally, a good exposure of the limestone at the quarry and west of it in the fields, and also north there are numerous and extensive outcrops. North of Duba's house and in Phelps' pasture the Upper Chazy beds appear and south of this on the west side of the road and on to the main north and south road the Middle Chazy is abundant. The great numbers of *Maclurea magna* in some of the layers is very remarkable. So too, in what seem to

be isolated patches, colonies of cephalopods occur in most interesting fashion. There is here a rich field for extended study of these beds. The Upper beds, with Rhaphistoma, etc., appear to run into the Middle beds with Maclurea, etc. Just above what may be called the Maclurea layer, though this form is found in all the beds of the Middle Chazy, is a thin layer which contains a peculiar Stromatoceroid fossil which is very abundant and characteristic and associated with it are greater or less patches of a very different rock which appears to be made up largely of finely broken fossils mixed with a brown sand. Below this comes a thick layer in which *Maclurea magna* is most abundant, in some parts of the rock filling it to the exclusion of other fossils. South of Goodsell's quarry the shore of the bay, which does not seem to have a name, is a stretch of sand as far as Holcomb Point.

Here the Middle Chazy appears, at first in low, gently sloping layers with a dip of 3°-5° N. W. The rock is here rather thin bedded of a dark bluish gray shade, not very fossiliferous, though a few species, as an occasional Maclurea, etc., may be found. Beneath these layers are others containing numerous fossils. These beds all dip 3°-4° N. 20° W.

Below Holcomb Point the Upper beds are thin and in some cases shaly. Stromatocerium appears. The dip increases to 20° and is more directly west. South of this the beds are heavy and filled with fossils, the weathered surface of some layers showing a small Maclurea in great abundance; elsewhere brachiopods are equally abundant. These massive beds form a very solid wall along the shore for some rods. Still farther south, these beds are underlaid by those that are more shaly, but before these latter appear, the massive beds thin out and there is a well defined fault. The shaly beds have been cut into by the waves leaving the upper ones more or less overhanging. Back from the Lake, there are two quarries not now worked, but from which in times past a good deal of stone has been taken out.

North of Waite Bay, for a quarter of a mile the shore is low and strewn with a great variety of, mostly small, boulders.

Then there are some rods of clear sand and then, on the south side of the bay, limestone beds 2 or 3 feet thick come to the surface some 20 feet back from the water. These beds are probably Lower Chazy, though I found no characteristic fossils. The rock is hard, siliceous, in some layers, softer and shaly in others.

On the Reynolds property it forms cliffs 10 feet or more in height. Just beyond the boat house on this property, a brecciated layer similar to that mentioned previously, is again met, and beyond, it forms the mass of a high cliff.

There is here a fault running from Waite Bay S. E. and on across Cloak Island. In some places the rock is finely glaciated and capped by glacial clays and beach formation in which is abundant *Mya arenaria* but nothing else. Further on around the Point, the limestone is more strongly tilted, S. E.; however, the beds are here so disturbed by the faulting that no dip of much value can be taken. The structure of this Point, which so far as I could discover has no name, is substantially the same as that of Cloak Island a few rods S. E., and evidently the beds were originally continuous through the present water way. Nearly in front of the Reynolds house, the cliff is composed of layers as follows: At the water there are 10 or 12 feet of a peculiar muddy layer made up of a rust colored cement in which there are usually rather small masses of corals and bryozoa so that it closely resembles breccia or conglomerate. Above this there is a layer some 16 inches thick of strongly tilted, dark shale. Then comes a bed of gray limestone filled with small fossils, then another layer of shale 6 inches thick. On top of all is a mass of limestone 3 or 4 feet thick similar to that mentioned above filled with inclusions of fossiliferous rock, but these are larger, being in some cases as large as one's head.

The whole cliff is 40 feet high and rises steeply from the water. After passing these crumpled and much disturbed beds and turning westward one comes to a little bay with the usual sandy shore and then begins a series of regular, wall like cliffs. It is not more than 100 feet from the faulted and much disother and heavy Chazy beds rising in three or four great terrace-like masses with vertical faces towards the Lake and gradual sloping surfaces towards the north. For the reason given above, i. e., the variation in the same layer at different points, it is not possible to give any minute description of these beds which will hold good for all parts of the Head. It is also to be noticed that the following is little more than a list of the different layers as they appear one after another along the Lake shore.

Beginning on the shore a short distance east of the dock at Fleury's quarry there is first a yellowish gray granular limestone containing numerous small fossils which are generally broken. This forms a bed about 9 feet thick. Below this is a bed which does not seem to be fossiliferous to any extent which is 4 feet 8 inches thick. There is some evidence of a fault here, but I am not certain as to this. This bed is as a whole thick and in some places solid, but it is evidently made up of numerous thin, shallow water layers containing more or less sand and often very irregularly bedded. Farther east, near the dock, there rises in a gradual slope a softer, yellowish gray stone with few perfect fossils, but an occasional mass of Stromatocerium. This layer rapidly grows thicker towards the east and in places is friable, in places shows cross bedding and extends for a considerable number of rods with little inclination. Where heaviest it is 18 feet thick and is on the whole the most massive bed on the Head. Below this is another thick bed, of hard, dark gray, compact limestone 10 feet thick and, together with the preceding, forms a solid cliff which rises directly from the water for about half a mile. These beds are seen in Plate LXI. Next below this is a thin, shaly layer not more than 1 foot thick in which are worm tubes, ripple marks, fucoids, etc. Then comes another solid layer very full of Orthis and other fossils. This is 4 feet thick. Below this is a similar layer 4½ feet thick containing the same fossils. Next comes a very singular and interesting layer in which we have fine cross bedding. This is shown in Plate LXII. The oblique layers are very plainly seen and in direction they vary more or less as they are followed east.

Heavily Bedded Chazy, at the Head, Isle La Motte.

Cross Bedded Layer Chazy, on the Head, Isle La Motte.

The same Layer, a few rods East.

Plate LXIII and, because of its rust yellow, while the Chazy above is dark, is very conspicuous. Below this are compact siliceous beds 2 feet thick and a compact but friable bed 2½ feet thick. The next bed is compact above, but shows a tendency to become shaly below. This is 3½ feet thick. Then comes a layer of shaly rock 1 foot thick and after this a layer much like that shown in Plate LVIII which weathers into cubical blocks. This is 15 inches thick. Following this is a siliceous limestone of quite uneven thickness in different parts, about 1 foot thick. Then there is another of the layers which is solid above, but shaly at the lower part. There are 3 feet of this. Then there are 7 feet of shaly layers followed by a bed made up of thin and very hard layers, 9 inches in all. Then comes a very thick bed, Plate LXIV, upper layer, which is compact, but brittle, and breaks in a curious conchoidal fashion leaving a most singular series of angular blocks. The layer seen below is a dark, hard layer 15 inches thick, and a similar but lighter layer next below, 7 inches thick. Plate LVIII shows the same layer with some adjacent layers. The bottom layer seen in Plate LX is another of the apparently very solid layers which weathers shaly. Below this is another quite similar where the solid top layers pass gradually into shaly ones at the bottom. This is 3 feet thick. Below this is a series of layers which form a single member composed of first a light layer 14 inches thick, a bluish layer 8 inches thick, and another yellowish layer 14 inches thick. On the weathered surface, these are very clearly distinct, but where freshly broken they are all dark bluish gray. Below this is a little layer, 2 inches thick, of white calcite and there are here slickensides showing a slipping of beds upon each other. Below this is another of the hard, cubical splitting, light weathering layers 14 inches thick. Then there is a solid layer of dark gray color 30 inches thick, and below this another 9 inches thick and then a curious bed of muddy and shaly layers over 4 feet thick followed by a series of thin, shaly siliceous layers, in all 32 inches, and then a second slipping and 2 or 3 inches of white calcite and below the slip surface, nearly 3 feet of the bluish compact rock and then a third slip surface followed by 3 feet of hard rock, then there are over 3 feet of much the same sort,

PLATE LXIII.

Contact of Chazy and Beekmantown, on the Head, Isle La Motte.

and, finally, a series of thin layers of the hard, bluish, siliceous limestone 30 inches, 16 inches, 12 inches and 20 inches. This ends the western side of the low anticline. As has been shown the rocks are nearly horizontal for a number of rods and then substantially the same series in reverse order is passed over, going on eastward.

Returning to our starting point east of Fleury's dock and going west we find the shore at first sandy and strewn with boulders. A little east of Fisk's dock, the limestone again appears and can be studied in low, flat exposures, most of them covered at high water, until not far north of Fisk Point they cease and from here on for several miles up the west side of the island, around the north end and south to Cooper Point, no rock is seen in place. At Limekiln Point, a little promontory not named on the map, not far from the Alburg bridge, there are some large masses of Trenton which appear to be in place, but we could not make sure that they were not large, half buried boulders.

A few general remarks upon the region we have just gone over may add to the value of what has been said. The contact between the Upper Beekmantown and the Lower Chazy is well shown in Plate LXIII. The contrast in color between the two is not as great as the photograph would indicate for the difference is emphasized. Indeed, in some places, the lowest Chazy and the top of the Beekmantown are much alike in appearance, especially before weathering. The Lowest Chazy is characterized by few fossils, the most prominent being a large *lingula* which is very likely undescribed. The top of the Beekmantown contains a species of trilobite, *Isochilina* which characterizes it.

It should be remembered that the list of layers and beds given above includes only those that are seen in the natural section along the shore. The "Head" forms the extreme south end of Isle LaMotte. It is a mass of rock about 1½ miles in extreme width and about 1 mile from North to South. On the southern side it rises abruptly from the Lake to a height of 150 feet at the highest point, though most of its area is much less. The northern slope is gradual. As has been seen it is composed of Chazy limestone underlaid by Beekmantown. Aside from those beds near the fault which crosses the point on the Reynolds place, the strata are very little disturbed. Back from the shore, in Fleury's pasture, there are large spaces of bare rock, the surface soil which once covered them having been washed off. Here is a most admirable locality for the study of the upper beds of the Lower Chazy, and as fossils are very abundant here, and the shore, with its numerous beds, is not far distant, the locality can hardly be excelled if one wishes to study this formation.

About three-fourths of a mile northeast of Fleury's on the Reynold's farm is another very interesting locality in which similar broad exposures abound. Especially conspicuous here are very numerous and sometimes huge masses of *Stromatocerium: Brachiopoda*, *Columnaria parva*, various *Cephalopods*, Trilobites, etc., also occur here more or less commonly.

Another interesting exposure of the Chazy is found on the east of the main island north and south road a mile or so south of the swamp. Here the rock is Middle Chazy. *Stromatoceroid* forms are very common here as well as *Protarea*, *Maclurea*, *Cephalopods*, *Brachiopods*, etc. From this main road over to the east shore the rocks abound in good fossils. I greatly regret that there was not time for investigating these interesting forms so that a list of them could be given as was at first intended.

CLOAK ISLAND. This little island, shown in Plate LXV, from the east shore of the Head is a mass of chazy, mostly, about fifty rods southeast of the larger island. It is a much disturbed upthrust of Middle and Lower Chazy, with a little Beekmantown at the southern end. The island is rather more than forty rods long and about thirty wide. The fault which crosses the southwest portion of Cloak Island has affected the whole body of rock which forms it.

On the southwest side of the island the lower 12 feet of the rock is a mass of hard silicious beds which are either Lowest Chazy or Beekmantown, I am not sure which, as no fossils could be found in the time that we spent there. Above these hard beds is a mass of more or less shaly rock 12 feet or more thick. Above this, which is all Lower Chazy, there are 30 feet of Middle Chazy, most of it brecciated like that described at

PLATE LXV.

Cloak Island, East of Head, Isle La Motte.

the east. As a rule the Black River strata are little disturbed. Both north and south from Hill's quarry the strata are very regular. The total outcrop of the Black River is 1,750 feet from north to south.

At the north end, where it is followed by the Trenton, there is a small fault and near this the layers are greatly disturbed. A few of the layers are quite fossiliferous containing large Maclureas as well as other molluscs, corals, etc., but for the most part the rock, as I believe it is everywhere, is not highly fossiliferous. In all there are 24 feet of strata seen in the quarry. North of this the limestone forms a broad shelving mass smoothly glaciated. No rock that I have seen, shows more beautiful examples of glacial striae than recently uncovered Black River Limestone.

The Black River probably extended far more widely than its present exposure would indicate. The Trenton beds rise very abruptly west of the Black River and it is likely that originally, the two were in contact, but now there is everywhere, except at one or two very limited places, a greater or less space between. A striking example of the power of ice to tear up the ledges was seen in the Black River ledge north of the quarry. At this place the limestone is a smooth, gently sloping ledge and until this spring its surface was unbroken, but this season during the spring breaking up of the ice in the Lake in some way a space several square feet in extent and a foot deep was gouged out of the solid rock as if pried out by a crowbar.

TRENTON. The Trenton is well represented in the north half of the island on the east side. It begins a short distance north of the marsh and continues north through the village on both sides of the main road and then bears northeast to Cooper Point where it ends, unless the doubtful masses before mentioned at Limekiln Point prove to be in place in which case its area will be a little enlarged. Thus the Trenton covers an area about two miles long from north to south and about one mile in width, at the widest. Throughout this area, the Trenton beds appear in a succession of low outcrops on the west side and of simply marked cliffs on the east. In the midst of the area is a

PLATE LXVI.

Trenton Limestone with Veins of White Calcite, East Shore, Isle La Motte.

smaller one which is raised above it and reaches 100 feet or more above the Lake.

And this, except a small bit of Chazy at the Head, is the highest rock on the island. This limestone comes to the east shore at three places. Elsewhere it is kept from the shore by the Utica. Cooper Point is wholly Trenton which rises here 40 feet above the water. Some of the layers here are full of fossils and would doubtless well repay study. There has been some faulting for near the north end of the outcrop there is a heavy gray bed which is uncomformable with the rest and apparently has been raised and thrust forward over the beds below. The species are Upper Trenton, *Leptoeno*, *Monticulipora*, *Calymene*, *Asaphus*, etc.

West of this the rock is covered with clay, but soon reappears and extends to and beyond the main road from the bridge. Much of the rock is black, fine grained, compact with about the usual assortment of fossiliferous and nonfossiliferous layers. On the shore not far from Cooper Point there is a small but very interesting anticline and just south of this and pushed up against it are Utica beds, the contact being very distinct.

This is not, however, an ordinary contact for the Utica beds have been pushed and thrust over the Trenton and the latter show abundant evidence of great compression in numerous calcite veins as shown in Plate LXVI. Not only veins, but, as the Plate shows, there are masses of white calcite thickly scattered through the dark limestone. Though shoved over the Trenton the Utica is not greatly disturbed or folded but is nearly horizontal.

There is here a stretch of some 500 feet of Trenton along the shore. The beds at first are not much uplifted, but they gradually form an anticlinal fold and then there is a fault south of which the beds are again nearly horizontal. This anticline is about 60 feet across from north to south and 20 feet high. Some of the Trenton layers at this place are lenticular and some are compact and gray instead of black as are most. For more than a mile south of Cooper Point the Utica forms the shore. Then south of the crossroad and after passing a little bay with its sandy and clayey border, strewn with boulders, there appears a small mass of Trenton, much glaciated and rounded on the north end and from here the same rock continues along shore for 200 feet and then it suddenly disappears and there is a shingly beach. A fault and the Utica again appears and continues for 700 feet when, after some 12 feet where the rock has gone out, another small outcrop of Trenton comes out. These beds dip 5° N. E. and follow the shore for 325 feet. Back from the shore, the same rock forms a steep bank, where a section 6 to 8 feet high is exposed. These rocks meet the Black River a few rods north of Hill's Quarry as has been noticed. The exact western extent of the Trenton cannot be ascertained because the beds run under the glacial clays.

On the east side of the main road, north of the Corners, the outcrops are some of them low, but mostly they are in ridges. On the west of this road, however, the outcrops are low and flat. Where the clays cover and conceal the rock as at the Corners, the wells, which are from 10 to 20 feet deep, reach the same rock. West of the Black River and north of the cross road, strong Trenton beds occur in ridges. North of the road the strike is in general north and south, but south of the road the ridge turns west and reaches across nearly to the main road not far north of where it enters the marsh. West of the main road at this point, there are in Capt. Montgomery's pasture a great number of large Trenton masses which seem to be in place, but as they dip in all directions, one this way and the next one in the opposite, it seems certain that they have been moved. Some of them may be the outcropping ledge as they certainly seem to be, but many cannot be. At any rate it is a very singular collection of blocks and they have not been transported far enough to be worn on the angles or edges.

West from Hill's quarry, the surface is nearly level where the Black River has been carried out and then, after a few rods, the Trenton beds begin, forming a considerable ridge with a north and south axis the beds dipping from 3° to 10° N. E. From this ridge, which in some places is 100 feet above the Lake, the limestone extends west for a mile. North of the road from the Corners to Hill's quarry the ridges are much higher and heavier than south of it. These beds are often very fossiliferous, containing the usual Upper Trenton species.

It is evident that there has been much erosion of these Trenton exposures and therefore that they were originally much more extensive than now.

Utica Shale. For about a mile and a half the Utica Shale forms the north eastern shore, but the areas are very narrow, and the total space occupied by this rock on Isle La Motte is quite small, as the red patches on the map show. It is evident to any observer that what is now found of the shale is only a mere remnant of what once existed, and it is also evident to anyone who watches the action of ice and waves on the shore that what little there is left will ere long disappear. As we have seen, the strata of the other formations found on the island are not as a rule much disturbed, but the reverse is true of the Utica, for all the beds of this are very much disturbed and crushed. While nowhere do we find such superlative disturbance as that shown on Grand Isle in Plate XLII, yet everywhere the layers are tilted, folded and broken. As has already been noticed, the Utica covers wholly North Hero and Alburg, and a considerable portion of Grand Isle. Hence, though comparatively insignificant on Isle La Motte, it is,taking the county as a whole, a most important formation. We have already seen how through the Utica the various islands and the mainland were connected, the passages between them having been cut out of the comparatively soft rock by ice and especially water. There is no doubt that the present bottom of the Lake between these bodies of land is of this rock.

The Utica is never, as elsewhere, continuous with the Trenton, but here the distinction between these formations is always very definite. The whole east shore of the island, at least that part of it north of Holcomb Point, seems to have been greatly disturbed at some time after the close of the Utica. In almost all of the outcrops of the shale, there is evidence of slipping, faulting, pushing or like change in the original positions of the layers. Calcite veins, as we have seen, are sometimes very abundant in both Trenton and Utica.

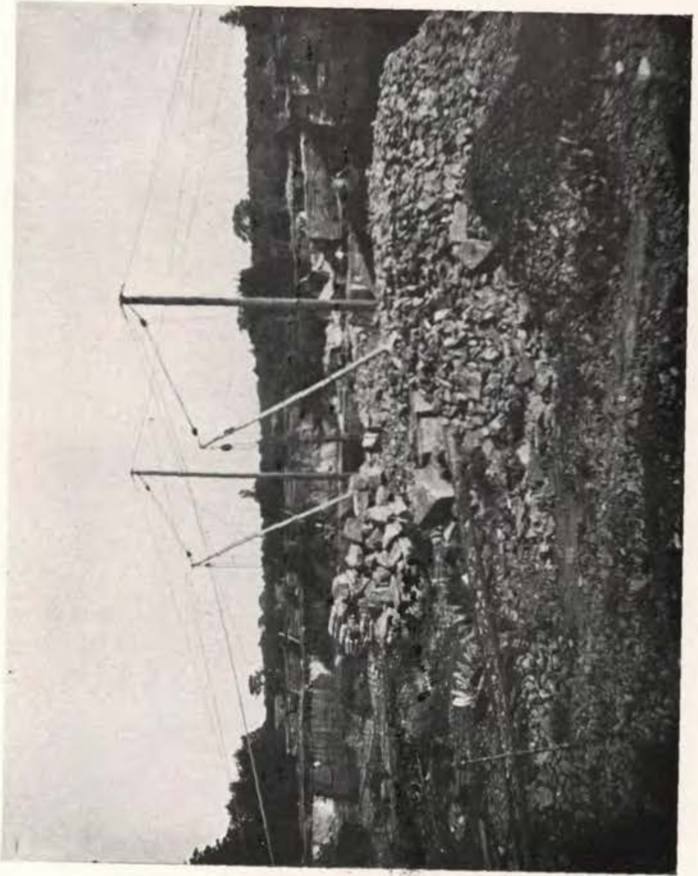
At no point does the Utica extend back from the shore more than a few rods, and usually not more than a few feet.

At one place, perhaps a quarter of a mile north of the Black River outcrop, the Utica runs across the shore road, but it rarely is found as far as this from the shore. In a few places about the middle of the largest exposure of the Utica, that nearest Cooper Point, the shale is regular, thin bedded and with less dip than common. There were layers which showed a dip of only 10°, but most showed far greater inclination. Indeed, so completely upset and folded were some layers that it seemed quite useless to take any dip.

Beginning near Cooper Point, where the Trenton goes inland from the shore, the Utica continues, as has been shown, for over a mile southward in a very narrow strip, which slopes down into and under the Lake. Not only are calcite veins found frequently in the shale, but at its southern end it shows the same banding noticed on Grand Isle, that is, the ordinary black stone banded with broad stripes of dark olive. In general the shale has a dip to the N. E. The first or northern exposure of shale ends a little south of one of the roads, the first north of the village. South of this there is a little sand and boulder-covered beach, then there is the sharp Trenton uplift mentioned above, and then a second uplift of shale, which is about 900 feet long. Here the rock rises abruptly and forms a low and nearly perpendicular wall, which increases in height to 20 feet and contains an anticline with the usual breaking and distortion, and beyond this there are low masses of shale. The only other mass of Utica found on Isle La Motte is more than one and one-half miles south, below Jordan Point, where it comes in contact with the breccia beds. Here it is even more disturbed than elsewhere on this island. This most southerly mass of shale is 450 feet long, and at the highest 15 or 20 feet above the Lake. But it has nearly all been carried off, and forms only a thin sheet in front of the Chazy.

There has been double faulting here, for not only is the breccia shoved up against the limestone, but the shale is in turn shoved against the breccia. Everywhere in these exposures the more common Utica fossils occur, but with the usual rarity.

PLATE LXVII.



Fleury's Quarry, Chazy, Isle La Motte.

GLACIAL DEPOSITS. As the map, better than words, shows a larger part of the surface of Isle La Motte is covered by Glacial Clays and Beaches than by any of the formations thus far considered. These are denoted by purple on the map.

As has been indicated, it is doubtless true that much of what is marked on the map as covered by clays, is underlaid by limestone. Probably a good deal of the rock has been carried off by glacial or other erosion where now only clay appears. From the rock which is visible we may very reasonably infer that south of the swamp the clays are underlaid by Chazy and north of it by Trenton, so that we may consider the rock basis of Isle La Motte as almost or quite wholly of these two formations.

The great extent and variety of the Glacial deposits found on Isle La Motte has been repeatedly mentioned. The region seems to have been a scene of more than usual glacial activity.

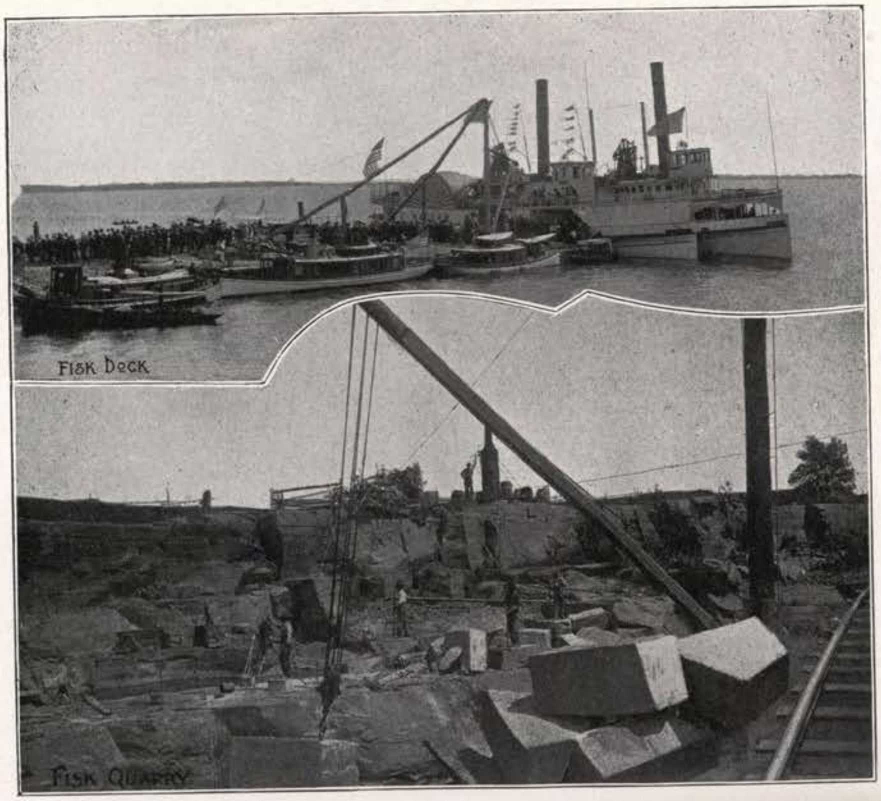
For the reason mentioned in considering the glaciation of North Hero the striated rocks were more than usually well displayed during the season of 1903. The many new surfaces laid bare by the high water of that spring showed striation that had been covered since glacial times. These striae differed more or less at different places both as to direction and character.

As would be expected by anyone familiar with the glaciation of New England, the most common direction of striae is S. W. Perhaps in most parts of Isle La Motte the most common direction is S.20° W.

On the beautifully striated surface of the Black River north of Hill's quarry the following striae were observed: S. 40° W., S. 20° W., S., S. 10° W., S. 5° W., E. 65° W., E. 20° N., E. 40° N. North of Wait Bay the following occurred: S. 60° E., S. 40° W., S., 20° W., S. 10° W., S. 25° E., S. 40° E., S. 10° E. N. & S. On the headland near Reynold's the striae were S. 20° W., S. 40° W. North of Goodsell's quarry, S. 20° W., S. 40° W., S. 60° W. On the top layer in Fisk's quarry, S. 10° W., S. 20° W., N, 45° E., S.

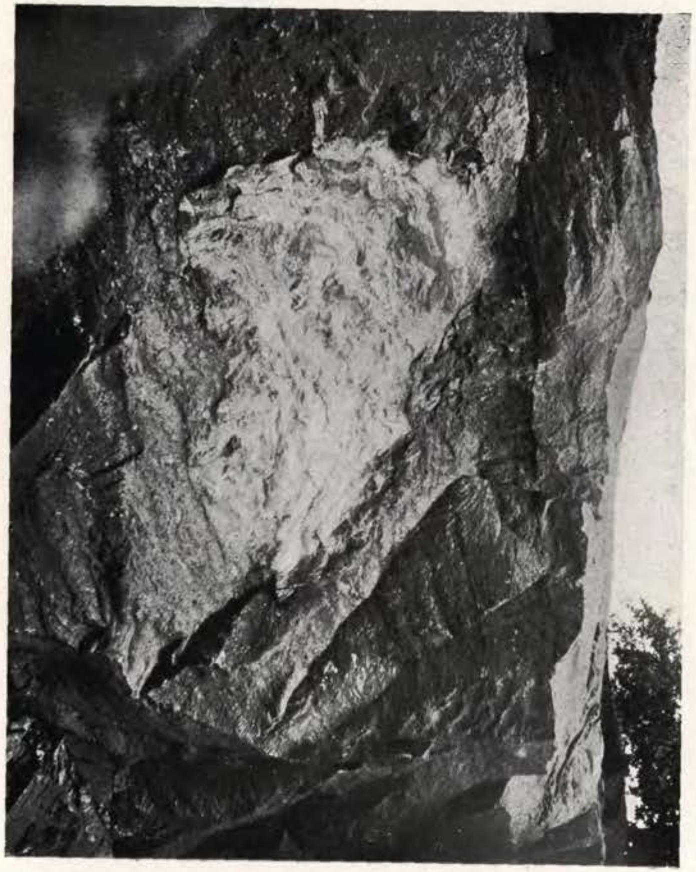
THE QUARRIES. Probably more limestone for building purposes has been taken from Isle La Motte than from any other part of Vermont. In his First Report, Professor Adams states that in the year 1844 there were 3,300 cubic feet sent to Swanton to be sawed into slabs and sold for black marble. This sufficiently indicates the use of this stone for ornamental purposes, but vastly greater was the quantity sold in blocks for the walls of buildings, piers of bridges and the like. No one can to-day explore the quarries without being fully convinced that a large amount of stone has been taken out and carried away. At present, and for some years past, only two quarries have been worked, at least to any extent. Most of the black marble from Isle La Motte has come from Hill's quarry, but the Chazy limestone south has some black layers that take a good polish and finish handsomely, and the Chazy affords much the strongest stone. Much of it has gone into the piers of the Victoria, Brooklyn, Chambly and other large bridges. Beginning at the north, the first quarry of importance in the Chazy is Goodsell's, which is located about half a mile north of Holcomb Point. This is an extensive quarry in Middle Chazy, and was worked until within a few years. According to Professor Seely, we have here the following strata: Top, blue limestone, 4 feet. Below this "bastard" limestone, 5 feet. Then a fine gray stone, the best commercially in the quarry, 16 feet, and at the bottom blue limestone, 4 feet.

West and southwest from here there are several smaller openings from which stone has been taken, and south of Holcomb Point, between that and Wait Bay, there are two quarries in the heavily-bedded Chazy. These quarries are quite near the Lake, so that the blocks could be easily loaded into a boat. The beds in the larger quarry are 14 to 16 feet thick. Fort Montgomery was built of stone from this quarry. On the Head there are places where good quarries could be opened, but there is no good harbor at hand for the boats which must take the stone away. On the southwest side of the Head a little back from the shore is Fleury's quarry, and back of this a few rods is an older one, both of large size. That nearest the Lake is now worked by Mr. E. S. Fleury. In this quarry the beds are nowhere very thick, not over 15 feet, but the layers are nearly horizontal and easily quarried. Plate LXVII is a view of this quarry. In the quarry is one very solid and hard layer, 6-8 feet thick and several thin-



Quarry of N. W. Fisk, Isle La Motte, Chazy Limestone.

PLATE LXIX.



Large Mass of *Stromatocerium* Lamottense, Upper Layer, Fisk's Quarry, Isle La Motte.

ner ones. The beds dip slightly N. W. and the rock is Lower Chazy. Just below the quarry on the shore the lowest bed of the Chazy appears. A tramway carries stone from the interior of the quarry to the end of a dock from which it can be loaded.

One of the oldest quarries in Vermont is Fisk's, which has been continuously worked for more than a hundred years. Plate LXVIII shows this quarry, and Plate LXIX shows one of the great masses of *Stromatocerium lamottense* Seely, in its original place in the top layer of the quarry. An immense quantity of stone has been removed from this place, and the work is still vigorously going on. In all the rock wall exposed in Fisk's quarry is 2,000 feet long, and from 15 to 25 feet high. In places the floor, which ordinarily is about at the level of the highway, has been cut out 5-6 feet deeper, and this should be added to the above. The beds dip only 1° or 2° for the most part. The layers differ to some extent in different parts of the quarry. Much of this stone is sound and durable, but there are layers that after a time split into thin sheets, and crumble, still these should not give character to the whole. There are now in front of Mr. Fisk's house columns that were taken from the quarry a hundred years ago, and they are perfectly sound, and the well known fact that much of the stone used in the piers and abutments of the Victoria bridge came from this quarry is sufficient proof of its strength and durability.

Some layers here are dark gray, some almost black. The layers are from 4 inches to 8 feet in thickness. The rock is not deeply covered, the layer of clay being only a few inches thick.

The top layer is much more fossiliferous than the others. This layer is 3 to 4 feet thick. Below it is a layer of more compact stone which reaches a thickness of 8 feet. From this layer splendid blocks can be quarried. Below this is a layer 2½ feet thick and very compact.

The abundance of *Stromatocerium* and similar forms in some of the Chazy layers has been previously noticed. During our explorations Professor Seely and myself collected many of these corals, and I consider it a fortunate circumstance that Professor Seely has been able to make a careful study of these specimens and furnish the following account of these interesting structures.

The Stromatoceria of Isle La Motte, Vermont.

A preface and a help to the study of the various forms of Stromatoceria in the divisions of the Chazy rocks will be found in a fresh reading of Professor James Hall's description of the genus and the typical species. The essential portions of the description are here reproduced. Reference is especially made to Hall's Pal. N. Y., Vol. I, Page 48, and Plate XII.

"GENUS STROMATOCERIUM."*

"In the black marble of Isle La Motte, and in the same rock at Chazy but particularly in the dark limestone containing *Columnaria* we find numerous specimens of obscure corals having a structure represented in figures (given). They are completely silicified so that the more minute structure cannot be decided; but since they are abundant and require notice I have proposed the provisional name *Stromatocerium*, from *Stroma*, a layer, or lamina, and *Karion*, honeycomb."

"STROMATOCERIUM RUGOSUM."

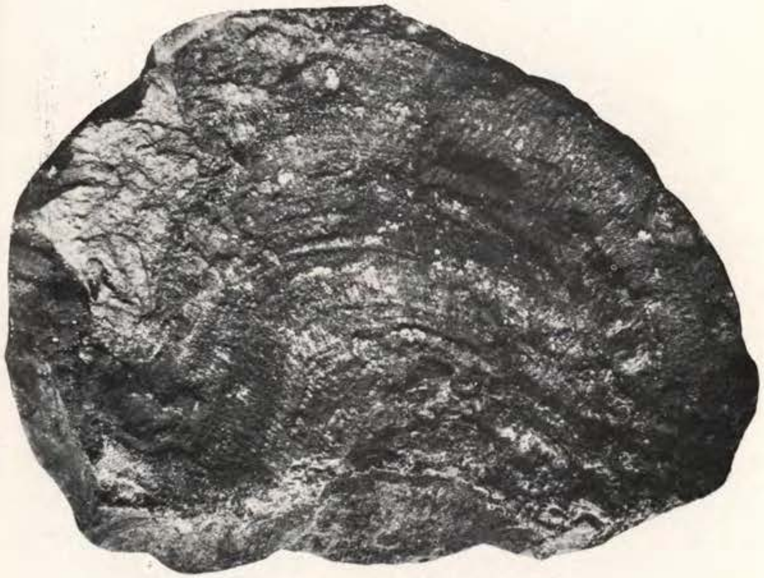
Pl. LXX, Pl. LXXIV, fig. 5.

"Coral hemispherical; growth in concentric laminae or strata; laminae, numerous, wrinkled; some faint indications of vertical tubes or cells.

"This coral usually appears as a rough, shapeless excrescence upon the surface of the limestone; but a little examination shows it to be composed of concentric layers which are evidently the skeleton of some coral.

"Position and locality. This coral as far as is known is confined to the Black River limestone. * * * It occurs in the dark marble quarried on the east side of Isle La Motte. But

PLATE LXX.



Stromatocerium rugosum.

this mass lies much above the *Maclurea magna*. * * * It occurs at Chazy Village, Watertown and other places."

The fossil to which Professor Hall gave the provisional name *Stromatocerium* has proved a good genus, and the early description still holds. Its characterization as a subhemispherical mass often silicified, as an excrescence upon the surface of the limestone, is strikingly characteristic. Its horizon is so well fixed that it has become a guide to the Black River, and its silicified mass has helped to distinguish the rock when all other fossil forms have disappeared. The specific name *rugosum* was well chosen the wrinkly character of the laminae usually accompanying the genus.

The number of localities where the fossil is found has been greatly increased. Along the islands south and through the Valley of Champlain wherever the Black River appears there the *Stromatocerium* finds a place. A most remarkable display is found in a stratum of rock near two feet in thickness made up wholly of *Stromatocerium* and *Columnaria* on a little island just off the shore of Ferrisburgh, Vt., known as Button Bay Island.

Though referred to in the original description as a coral its systematic position in classification like so many other ancient and extinct forms has remained somewhat in doubt.

The existence of this form has seemed entirely unique, a bubble on the crest of the sea of life, it appears, then as suddenly disappears.

Yet this isolation of species is seeming, not real. Whatever may be said of the notable mutation or sudden disappearance of this form, a careful study of the underlying rocks will show that an assumption of its sudden appearance is without foundation. The Chazy rocks of Isle La Motte offer complete evidence of the long time existence of the genus *Stromatocerium;* that the species *rugosum* does not stand alone. Two well defined species at least exist. Other forms for the present considered varietal may very likely be found to be really good species. And more, there are other examples which suggest close relationship to *Stromatocerium*.

wavy, coarse, irregular; texture, tough; the stone admitting of working and polishing as a marble. The exceeding massiveness and broad lamination especially characterize the species.

Horizon. B Chazy.

Illustrations. Massive fossil in wall of quarry. Plate LXIX. Entire specimen, reduced Plate LXXII, upper figure. Part of the above natural size showing coarse, irregular lamination. Plate LXXII, lower figure. Microscopic view. Plate LXXIV, Fig. 1.

This may be the proper place to call attention to the fact that while the forms *S. Eatoni* and *S. lamottense* have thus far been observed only on Isle La Motte the genus *Stromatocerium* exists in the Chazy rocks at other localities. The examples so far collected have come from the horizon that has afforded *S. lamottense* Middle B. Chazy. They have been obtained along the Valley of Champlain from Basin Harbor, Vt., Appletree Point, Vt., South Hero, Vt., and from the classic ground the Fisk Farm, Chazy, N. Y. These localities, particularly Chazy, N. Y., have yielded hemispherical masses of the shape of the old time straw beehive though much smaller in size. These examples so differ from *S. rugosum*, *S. Eatoni*, and *S. lamottense* in size, in manner of growth, in lamination, that they seem almost to demand a specific position. A valid species they may prove to be. But until the fields can be more carefully gleaned, and the examples more fully assembled and compared, it may be best to accord to them only a varietal place.

The form may have a provisional name.

STROMATOCERIUM LAMOTTENSE var. CHAZIANUM.

Pl. LXXIII, upper figure.

A stromatoceroid fossil mostly hemispherical in form, distinguished from *S. rugosum* by its greater size, and less rugose character; from *S. Eatoni* by its compact mode of growth, from *S. lamottense* by its inferior size and its finer lamination.

Horizon. B. Chazy.

Localities. Basin Harbor, Vt. Appletree Point, South Hero, Vt. Chazy, N. Y.

PLATE LXXIII.

Stromatocerium Lamottense, var. Chazianum, Seely.

Stromatocerium Moniliferum.

Returning now to the C. Chazy, and particularly to the horizon of *Stromatocerium Eatoni*, there are to be noticed some forms of fossils, fringing along the genus *Stromatocerium*, but whose relationships are still in doubt. In some cases they are so associated in the rock, running into each other in such intricate ways that their boundaries are obscure.

In one particular case the fossil forms a rock-mass blue in color, fine in texture, thin in structure, not readily distinguishable from the associated rocks. But to careful observation the weathered surface reveals a rippled or wavy appearance, and by polishing a banded structure is exhibited.

It is, however, when under magnification that the noticeable and real character appears. In thin sections the lighter laminae of the fossil show parallel close lying tubes or bands, simulating somewhat the structure of a coarse *Solenopora*. But the great peculiarity exists, that a portion of these tubes become, at evenly recurring places, suddenly contracted and then again enlarged, so that the structure appears like a chain of beads, illustrating completely the term *moniliform*. These bands or tubes and these beads when measured have a diameter of $\frac{1}{500}$ to $\frac{1}{300}$ of an inch.

The relationships of this necklace like fossil are not quite clear. The form itself hints at a connection with the sponges, also with the corals. In some respects it seems a stepping stone from the sponge to the coral. It certainly approaches the *Stromatocerium* in character.

Instead of introducing a new generic term to accommodate this peculiar form, it may be well to leave it provisionally with the *Stromatocerium* and give it a descriptive specific name.

STROMATOCERIUM? MONILIFERNUM n. sp.

Pl. LXXIII, lower figure. LXXIV, figs. 3, 4.

A pure calcareous fossil, with wavy moss like expansions, covering the exposed weathered surface. The polished surface exhibits irregular darker and lighter bands. Under microscopic enlargement the lighter of these bands are characterized by parallel tubes a portion of which are of a necklace like structure.

Horizon. C. Chazy.

an excrescence, offers very little by way of suggestions to settle these points. Yet some cases of unsilicified and apparently immature examples give a hint. These taken with the newly observed forms do go quite a little way in answering some of the questions. *S. rugosum* exhibits in growth a dome like mass, with few furrows or corrugations and with lamina above lamina. The connection of the overlying lamina with that below is obscure, yet in some cases there seem to exist pillars or tubes reaching from below upward, though without uniform system.

The mode of growth of the much later *Stromatopora* is very suggestive as to the growth of *Stromatocerium*. Instead of passage through tubes or hollow pillars (?) circulation through porous calcareous stroma of the *Stromatocerium* may have been possible.

The weather worn sections of *S. Eatoni* indicate that the surface of the living form bore close set eminences or mammillae, growth taking place over and among these. See Plate LXXI.

The *S. lamottense*, so far as observation has gone, had its upper surface raised into a series of waves, a coarse ridgy growth. This in cross section shows saw or sierra like projections as may be seen in Plate LXX, lower figure.

The relationship of these ancient animals is yet obscure. While verging in some ways toward the coralline structure they still seem to be holding to a sponge like form. Here among the sponges, where so many uncertain species are provisionally consigned, the *Stromatocerium* may rest.

Some suggestions are here offered as to the possible relationships between the genus *Stromatocerium* and genera, both below and above. While *S. rugosum* was regarded as the sole representative of a genus that appeared and disappeared with the Black River, scarcely a hint could be expected. But from the discovery of the species here recorded, which existed at lower horizons and in far greater mass, it seems probable that *S. rugosum* was a decadent or rapidly mutating form, the culmination of the genus passing with the species *S. lamottense*.

If we now inquire as to like forms we shall see a general resemblance of the *Stromatocerium* to the *Cryptozoon* below and the *Stromatopora* above. The upper trend of life and development would be then *Cryptozoon* of the Beekmantown, *Stromatocerium* of the Champlainian, *Stromatopora* of the Devonian.

This suggestion is greatly favored by the minute structure of these genera.

H. M. SEELY,

MIDDLEBURY, VT.

On the Lignite or Brown Coal of Brandon and its Fossils.

BY GEORGE H. PERKINS.

The deposit of Lignite near Brandon was first discovered in 1848 while sinking a shaft for the purpose of working a bed of iron ore. Lignite has not been found anywhere else in the State, and at Brandon so far as can be ascertained the deposit is not of large extent. However, it is so concealed by drift that it is quite uncertain how far the deposit may reach.

The deposit does not appear to have attracted the attention of any scientific observer until in 1851 President Edward Hitchcock received specimens of lignite and of the fossils contained in it. In the American Journal of Science and Arts, 2d. Ser., vol. XV., p. 95, 1853, President Hitchcock describes his first visit to the locality as follows: "Early in the spring of 1852 I visited Brandon and found that the fruits were obtained from a bed of brown coal connected with the white clays and brown hematite of the place."

"At this spot we find the following varieties of substances in juxtaposition:

1. Beautiful kaolin and clays colored yellow by ochre, rose colored by manganese and dark by carbon.
2. Brown hematite and yellow ochre.
3. Ores of manganese.
4. Brown coal.
5. Beds of gravel connected with the clays.
6. Drift overlying the whole.
7. Yellowish limestone underlying the whole.

The position of the clays it is difficult to determine exactly, as there seems to have been a good deal of disturbance of the strata, perhaps only the result of slides. The iron is generally found beneath the clay, as is also the manganese. The coal shows itself in a few places at the surface. In one spot a shaft has been carried through it only a few feet below the surface, and the same has been done in the same bed nearly 100 feet below the surface. In both places it was about 20 feet thick. I found it to be the impression of the miners that the mass of coal forms a square column of that thickness descending almost perpendicularly into the earth in the midst of the clay. My own impression was that it is a portion of an extensive bed having a dip very large towards the N., perhaps separated from other portions of the bed by some disturbance of the strata. But I found great difficulty in tracing its exact position. The greater part of the carbon of the deposit is in a condition intermediate between peat and bituminous coal. It is a deep brown color, and nearly every trace of organic structure save in the lignite and the fruits is obliterated.

"Disseminated through it are numerous angular grains, mostly of white quartz, rarely exceeding a pea in size. It burns with great facility with a moderate draught and emits a bright and yellow flame, but without bituminous odor. After the flame has subsided the ignited coals gradually consume away, leaving, of course, a quantity of ashes. Interspersed through the carbonaceous mass above described occur numerous masses of lignite. In all cases which have fallen under my observation they are broken portions of stems or branches of shrubs and trees varying in size from that of a few lines to a foot and a half in diameter. They all appear to me to be driftwood. The largest mass which I have seen resembles exceedingly a battered piece of floodwood. The large mass now in the cabinet at Amherst College is 4 feet long and 16 inches wide in its largest diameter. With perhaps one or two exceptions, all the lignite of this deposit belongs to the exogenous class of plants. In general the texture is close, and some of the wood is very fine grained and heavy. The bark is often quite distinct. I have been inclined to refer some of the wood to the maple, yet probably a good deal of it is coniferous."

After these general remarks there come figures of twenty-six of the fossils found in the lignite. There are, however, no descriptions except most brief and meagre, and none are named. Of this Dr. Hitchcock says: "Probably a sagacious botanist skilled in fossils would detect more species among my specimens. Some of them resemble a good deal drawings of the fossil fruits and seeds of the London clay as figured by Mr. Bowerbank in the first number of his work on that subject." And finally the following "conclusions" are given:

"1. The Brandon deposit belongs to the Tertiary formation.

2. The carbonaceous matter in this deposit is strikingly analogous to that of the brown coal formation in Europe.

3. The fruits and lignite of this deposit appear to have been transported by water, and probably the accumulation took place in an ancient estuary.

4. The Brandon deposit is the type of a Tertiary formation hitherto unrecognized as such extending from Canada to Alabama.

5. This deposit belongs to the Pliocene or newer Tertiary."

The above article was republished without much change in the first volume of the *Geology of Vermont*, 1861, p. 226.

In the Vermont Report there are a few additional statements and three additional species are figured.

In this connection the following letter from Professor J. W. Bailey is of interest:

"West Point, Dec. 10, 1852.

"President Hitchcock:

Dear Sir:—The specimens of fossil woods and fruits from Vermont which you sent long ago reached me safely, but I have been unable to attend to them until very lately:

I have recently made sections of some of them for microscopic examination, but have obtained only negative results. The woods are not coniferous, and do not present characters by which I can distinguish them from any ductiferous woods. One of them is remarkable for the large number of very large cells scattered in radiant plates among the silver grain or medullary rays.

The small, nut-like fruits have been studied by me most carefully, and at first were a complete puzzle, as the cross section showed nothing but hard tissue or sclerogen without any distinct cavity for seeds, and yet its exterior markings and internal structure showed that it was probably composed of either three or six carpels, and if a capsule of course should contain seeds or a place for them. By sacrificing the most perfect specimen I at last found the seeds, which appear to have been six in number, and arranged in a radiant manner around the axis, as indicated in the cross section. I succeeded in getting several seeds partly exposed. * * * The testa alone of the seed is preserved, and is very brittle. I am not much versed in carpology, and therefore can aid you little in determining the family to which the fruit should be referred. It is certainly unlike any of our northern fruits, and I would suggest its comparison with some of the Sapotae. * * * A putamen, or else an envelope, as in some of the palms, could alone furnish the hard tissue of which these fruits are almost wholly made up. * * * I remain yours truly,

J. W. Bailey."

The fruit described above seems from Prof. Bailey's figures to be like that shown in Plate LXXXI, figs. 156 or 157.

Lesquereux wrote at about the same time, I judge, as follows:

"I am acquainted with the Brandon fruits from specimens, very few, presented to me, and especially from the excellent pages describing them in the XVth vol. of Silliman's Journal. Most of the fruits published, or rather figured, there can be referred to species of the Upper Tertiary. They agree especially with the flora of Oeningen, and I have no doubt that the Brandon lignites belong to the same epoch as the upper bed of the lignite of the Tertiary. * * *" Geology of Vermont, 1861, p. 240.

After the publication of Dr. Hitchcock's article in 1853, nothing appears to have been written concerning these fossils until

in 1861, Lesquereux published descriptions and assigned names to those that had been figured eight years previously. Meantime more specimens had been collected and sent to Lesquereux, the examination of which caused him to reiterate his former opinion that the fossils represented an upper Tertiary flora. This article was first published in Am. Jour. Science and Arts, Vol. XXXII, 2d Series, pp. 355-363, 1861. It was soon after republished by Dr. Hitchcock, then State Geologist of Vermont, in the second volume of Geology of Vermont, pp. 712-718, 1861.

In this latter article, the author says "It cannot be expected that the examination I was requested to make of these fruits can afford any exact botanical determination. Indeed an accurate analysis of the fossil fruits is mostly impossible. * * * It is only to point out the relation of some of the Brandon fruits with some fossil species found elsewhere, or with genera of plants now living, and, especially, to try to come to a satisfactory understanding about the geological age of the lignite deposit where they are found that the few following remarks are made." Then follow exceedingly conservative descriptions of twenty-three species. After this he adds, "I have still to mention a piece of wood from the same lignite of Brandon. The wood, though somewhat hardened and blackened, is still in good state of preservation. It is soft enough to be cut with a knife or at least easily broken and by a section shows on both its sides the characters of dicotyledonous wood."

I do not find that anything further concerning the lignite or its fossils was published until an article by Professor F. H. Knowlton appeared in Torrey Bulletin of November, 1902, pp. 635-641, Plate 25. From this article the following quotations have been taken: "The largest specimen (of lignite) in my possession was given me by Dr. D. W. Prime, of Brandon. It is almost 12 inches long and 4 inches broad. It breaks up very readily into small irregular fragments which appear destitute of structure in their transverse fracture. but when split along certain lines, notably in the direction of the medullary rays, very plain structure may be observed, even by the naked eye. In general the only specimens that can be obtained for examination are small fragments hardly more than an inch in length. Hitchcock was of the opinion that little if any of the lignite could be regarded as coniferous, while Bailey in his letter before referred to states positively that the woods are not coniferous.

Contrary to these statements and to my expectations a large proportion of lignite examined proved to be undoubtedly coniferous in character. These later results are perhaps due to improved methods of study, or possibly its character may differ in different parts of the area.

When specimens prepared as indicated above are placed under the microscope, a glance suffices to show that they have been much crushed and distorted by pressure. In transverse section the lumen of the cells is almost entirely obliterated and they have been distorted in other ways. But by repeated selections of material and its careful study, points that have been especially favored during the process of fossilization, are usually to be found and from a study of these in numerous examples, a pretty complete idea can be formed of its nature and appearance when living. The large specimen in my possession, mentioned above, was found to be undoubtedly coniferous.

Selected sections from it show clearly the characteristic pits on the radial walls, Fig. VIII, 9. The walls of the tracheids were also found to be thick spirally on the interior. In longitudinal tangential section the ends of the medullary rays show plainly, Fig. VIII, 10. They have been very considerably distorted, yet their arrangement can be made out. They are usually simple, that is, consist of a single layer of cells, yet scattered along these are a few compound rays with a single included resin duct, a well known character of the genus Pinus. Indeed, after a careful study, I am scarcely able to distinguish the Brandon lignite from a species of *Pityoxylon*, described by Schmalhausen from the Eocene and Braunkohle, of southwestern Russia. The material studied by Schmalhausen was better preserved and he was able to work out the details of

structure in a more satisfactory manner than is the case with the Brandon material. Yet, on the whole, I am inclined to regard them as of only varietal difference. Schmalhausen has named the Russian species *Pityoxylon microporosum*. For the Brandon form I propose the name *Pityoxylon microporosum brandonianum*.

The type is as follows: Annual rings plainly marked, rather thick, medullary rays rather numerous, the simple ones 1-7 cells high, the larger enclosing the resin duct about 1-8 cells high; wood cells marked by numerous lines, the pores small and remote; pores on the medullary rays large, oval, 2 to the width of each wood cell.

The Brandon form differs in the narrower annual rings and the smaller size of the cells in general. It is not well enough preserved to show markings on the medullary rays if these be present. The walls of the tracheids are thickly covered with fine spiral lines, and the bordered pits are also smaller than in the type. The contents of the resin tubes cannot be made out.

While, as already stated, the bulk of the lignite examined proved to be coniferous, I fortunately secured one small but well preserved piece that was with equal certainty dicotyledonous. The accompanying figure Plate XXV, fig. 14, shows it in longitudinal tangential section, and brings out the fact that it was provided with large dotted ducts and numerous medullary rays, the latter of about uniform size. It suggests a wood allied to Betula, but of this I am uncertain."

Dr. E. C. Jeffrey of the Botanical Department of Harvard University has been studying the specimens of the Brandon lignite during the past year. His investigations are not yet so far completed as to justify publication, but it is expected that in the next Report they will find place with such illustrations as may seem desirable. Meanwhile it may be stated that as Dr. Jeffrey writes, "Most of it (lignite) is a species of Lauroxylon in a more or less good state of preservation. There is one small piece of coniferous wood and a good deal of dicotyledonous material in which only the medullary rays show any structure."

The samples of lignite which I sent to Dr. Jeffreys were taken from a large quantity collected at different times, some of it recently, some twenty years or more ago. I also tried to select as great a variety as possible in order that the result might give as complete an idea of the character of the wood from which the lignite was formed as possible.

As the collection of the fruits here described shows and as the fragments of the leaves found show, the larger part of the lignite is composed of dicotyledonous wood, although, as Professor Knowlton's investigations show, there is also coniferous wood.

The opening mentioned by Dr. Hitchcock has long since been filled up, but other shafts have been sunk through the lignite deposit, notably for the purpose of obtaining clay for the manufacture of the "Brandon Paint," and thus more or less of the lignite has been brought to the surface, and from it a small number of the fossil fruits have been obtained. Digging for clay ceased some years ago when the paint works stopped, and for the ten years or more prior to 1903 very few fossils were found.

Two or three years ago a small shaft was sunk for the purpose of getting white clay for use in paper making, and a small quantity of lignite was thrown out as the shaft was carried through it. From this I was able to collect a small number of the fossils. As in previous digging, the work here was not long continued, and no other specimens could be obtained until the coal famine of the fall of 1902 forced people to look in all directions for fuel. The lignite then for a time came to the front, and more was dug during that fall and winter than ever before. It was sold to the people of Brandon and burned in stoves. Over a hundred and fifty tons were sold. During this time collectors in my employ watched the lignite as it was brought to the surface and supplied me with the fossils. The fruits appear to be abundant in the lignite, and if only this could be easily reached, there would be no difficulty in securing large collections. As it is, however, they are very rare because the lignite is completely covered by from 15 to 30 or more feet of drift. President Hitchcock's account shows that in his day there were surface outcrops of the deposit, but for many years there have been none, the old ones having been either dug out or covered with waste from the clay pits. For the same

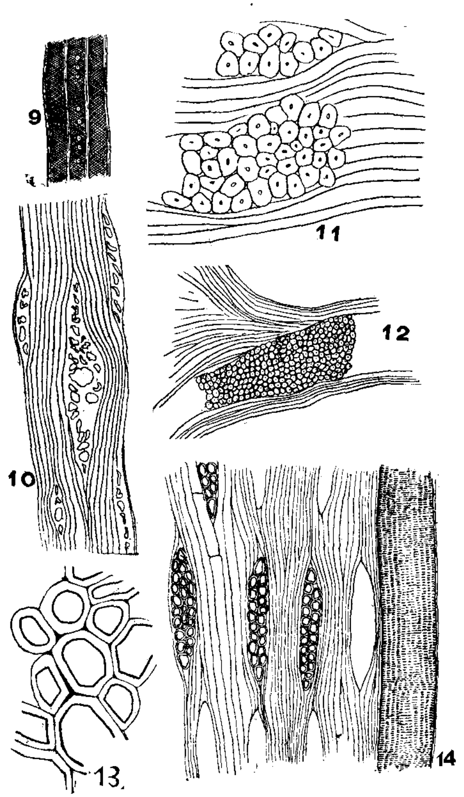


Fig. VI.

9. Pityoxylon microporosum brandonianum, Kn. Radial section.
10. Same tangential.
11. Carpolithes brandonianus. Section near the base x50.
12. Carpolithes brandonianus, Lx. Section near base x50.
13. Aristolochites. Section near the middle x45.
14. Dicotylenous Wood. Tangential Section x75.

reason the full extent of the deposit can only be conjectured. Mr. G. E. Laird, who was foreman of the old paint works, and is therefore familiar with the locality and its deposits, states that in one place a shaft was sunk 50 feet in the solid lignite, but did not go through it. The whole mass evidently dips to the west. Mr. Laird tells me that at one point in digging a shaft the lignite was reached at a depth of 40 feet, and another shaft not far west was sunk 60 feet before reaching lignite. Mr. Laird, from what he had seen in the shafts, thought that the entire area of the lignite was not more than 400 square feet. He says that in digging shafts white clay was invariably found adjacent to the lignite, and that below it there was always sand, with white quartz fragments. Professor T. N. Dale of the United States Geological Survey has spent several seasons in the vicinity of Brandon, and has furnished the following notes with the map which Prof. Dale has drawn at my request :

Note on the Geological Relations of the Brandon Lignite Deposit.

By T. Nelson Dale.

[Published by permission of the Director of the United States Geological Survey.]

The long known lignite deposit of Brandon lies two miles northeast of that village and about a mile S. S. W. of Forestdale, at the western foot of the Green Mountain range. As shown on the accompanying sketch map, it lies a little west of the uncertain boundary between the Cambrian quartzite and schist and the magnesian limestone (dolomite) which underlies the eastern part of the Vermont valley. It is on the eastern side of a N.—S. hollow formed by a series of dolomite knolls on the west and a quartzite and schist ridge on the east.

The supposed areal extent of the lignite and its associated limonite and kaolin are shown on the map by dark shading. It covers approximately a fifth of a mile square.

As the present diggings nowhere reach the underlying rock it is uncertain whether the formation overlies the quartzite or the dolomite, but the probabilities are favorable to the latter supposition. The lignite, limonite and kaolin seem to be irregularly interbedded with one another. The fact that the kaolin contains pebbles of decomposed quartzite, evidently from the adjacent Cambrian, which must, therefore, have been above water during the deposition of the kaolin, and the fact that the fossils of the lignite are of Tertiary age prove that this limonite deposit is not at all to be confounded with such limonite bodies as those of Western Massachusetts which lie between the Stockbridge Limestone and the overlying Hudson (Berkshire) Schist, and are, therefore, either of Trenton age or were formed later by a process of subterraneous weathering.

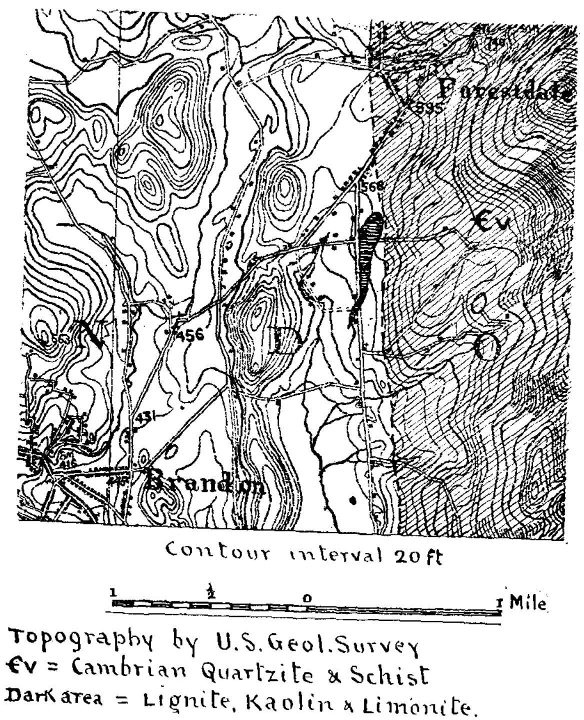


Fig. VII.

Map of a portion of Brandon showing the location of the Lignite Deposit.

Drawn by T. N. Dale.

The Brandon lignite attains a thickness of 20 feet and the adjacent kaolin is at least 78 feet thick.

The kaolin must be regarded as the product of the weathering of feldspathic rocks such as the gneisses and quartzites of the

Green Mountain range. The quartzites contain many grains and small pebbles of feldspar. As limonite is frequently associated in its origin with decomposing vegetation, its association here with lignite is quite normal. A little manganese ore, pyrolusite, is found with the limonite.

The kaolin is being mined by Messrs. Horn, Crockett & Co. for use in the manufacture of paper and the lignite during the recent coal strike came into local demand for fuel. The scientific interest attaching to the Brandon lignite is very great, for out of all the floras and faunas which must have flourished in this region since the retreat of the sea in Silurian time we have here preserved the only remnant of them found as yet; and that belongs to one of the later floras.

July 15, 1904.

In addition to the above, I have received from Dr. J. M. Clarke, Director of the Geological Survey of New York, the following notes by Professor J. B. Woodworth, who has for several years been studying the Pleistocene geology of the Champlain valley in connection with the New York Survey.

Dr. Clarke has kindly given permission to include the notes in the present Report.

The Brandon Clays.

By J. B. Woodworth.

The lignites of Brandon, Vt., have recently been studied by Knowlton* from the palaeobotanist's standpoint. The most comprehensive report upon the stratigraphy of the beds enclosing the lignites is the original account by Hitchcock.† No good exposure of the lignite beds has been made since Hitchcock's report was written. The present writer visited the locality in July, 1904, primarily to determine the relations of the lignitiferous deposits to the pleistocene or glacial drift.

In regard to the relations of the glacial deposits to the lignitic series the present state of the ground along the narrow north and south belt in which the old workings mainly occur is unfavorable to making a definite statement, but on the eastern border of the abandoned pits a till-covered ridge appears. On the flat extending westward from the pits there is stratified sand of undetermined thickness. All the surface indications today as well as the information obtainable from the present owners of the property confirm Hitchcock's original statement that the lignite deposits underlie all traces of glacial drift. Knowlton's determination of the age of the fossil plant remains as probably Miocene is sufficiently explicit to the same effect.

It was impossible at the time of my visit to draw any inference as to altitude of the lignitic beds, and consequently no statement can now be made as to the effect of ice pressure in deforming the strata.

Messrs. Crockett, and Horn the present owners of the property,

*F. H. Knowlton:—Notes on the fossil fruits and lignites of Brandon, Vt., Bull. Torrey Botanical Club, 29, Nov., 1902, pp. 635-641.

†C. H. Hitchcock, and A. D. Hagar:—Report on the Geology of Vermont, 1861, 2 vols.

have sunk a shaft 118 ft. deep near the southeast corner of the cross-roads, and have run two levels at 80 and 90 ft. toward the east. I descended this shaft to the 80 ft. level and went some 40 feet east in the drift. The clays in the 80 ft. level have all the appearance of a decomposed schistose rock and appear to me to be altered bed rock underlying the lignitic series.

The clay at the end of this drift was almost pure white, with a banded structure dipping as nearly as I could determine about 35° to the north of west. Hand pieces of this lamellar structure showed bands of white Kaolin in angular pieces, and here and there layers with a typical augen-gneiss structure. Farther than this there were rare flat lenticular occurrences of vein quartz parallel to the banded structure. The quartz was cracked and broken into small angular fragments, but showed its origin clearly in situ. This clay in the drift has a very compact structure very unlike that of sedimentary clays. I did not determine the nature of the original rock as to whether a silicious limestone, felsite schist, etc.

According to Mr. Horn, no lignite was encountered in sinking this shaft. The principal lignite deposit was encountered on the north. A trace of lignite was found in sinking a shaft a few yards south of the present open shaft. It is not known whether the clays in this shaft above the 80 ft. level were sedimentary or sedentary. It appears though that a good quality ot Kaolin derived from the decomposition of the bed rock here underlies the neighboring lignite deposits. The depth of this decomposed rock at this point has not yet been determined.

In conclusion it can only be pointed out that the Brandon lignite deposit is very similar in its underlying sedentary clays to those products of preglacial decay farther south in the Berkshire Hills described by Crosby.

If we may draw any inference from the erosional history of New England during tertiary times it is to be concluded that the Eocene was a time of erosion, and that the Eocene deposits if any came into existence were stripped away, and that these sedentary clays do not antedate the Miocene, deposits of which age occur at

Marshfield, Mass., in pockets in the granite, and probably also, as Knowlton points out, at Brandon.

Professor Dale's map, Fig. VII, shows the area of lignite and associated material, but the lignite has not been found in all parts even of this limited area.

Use as Fuel. As has already been mentioned the lignite has been at different times used as fuel. Several attempts to heat the boilers in different works have been made with some degree of success, though it did not prove altogether satisfactory in any case. In all, a good many tons must have been consumed. At no time, however, was anything like as much dug and used as during the coal strike in 1902-1903. I have enquired of different people who used this material in cookstoves and heaters as to its value as fuel. Opinions differ considerably as to its value as fuel. Some speak highly of it, others do not.

It burns without difficulty, giving a yellow flame and a peculiar odor. It leaves a large amount of ash, much more than ordinary coal. It burns more speedily so that fires fed with it need close attention or they go out and it does not produce as great heat as coal.

A few of the housekeepers who used it for cooking said that it was better than wood, but most were very glad to drop it as soon as they could get coal. The fact that, so far as I can discover, no one used it after the supply of coal increased, is significant.

Appearance. The Brandon lignite varies in appearance as it does in hardness, compactness and durability. Some of it is so compact and firm that it can be polished, when it closely resembles ebony, and less commonly, it is like bitumen or albertite. Most of it, however, is dark brown, brittle, easily cut with a common knife. When exposed to the air much of it breaks into small, more or less angular pieces, and if out of doors finally becomes a soft black mud. Some of it does not break up thus, but remains for years in solid masses. Specimens in the State Museum which were collected in 1859

are still firm and, except that they are harder, resemble partly decayed wood. Occasionally there is pyrite mixed through the lignite, and of course, this causes breaking up of the mass. In the quotation given on a previous page, Professor Knowlton speaks of having only quite small pieces, but of late there has been no difficulty in getting much larger pieces than he mentions. Bits several inches, 4-6, long are not uncommon in the piles thrown out and there are several pieces much larger. The largest piece in the Museum of the University of Vermont is 19 inches long, 6 inches wide and 3 inches thick. There are several large pieces in the State Museum at Montpelier, though not as large as the one just mentioned. The largest piece of which I am cognizant is that already mentioned by Dr. Hitchcock in the Amherst Museum. This is now 18 inches wide, 19 inches long and 6 inches thick. It is almost black, very compact, but has cracked considerably because of pyrite which permeates it. Yet, in spite of this, it has remained in fairly good condition. There are two pieces in the Museum of Comparative Zoology at Cambridge which are 12x9x3 and 9x8x3 inches. When first taken from the ground and, of course, wet, the lignite is always very dark. After drying it is lighter and then usually grows dark and remains so. The only analysis of this lignite which has been made so far as I know, is that given in the Vermont, 1861, Report, p. 814, as follows:

Volatile matter	4.50
Carbon	93.50
Ash	2.00

Many of the pieces of the lignite show the woody structure very plainly, in many the material is merely a mass of dead matter.

Dr. Hitchcock evidently thought that the Tertiary formation was somewhat extensively displayed in Vermont. He says, Vt. Report, p. 234: "Wherever we have found brown hematite and manganese, or beds of ochre, or pipe clay, white, yellow or red, in connection with beds of coarse sand or gravel, all lying beneath the drift, and resting on rocks beneath, we have regarded the deposit as an equivalent of that at Brandon, even though not more than two of these substances named be present." In the map of the State given at the end of the second volume of the Report, we find Tertiary rocks indicated, extending in a narrow strip from Monkton south into Massachusetts and there are also patches in Georgia, Colchester, Bristol, Tinmouth, Dorset and Readsboro. Besides this, the text mentions patches not shown on the map at Swanton and Plymouth. Further investigation is necessary before Dr. Hitchcock's opinion can be either accepted or rejected, but it seems to the writer at least, very doubtful if all of these areas can be shown to be Tertiary and perhaps none of them are of this age.

As to the age of the Brandon deposits, the following, written in 1860 by Mr. Lesquereux, is of interest: (Vt. Report, p. 717) "Before I had the opportunity of examining the fossil fruits of Brandon, and judging only from the drawings and descriptions made by Prof. E. Hitchcock in Vol. XV of Silliman's Journal of Science, I had in a letter to Prof. J. D. Dana given the opinion that the Brandon lignites were of the same age as the Upper Tertiary deposits of Oeningen. It is true that the identity of species is not ascertained; but this, of course, cannot be expected, and it is enough that the greatest number of Brandon species are more generally related to the fossil species of Oeningen than to species of any other stage of the Tertiary to authorize the above conclusion and render it creditable."

By the very efficient aid of Mrs. G. E. Laird, who collected from the lignite during the coal famine, when such an unusual opportunity was presented, a very large series of the fossils have come into my possession, probably more than are to be found elsewhere in all museums together. In addition the quite extensive collections of the State Museum and that of the University of Vermont have been in my keeping. In all, there are several thousand perfect, or nearly so, specimens in these collections. I have also, through the kindness of the various curators, had full access to the collections at Middlebury, Amherst, Dartmouth, Boston Society of Natural History, Museum of Comparative Zoology at Cambridge, and American Museum of Natural History at New York. The collection of the Boston Society contains a goodly number of very perfect specimens and the Museum of Comparative Zoology has a larger number, many of which may be regarded as Lesquereux's types as they bear his labels and were undoubtedly a part of those he studied, having received them from Dr. Hitchcock. The most valuable collection outside of Vermont is that at the American Museum of Natural History.

To this frequent references will be made in what follows. It contains the original specimens from which were drawn the illustrations in the article by Dr. Hitchcock in Vol. XV of the Am. Jour., which has been already often noticed, and which are repeated in Vol. I, of the Vt. Report of 1861, and from which, especially, Lesquereux drew his descriptions in Vol. II, of the Vt. Report, which are a repetition of his article in Vol. XXXII, of the Am. Jour. Science.

As was stated above, Lesquereux undoubtedly had in hand the specimens bearing his labels in the Cambridge Museum, but a comparison of the specimens and illustrations shows conclusively that the New York specimens are those figured and described in the Vermont Report of 1861.

Moreover there are in New York quite a number of species which have been figured and described, which are not represented in the Cambridge collection. Professor C. H. Hitchcock, of Hanover, N. H., writes in answer to an inquiry, "The specimens of the Brandon fruits you saw in New York were the originals sent by my father to Lesquereux."

It may be proper to add, that I have been somewhat particular to give the above facts because there has been some question as to where the original types of Lesquereux's descriptions were located. There can be no doubt that the New York specimens are all types and it may also be said that so far as they go, the Cambridge specimens have also the value of types. In the article in the Am. Jour., Vol. XXXII, p. 355, Lesquereux writes, "I owe to the celebrated Professor of Amherst College, not only the communication of the original specimens from which the drawings have been made, but also a number of corresponding specimens that he had the kindness to present me." The first are, I have no doubt, the New York specimens, the second those at Cambridge.

It is very plain to anyone going over Lesquereux's specimens that he had by no means completed his work on them. For instance, there are in the Cambridge Museum in one of the trays a number of specimens all labelled *Apeibopsis Gaudinii* Heer, M. C. Z., No. 1953, and yet there are certainly four or five different species in this lot, and it is a question whether any of them belong to Heer's species. The same thing is true of the contents of other trays in both museums.

The confusion being what it is, there is no possibility in many cases of discovering, even with the types at hand, just what form Lesquereux had in mind when he wrote his description of this or that species.

It has been the constant aim of the writer to preserve as much of Lesquereux's work as possible. When the study of the Brandon fossils was first taken up I had no other idea than to identify as many as possible with Lesquereux's species as published and as represented in museums, especially the two named above, but, as the investigation progressed, and an unexpected and unparalleled collection of the fruits came into my possession, it was soon seen that the original plan was wholly impracticable, and that many entirely new species had appeared in the recent finds. Obviously, the easier task, the imperfections and errors of the previous work considered, would be to reject all of the older work and commence anew, but this seemed to the writer neither a gracious nor wholly necessary solution of the difficulty. Accordingly, as has been stated, as many of the older specific names have been retained as possible. In some cases, rather arbitrarily it must be admitted, for where two quite distinct forms were both labelled as the type, either the type must be rejected or one of the forms assumed to represent it. Lesquereux himself often expresses doubt

as to the identity of some of the forms he has included in a single species. He also had a very small series of specimens to work with.

In correlating any fossil forms with those now living very great difficulty often arises. This is especially true in the present instance, for in the Brandon beds thus far little else than fruits and wood have been found. Only small fragments of leaves are found and these very rarely. It may be that somewhere in the deposit leaves exist in greater number, but they have not yet been discovered. Hence there is little except the fruit to guide the student to a knowledge of its botanical affinity.

A more complete study of the relations of the fossil fruits to modern species is of necessity left to the following Report, when it is my hope to continue the investigation begun here. Already much time has been given to this part of the subject, but without as satisfactory results as could be desired. Through the kindness of several of our leading botanists, I have been able to examine many seeds and fruits of modern plants, but the results have been largely negative. At least, I am convinced that for the most part, the Brandon fruits do not belong to living species, if any of them do, as indeed Lesquereux declared long ago.

I have studied the herbarium of the University of Vermont, which contains the collections of Mr. C. G. Pringle, and is probably not surpassed as far as American plants go. I have also, by the very great kindness of Professors G. L. Goodale and B. L. Robinson, had full access to the large collections in the University Museum at Cambridge and the Gray Herbarium. I also owe much to these gentlemen for many suggestions and references.

There is a collection of Australian fruits in the Harvard University Museum at Cambridge, which contains a number of species which closely resemble Brandon forms, and it is among the tropical and sub tropical living species that we should expect to find the most close allies to the Tertiary forms.

Description of Species Found in the Tertiary Lignite of Brandon, Vermont.

The genus Carpolithes is better known through the species brandonianus than any of the other forms found in the lignite. Indeed, it is almost the only species which has been figured in geological works. The genus was established by name merely, no characters being given, by Schlotheim, (PETRIFACTENKUNDE, 1820, p. 418.)

It seems probable that Schlotheim purposely left the name without definition in order that it might be conveniently used for diverse, but more or less indefinable forms, the botanical affinities of which could not be made out. At any rate, the name has often been used in a most general way by subsequent writers. Although the use of indefinite terms must always be objectionable, yet it is necessary in some cases. In this instance, it will speedily be obvious to anyone who has occasion to examine the list of species now included in the genus Carpolithes that very unlike and botanically unrelated forms are placed together in this group. Naturally, a larger number of specimens and a more thorough study of both living and fossils forms than has been possible in the past will inevitably restrict the use of such genera as Carpolithes, Carpites, etc., so that each will contain a less heterogeneous assemblage of species.

Carpolithes for example now includes at least twenty-two species in the Coal Measures and many in the Tertiary of North America, and there are numerous European species in addition.

It is scarcely possible, after past usage, to attempt even to set bounds to these too general terms, but in the following descriptions and for our present purpose, it has seemed best to restrict these and other generic names. I shall therefore aim to include in any given genus only such forms as may reasonably be supposed to have grown on trees of the same genus, and

this is far from true of the previous use of more than one of these names.

Without intending to control the use which these terms may receive from others, they will be more or less fully defined for use in this paper. With the above understanding, the genus Carpolithes may be defined as follows:

CARPOLITHES, Schlotheim, 1820. Fruit large, 25-35mml 1½ inch long and 12½ inch wide, as shown in Plate LXXV. As found, the fruits are more or less flattened, see fig. 20, so that cross section is long oval. The fruit is one cell with rather thick walls. As seen in Plate LXXV, figs. 17 and 18, the thickness is greater in some species than in others. In the fresh fruit probably the thickness was much more than it is in the fossil. The dehiscence is by a single usually mucronate valve.

Lesquereux named and described six species from those sent by Hitchcock. Some of these for reasons given have been referred to other genera, while some have been divided. In all twelve species are herein described. There are several other species among the material not yet studied with such care that it is best to publish the results, but they are to be taken up in the following Report.

GENUS CARPOLITHES, SCHLOTHEIM.

CARPOLITHES BRANDONIANUS, LX.

Plate LXXV., figs. 10, 11, 20.

Am. Jour. Sci. 2d series, vol. XV., p. 95, XXXII, p. 356.
Geology of Vermont, 1861, vol. 1, p. 229, fig. 111, vol. 2, p. 713.
Bulletin Torrey Botanical Club, vol. 29, 640, Plate 125, figs. 1, 2, 11, 12.

Lesquereux's original description of this species is as follows: "Carpolithes brandonianus, sp. nov. Capsule thick, flattened, oval or nearly round, obtuse at both ends, valvate. Valve obscurely pointed, generally opening to half the length of the capsule." Lesquereux included under this name several forms which seem to me quite different. Some of these which he considers varieties have been made species. In most cases Lesquereux saw no mo re than three specimens, and in some cases only one. Hence his conclusions may be very properly revised when a very much larger series is found. Still the description given above may well stand for the species. It is usually fairly regular in form, though Knowlton's figure Torr. Bull., vol. 29, Plate 125, fig. s l, 2, shows a specimen of quite unusual regularity. In most cases, the lower end is narrower and more rounded than the upper. Length, 25-35 mm., 1-1.4 inch. Width, 18-30 mm., ¾-1.4 inch. Thickness, 8-10 mm., 3.34 inch.* Of this Knowlton in the article cited above says : "One of the most abundant and conspicuous of the fruits was named Carpolithes brandonianus by Lesquereux. * * *

It has been suggested that its affinity is possibly with the living Jeffersonia diphylla, the well known twin leaf. A section through the basal portion showed the thick fruit to be made up of very thick walled tissue in which the lumen was reduced to a mere point, Fig. VIII, 11, 12. It had been so distorted that its true relationship could not be made out. Its appearance is shown in the two figures. I was not able to secure working material of Jeffersonia, so I am unable to speak of the relationship beyond the superficial resemblance, which is really striking." In looking over a series of fruits of Banksia in the Gray Herbarium, I was struck with the external resemblance of many of the Brandon Carpolithes to the carpels of this genus.

The originals of the figures in the Vermont Report and Am. Journal are in the American Museum of Natural History, New York. The originals of all the species here figured are in the State Collection at Montpelier, and a duplicate set is in the Museum of the University of Vermont at Burlington. All the figures are from photographs taken directly from the specimens.

CARPOLITHES ELONGATUS, SP. NOV.

Plate LXXV., figs. 1, 2, 3.

Carpolithes brandoniana, var. elongata, Lx. Am. Jour. Sci., vol. XV., p. 97, fig. 1.

Carpolithes brandoniana, var. elongata, Geology of Vermont, vol. 1. p. 229, fig. 111, 113, Vol. II, p. 713.

*NOTE—All of the following measurements are taken at the largest part of the specimens.

Capsule more or less irregular, much longer than wide, surface roughened, valve opening more than half the length of the capsule, valve broadly lanceolate, thickness nearly equal throughout. Figure 1 shows the front, fig. 2 the back and fig. 3 the side or edge of this species.

Specimens vary considerably in size, but ordinary specimens measure as follows : Length, 35-40 mm., 1.4-1.65 inch. Width, 20-22 mm., 8.85 inch.

In the Museum of Comparative Zoology, No. 1952, there is one of Lesquereux's specimens which is 50 mm. long, but this is unusual.

CARPOLITHES EMARGINATUS, NOV. SP.

Plate LXXV, fig. 4.

Capsule similar to the preceding, but smaller. Valve opening less than half the length of the whole. Upper end plainly emarginate, as is shown in the figure. Length, 35 mm., 1.4 inch. Width, 21 mm., .85 inch. Thickness, 10 mm., .8 inch. This is a very rare form.

CARPOLITHES OBTUSUS, NOV. SP.

Plate LXXV., figs. 5, 6, 7, 8, 14.

Carpolithes brandoniana. var. obtusa. Lx. Am. Jour. Sci. vol. XXXII, p. 356.

Carpolithes brandoniana. var. obtusa, Lx., Geology of Vermont, vol. 1, figs. 144, 117.

Capsule broadly oval to orbicular, surface smooth and polished on the backside, fig. 7, bearing regular longitudinal grooves or furrows. Lower portion thicker, fig. 6. Valve opening often not more than a third of the total length. Front surface concave opposite nearly straight. Size quite variable.

Length, 25-30 mm., 1-1¼ inch. Width, 25-28 mm., 1-1.2 inch. Thickness, 8-10 mm .04 inch. This species is smoother and more nearly polished than any other, and the longitudinal furrows are not found in any other.

The type as figured in the Vt. Report is in the Am. Museum and in the Cambridge Museum, No. 1951, there are several specimens.

CARPOLITHES OVATUS, NOV. SP.

Plate LXXV, fig. 9.

Carpel smaller than most of the preceding, ovate, surface rough, valve sharply acuminate, back somewhat furrowed, concave in front, convex behind. Length, 28 mm., 1.1 inch. Width, 19 mm., .75 inch. Thickness, 10 mm., .4 inch. A rare form.

CARPOLITHES SIMPLEX, nov. sp.

Plate LXXV, fig. 12.

Carpel of medium size, surface quite irregular, lower portion much swollen, only slightly acuminate at each end, valve opening about half the length, form, as shown in the figure, oval. Length, 27 mm., 1.05 inch. Width, in the middle, 20 mm., .75 inch. Thickness, below middle, 12 mm., .5 inch.

This species is noticeably thick below the opening and thin at the upper part.

CARPOLITHES GRANDIS, nov. sp.

(Not figured.)

In Am. Jour. Vol. XV, p. 97, and in the Vermont Report, Vol. I, p. 229, fig. 112, Hitchcock figures a very large specimen which Lesquereux included in *C. brandoniana*, but which seems to be well defined species. I have therefore called it C. grandis. It is considerably larger than any other of the Brandon fossils and of different form.

As seen from the front side this species is broadly wedge shaped. The upper edge is emarginate, the lower cut squarely off. The sides are rounded and thick. Length, 41 mm., 1.65 inch. Width, 32 mm., 1.3 inch. The only specimen of this that I have seen was among those sent by Prof. Hitchcock to the Am. Museum Nat. Hist., N. Y.

CARPOLITHES VERMONTANUS, nov. sp.

Plate LXXV, fig. 13.

Carpel ovate, blunt, pointed at each end, indistinctly sulcate, somewhat swollen near the lower end. Length, 25 mm., 1 inch. Width 20 mm., .75 inch.

CARPOLITHES MUCRONATUS, nov. sp.

Plate LXXV, figs. 15, 17.

Carpel rather thick and heavy, sub-quadrangular in cross section as may be seen in Fig. 17, which gives a side view. Upper end terminating in a sharp point. Surface indistinctly furrowed. Lower part swollen, upper contracted. Length, 30 mm., 1.15 inch. Width, 22 mm., .85 inch. Thickness, 13 mm., .5 inch.

CARPOLITHES SOLIDUS, nov. sp.

Plate LXXV, fig. 18.

Carpel as in the preceding, thick and heavy. Front flat, back very convex, surface rough, obscurely furrowed, valve lanceolate, opening deeply, end rounded. Length, 28 mm., 1.1 inch. Width, 15 mm., .6 inch. Thickness, 10 mm., .4 inch.

CARPOLITHES HITCHCOCKII, nov. sp.

Plate LXXV, fig. 19.

Carpel more linear than most and smaller. Blunt, pointed at the upper end, rounded at the other, surface, smooth. A thick, stout form resembling C. brandonianus. Length, 28 mm., 1.1 inch. Width, 15 mm., .6 inch. Thickness, 10 mm., .4 inch.

CARPOLITHES PARVUS, nov. sp.

(Not figured.)

Carpel small, elongate, oval, thick, surface fairly smooth. Mucronate at upper end, blunt, pointed at lower end. Length, 21 mm., 20 mm., .8 inch. Width, 12 mm. .45 inch. Thickness, 7 mm., .3 inch.

GENUS MONOCARPELLITES, Gen. Nov.

Among most common forms in Brandon lignite are those shown on Plate LXXVI, figs. 21, 31. They very closely resemble the nuts of some of the modern species of Juglans, notably J. rupestris and allied forms. Perhaps the species of this group should be placed in the genus Juglans, but as this is not to be, at least at present, determined, I have thought better to place them in the new genus MONOCARPELLITES which may be characterized as follows: Carpels from 20 mm., .75 inch to 33 mm., 1¼ inch long and about half as wide. Usually much flattened. One celled, Plate LXXVI, fig. 37. Surface ribbed longitudinally by usually sharp thin ribs. Ends pointed or rounded. As stated above most of these fruits resemble Juglans but the fact that they are one celled excludes them from that genus.

MONOCARPELLITES WHITFIELDII, nov. sp.

Plate LXXVI, fig. 21.

Carpel ovate, thin, convex on the side shown, flat on the opposite. Opening small, valve pointed triangular. About 7 ribs on each side. Lower end thicker than the upper. Length, 29 mm., 1.1 inch. Width, 20 mm., .8 inch. Thickness, 10 mm., .4 inch.

MONOCARPELLITES PYRAMIDALIS, nov. sp.

Plate LXXVI, fig. 22.

Carpel thick, triangular in cross section. One side much wider than the other two. Three ribs on each side. Upper end sharply pointed, lower flattened. Length, 24 mm., .95 inch. Width, 20 mm., .75 inch. Thickness, 11 mm., .45 inch.

MONOCARPELLITES SULCATUS, nov. sp.

Plate LXXVI, fig. 23.

Carpel somewhat irregular in form. Thick below, sloping to a sharp edge above so that a section taken at right angles with the figure is wedge shape. Ribs sharp, few, separated by wide sulci or grooves. Length, 25 mm., 1 inch. Width, 20 mm., .8 inch. Thickness, 14 mm., .55 inch.

MONOCARPELLITES ORBICULARIS, nov. sp.

Plate LXXVI, fig. 24.

Carpel more or less regularly orbicular in outline, often quite irregular because of compression. Usually much flattened. Six ribs on each side. Upper end mucronate, lower rounded. Length, 21 mm., .85 inch. Width, 20 mm., .8 inch. Thickness, 10 mm., .35 inch.

MONOCARPELLITES ELEGANS, nov. sp.

Plate LXXVI, figs. 25, 30.

Carpel small, somewhat pointed at each end, ribs few, 3 or 4 on each side. Length, 22 mm., .85 inch. Width, 16 mm., .6 inch. Thickness, 7 mm., .27 inch.

MONOCARPELLITES GIBBOSUS, nov. sp.

Plate LXXVI, fig. 26.

Carpel large, thick, especially in the lower part. Valve side flat, opposite, very convex, numerously and finely ribbed. The figure does not show these well. Somewhat quadrangular in section, mucronate above, rounded below. Length, 25 mm., 1 inch. Width, 20 mm., .75 inch. Thickness, 14 mm., .55 inch.

This species, as well as that shown in figure 22, are of the form of Tricarpellis but they appear to be one celled.

MONOCARPELLITES IRREGULARIS, nov. sp.

Plate LXXVI, fig. 27.

Carpel somewhat like M. orbicularis, but larger and more irregular, and more oval. Ribs irregular, prominent, not numerous, ends rounded. Length, 23 mm., .85 inch. Width, 20 mm., .75 inch. Thickness, 10 mm., .4 inch.

MONOCARPELLITES HITCHCOCKII, nov. sp.

Plate LXXVI, fig. 29.

This species is represented by only a single specimen which I found in the Amherst collection and which Prof. Emerson kindly placed at my disposal for study. It was probably collected by Dr. Hitchcock when on the Vermont Survey. The ribs are unlike those seen in any other specimen. In all the other forms which have been included in this genus the ribs are thin and consequently sharp, but in this species they are, as the figure shows, wide and heavy. The ends are slightly pointed, though as is almost always the case, the upper is much more so than the lower. Length, 18 mm., .7 inch. Width, 13 mm., .5 inch. Thickness, 10 mm., .4 inch.

MONOCARPELLITES MEDIUS, nov. sp.

Plate LXXVI, fig. 31.

Carpel rather small, oval, thin, about 5 ribs on each side. Length, 20 mm., .75 inch. Width, 17 mm., .6 inch. Thickness, 7 mm., .3 inch.

MONOCARPELLITES VERMONTANUS, nov. sp.

Plate LXXVI, fig. 34.

Carpel more elongate than others, thin, irregularly ribbed. Length, 28 mm., 1.1 inch. Width, 18 mm., .7 inch. Thickness, 8 mm., .3 inch.

MONOCARPELLITES OVALIS, nov. sp.

Plate LXXVI, fig. 35.

Carpel large, thin, regularly oval, irregularly ribbed, both sides flat. Length, 28 mm., 1.1 inch. Width, 21 mm., .8 inch. Thickness, 10 mm., .4 inch.

GENUS JUGLANS. LINN.

JUGLANS BRANDONIANUS, nov. sp.

Plate LXXVI fig. 36.

This fossil so closely resembles some of the nuts of *Juglans* that I have placed it in that genus and I am not sure that further study may not assign some of the species which I have place in *Bicarpellites* also in this genus. The species figured as 36 is larger than most of the Brandon fossils, somewhat irregular, triangular in section, apparently two celled, blunt pointed at each end, irregularly and not strongly ribbed. Length, 32 mm., 1.25 inch. Width, 20 mm., .8 inch. Thickness, 15 mm., .6 inch.

GENUS HICOROIDES. Gen. nov.

There are a number of specimens of a markedly different character from the rest which resemble the fruits of Hicoria more than any others which I have seen, but they do not exactly agree with the characters of this genus. I have, therefore, made the new genus HICOROIDES to include these forms from the Brandon lignite. The genus may be characterized as follows:

HICOROIDES, fruits of medium size, though usually smaller than Carpolithes. General form triangular, upper end pointed, lower rounded. Surface ribbed, ribs usually sharp and distinct, lower part swollen so that it is sub-globular. One side is very convex, the other is usually depressed in the middle.

HICOROIDES ANGULATA. nov. sp.

Plate LXXVI, figs. 28, 32, 33.

Fruit, orbicular in outline, as seen in fig. 33. Valve surface, fig. 33, smooth but irregular, strongly depressed in the middle. Opposite surface evenly and distinctly ribbed, fig. 26. One edge much thicker than the other and very sharply angled, fig. 42. Length, 20 mm., .75 inch. Width, 20 mm., .75 inch. Greatest thickness 10 mm., .4 inch.

HICOROIDES TRIANGULARIS, nov. sp.

Plate LXXVI, fig. 40.

One of the largest of the genus. Surface smooth, but irregular, ribs distinct at the upper end, fading out below, both sides convex. Length, 25 mm., 1 inch. Width, 22 mm., .8 inch. Thickness 13 mm., .5 inch.

HICOROIDES ELLIPSOIDEA, nov. sp.

Plate LXXVI, fig. 41.

Smaller than the preceding and more globular. Surface with a few incomplete ribs, otherwise smooth. In this species the valve opens on the convex side, while in most it opens on the flat side, fig. 33. Length, 20 mm., .75 inch. Width, 23 mm., .9 inch. Thickness, 13 mm., .5 inch.

HICOROIDES GLOBULUS, nov. sp.

Plate LXXVI, figs. 42, 43.

Small, sub-globular, much wider than long, surface as in the preceding. Length, 17 mm., .65 inch. Width, 20 mm., .75 inch. Thickness, 14 mm., .52 inch.

HICOROIDES PARVA, nov. sp.

Plate LXXXI, fig. 172.

Fruit small, round triangular, somewhat irregular. Width and height about equal. Costae few, distinct, sharp. Length, 15 mm., .56 inch. Width, 14 mm., .5 inch.

As has already been seen, triangular forms are common among the Brandon fossils. Some of these I have found by sectioning to be one celled, some two and others three celled. The latter I have included in the genus *Tricarpellites*. Knowlton's figures, Figure VIII, 7, 8, show the three celled form in section. The species I have placed in this genus vary much in form and size, but all are three celled and usually three angled outside. Plate LXXVII, figs. 49, 50, 56. The genus *Tricarpellites* was established in 1846 by Bowerbank in HISTORY OF FOSSIL FRUITS AND SEEDS OF LONDON CLAY, p. 76. "The form usually presented by these fruits is that of an elongated three angled capsule. If a transverse section be

made of one of these capsules, it will be found to be three celled and the whole is usually more or less three lobed. * * * Most are sharply pointed at the valve and the other end is more or less rounded." Forms answering well to the above are not uncommon among the Brandon fossils. In most of our specimens, one side and the valve on that side are much wider than the other two. Some of the species are ribbed, others not.

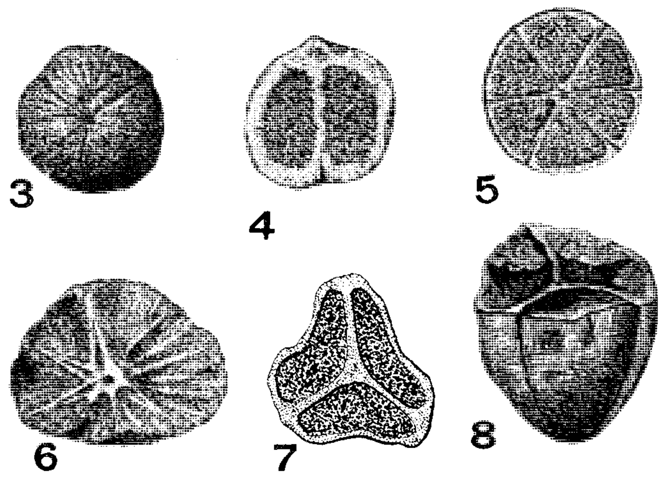


Fig. VIII.

All the figures somewhat enlarged.)

3. Cucumites Lesquereuxii, Kn. Basalview.
4. Cucumites Lesquereuxii, Kn. Split along median line.
5. Cucumites Lesquereuxii, Kn. Cross Section.
6. Aristochites, Sp.
7. Tricarpellites fissilis, Lx. Cross Section.
8. Tricarpellites fissilis, Lx.

Drawn by F. H. KNOWLTON.

The London clay species figured by Bowerbank are all very much smaller than the smallest Vermont specimen and it is not without hesitation that I include any of them in the genus, but on the whole it appears to be the proper place for them.

GENUS TRICARPELLITES, Bowerbank, 1846.

TRICARPELLITES INEQUALIS, nov. sp.

Plate LXXVII, fig. 44.

Form usually broadly ovate, edges sharp, sides very unequal, surface without ribs. Somewhat roughened. Length, 25 mm., .8 inch. Width, 20 mm., .75inch. Thickness, 15 mm., .6 inch.

TRICARPELLITES ELONGATUS, nov. sp.

Plate LXXVII, fig. 45.

Form long, slender, lower end much narrower than the upper, sides nearly equal, cross section sharply triangular. Surface with no ribs. Length, 33 mm., 1.25 inch. Width, 15 mm., .6 inch. Thickness, 10 mm., .4 inch.

TRICARPELLITES LIGNITUS, nov. sp.

Plate LXXVII, fig. 46.

This is a stout, irregular species, like many others sharply triangular above while becoming rounded and almost cylindrical or globular in some cases below. Surface, irregular. Length, 22 mm., .85 inch. Width, 18 mm., .7 inch. Thickness, 15 mm., .6 inch.

TRICARPELLITES CARINATUS, nov. sp.

Plate LXXVII, fig. 47.

One of the smaller fruits. Edges thin and sharp, surface with few and not distinct ribs, ends slightly pointed. Length, 24 mm., .9 inch. Width, 14 mm., .54 inch. Thickness, 10 mm., .4 inch.

TRICARPELLITES DALEII, nov. sp.

Plate LXXVII, fig. 48.

This is a short, rather stout species. The upper end is somewhat truncate, lower rounded, unsymmetrical. Surface with a few well defined ribs which do not show well in the figure. Length, 23 mm., .9 inch. Width, 18 mm., .7 inch. Thickness, 13 mm., .5 inch.

TRICARPELLITES ROSTRATUS, nov. sp.

Plate LXXVII, fig. 52.

This is a very peculiar form in which, as shown, the upper end is contracted to form a sort of beak. The lower part is subquadrangular in section. There are numerous indistinct ribs. The side shown in fig. 52 is less ribbed than the other two and what ribs there are do not show. Length, 26 mm., .1 inch. Width, 15 mm., .6 inch. Thickness, 11 mm., .45 inch.

TRICARPELLITES OVALIS, nov. sp.

Plate LXXVII, fig. 53.

Form long oval, surface without ribs, ends pointed bluntly. Length, 26 mm., .1 inch. Width, 15 mm., .6 inch. Thickness, 14 mm., .45 inch.

TRICARPELLITES CASTANOIDES, nov. sp.

Plate LXXVII, fig. 54.

Fruit small, pyramidal, one side flat with median depression, other sides very convex. Irregularly ridged. Resembles the common chestnut. Length, 20 mm., .75 inch. Width, 20 mm., .75 inch. Thickness, 18 mm., .73 inch.

TRICARPELLITES RUGOSUS, nov. sp.

Plate LXXVII, fig. 55.

Fruit irregularly oval, surface quite rough, ends pointed, one side flat, the other two form a convex surface as shown in the figure. Length, 25 mm., 1 inch. Width, 15 mm., .6 inch.

TRICARPELLITES ANGULARIS, nov. sp.

Plate LXXVII, fig. 57.

Fruit of medium size, rather irregular in form, edges very sharply angled, upper end acuminate, lower blunt, surface rough. Length, 28 mm., 1.1 inch. Width, 18 mm., .7 inch.

TRICARPELLITES AMYGDALOIDEUS, nov. sp.

Plate LXXVII, fig. 58.

Fruit shaped like an almond, pointed above, rounded below, surface somewhat ribbed. Length, 25 mm., 1 inch. Width, 14 mm., .55 inch. Thickness 12 mm., .45 inch.

TRICARPELLITES FAGOIDES, nov. sp.

Plate LXXVII, fig. 59.

Fruit triangular, resembling a beech nut, small, surface not ribbed, rough. Length, 16 mm., .6 inch. Width, 15 mm., .57 inch. Thickness, 11 mm., .45 inch.

TRICARPELLITES OBESUS, nov. sp.

Plate LXXVII, fig. 60.

Fruit irregularly globular, but flattened on one side. That shown in fig. 6 is very convex and furrowed like a melon. This is a very unusual form in this genus and perhaps it should be placed elsewhere, but it opens by three valves and appears to be three celled. Length, 20 mm., .8 inch. Width, 20 mm., .75 inch.

TRICARPELLITES FISSILIS, (Lx.)

Plate LXXVII, figs. 61, 62, 63, 64, Fig. VIII, 7, 8.

Carpolithes fissilis, Am. Journ. Sci. vol. XXXII, p. 356, 1861.
Carpolithes fissilis, Geol. Vermont, vol. II, p. 713, figures, vol. 1, p. 229, figs. 118, 119, 124, 1861.

Lesquereux describes this species as follows : "Capsule a little flattened, ovate, lanceolate, obtuse or rounded at one end, pointed at the other, obscurely ten costate, irregular, trivalved, dehiscent or closed." In the Vermont Report the species is spoken of as rare, C. brandonianus being considered as the common species. In the later findings this species is quite as abundant as the other, and neither is as common as some of the *Monocarpellites*. In the Vermont Report of 1861 several very different forms are included in this species, and some of the figures can-

not be in any way reconciled with the description. The figure numbered 121 in the Vermont Report corresponds better with the actual type specimens than any of the others, but even this is doubtful. Lesquereux's description quoted above may well stand for the species of which fig. 62 is a large specimen, most being somewhat smaller, and fig. 61 is a very open specimen, while figs. 63 and 64 show end views of this species. Fig. 62 is 33 mm., 1.3 inch. Width, 23 mm., .88 inch. Thickness, 15 mm., .6 inch.

TRICARPELLITES SEELYI, nov. sp.

Plate LXXVII, fig. 65.

Form regularly oval, sharply acuminate at the upper end, and rounded below, surface not ribbed. Length, 26 mm., 1.4 inch. Width, 15 mm., .6 inch. Thickness, 13 mm., .6 inch.

TRICARPELLITES MAJOR, nov. sp.

Plate LXXVII, fig. 66.

Fruit oval, large and rather coarse, looking much like a prune, surface rough, almost warty, ends blunt pointed. Length, 31 mm., 1.25 inch. Width, 18 mm., .77 inch.

TRICARPELLITES CONTRACTUS, nov. sp.

Plate LXXVII, fig. 67.

Fruit irregularly contracted at the upper end, lower end rounded, surface not ribbed. Length, 22 mm., .85 inch. Width, 13 mm., .47 inch.

TRICARPELLITES PRINGLEI, nov. sp.

Plate LXXVII, fig. 68.

Form more quadrangular than in other species, sides nearly equal, surface somewhat rough, but not ribbed. Length, 12 mm., .85 inch. Width, 19 mm., .7 inch. Thickness, 16 mm., .6 inch.

TRICARPELLITES ACUMINATUS, nov. sp.

Plate LXXVIII, fig. 83.

Fruit irregular, pointed above, rounded below, section oval, of medium size, surface without ribs, somewhat rough. Length, 22 mm., .87 inch. Width, 13 mm., .5 inch.

TRICARPELLITES HEMIOVALIS, nov. sp.

Plate LXXXI, fig. 171.

Fruit small, very inequilateral, cross section narrow oval, surface not ribbed. Length, 20 mm., .75 inch. Width, 14 mm., .55 inch.

GENUS BICARPELLITES, nov. gen.

On sectioning some of the fruits, I found them two celled. As has been noticed some of these are triangular in section and would, from their appearance, be placed in Tricarpellites, but they are two celled as shown in fig. 39, Plate LXXVI. Ordinarily, however, these fruits are flattened and resemble closely those that have been called *Monocarpellites* in foregoing pages.

The genus may be characterized as follows:

BICARPELLITES. Carpels usually flattened, though somewhat triangular. Oval or ovate in outline, distinctly costate. Open by a valve on each side. See figures 38, 39, 69, 72.

BICARPELLITES GRAYANA, (Lx. sp.)

Plate LXXVIII, fig. 69.

Carpolithes Grayana, Lx. Am. Jour. Sci. Vol. XXXII, p. 356, 1861.
Carpolithes grayana, Lx. Geology of Vermont, Vol. II, p. 714. Figure in Vol. 1, p. 250, fig. 122.

Fruit large, narrow, pointed at each end, five or six ribs on each side. A not uncommon form in the lignite. Length, 32 mm., 1.25 inch. Width, 15 mm. Thickness, 11 mm., .45 inch. The specimen figured is rather larger than the average and than the type specimen in the Am. Museum.

Lesquereux's original description is as follows: "Fruit oval, elongated, obtuse at one end, marked by a sharp point at the other, a little flattened, one inch long, less than an inch long, broad, obscurely costate." He adds, "This species has the form of the kernel of an almond. It is nearly related to *Carpolithes pruniformis*, Heer, abundant in the upper Tertiary of Europe, especially at Œningen."

BICARPELLITES OBESUS, nov. sp.

Plate LXXVIII, fig. 70.

Resembles the preceding in form, but is much thinner, with fewer ribs, and the ends are more rounded. The differences in appearance are greater in the actual specimens than in the figures. Length, 30 mm. 1.2 inch. Width, 15 mm., .6 inch. Thickness, 7 mm., .3 inch.

BICARPELLITES KNOWLTONI, nov. sp.

Plate LXXVIII, figs. 71, 72.

Carpel somewhat smaller and rounded below, thinner at the valves. General form, broadly ovate. Valves thin, pointed. Ends rounded. Fig. 71 side, 72 upper end. Length, 27 mm., 1.05 inch. Thickness, 15 mm., .5 inch.

BICARPELLITES OBESUS, nov. sp.

Plate LXXVIII, fig. 75.

Fruit evidently considerably shrunken. Original form probably globular. At present sub-quadrangular in section. Surface without ribs. Length, 22 mm., .85 inch. Width, 20 mm., .75 inch. Thickness, 14 mm., .55 inch.

BICARPELLITES ROTUNDUS, nov. sp.

Plate LXXVIII, fig. 76.

Fruit irregularly globular, longitudinally grooved, upper end blunt pointed, lower rounded. Valve openings small. Length, 22 mm., .85 inch. Width, 18 mm., .14 inch. Thickness, 16 mm., .6 inch.

BICARPELLITES MINIMUS, nov. sp.

Plate LXXVIII, fig. 79, x 5.

Fruit very small, surface lightly ribbed, ends blunt. The figure shows the fossil five times enlarged. Length, 7 mm., .27 inch. Width, 4 mm., 15 inch.

BICARPELLITES, VERMONTANUS, (Lx.)

Plate LXXVIII, figs. 88, 89.

Carya vermontana, Lx. Am. Jour. Sci. Vol. XXXII, p. 357.
Carya vermontana, Lx. Geology of Vermont, Vol. 1. p. 230, fig, 130, Vol. II, p. 714.
Hicoria vermontana, Knowlton, Bulletin G. S. 152, p. 118.

The specimens referred to this species do not correspond very well with Hitchcock's figure, but they do with the type specimens. Our specimens are not costate. They are somewhat variable in form and size. The measurements of fig. 88 are as follows: Length, 21 mm., .8 inch. Width, 11 mm., .45 inch. Thickness, 7 mm., .25 inch. Knowlton merely gives this a new name in his catalogue. It cannot, I think, be Hicoria.

GENUS BRANDONIA, gen. nov.

BRANDONIA. Fruit more or less globular, apparently fleshy when fresh. There is some indication that it was angular below.

BRANDONIA GLOBULUS, nov. sp.

Plate LXXVIII, figs. 73. 74.

Fruit as above, surface not ribbed except in one or two places, as the front of fig. 73. The specimens referred to this genus are quite unlike any others seen. The two figures are of the same specimens seen in two positions. Length, 22 mm., .85 inch. Width, 23 mm., .88 inch. Thickness, 13 mm., .5 inch.

GENUS, HICORIA. Rafinesque, 1808.

HICORIA BIACUMINATA, nov. sp.

Plate LXXVIII. figs. 77, 81.

This is one of the best preserved and finest of the fruits. It closely resembles some of the modern species of the genus Hicoria. As the figures well show, it is pointed at each end, quadrangular in section. At the end, shown in figure 81, there are ribs, but these soon disappear and the most of the surface is smooth. Length, 25 mm., .95 inch. Width, 20 mm., .8 inch. Thickness, 14 mm., .55 inch.

GENUS, RUBIOIDES. gen. nov.

RUBIOIDES. Fruit very small, globular, somewhat flattened, resembling the seeds of the modern Rubia.

RUBIOIDES LIGNITA, nov. sp.

Plate LXXVIII. figs. 80. 84. x5.

These little globular fruits are much like those of the modern *Rubia tinctoria*. Apparently, they were soft, globular, thin walled and berry like. The surface is not smooth in the fossils, but most likely was so in the fresh fruit. Diameter, 5 mm., .2 inch. Enlarged five times.

GENUS, CARPITES. Schimper Pal. Veget. Vol. III, p. 421, 1874.

There are certain of the fossils which I place in the above genus. They are none of them large or of very striking appearance. Further study of these forms may very likely enable one to locate them more definitely.

CARPITES INEQUALIS, nov. sp.

Plate LXXVIII. fig. 85.

Fruit very unequilateral, one edge rather thin, the other rounded, cross section triangular, a few irregular costae. Length, 18 mm., .14 inch. Width, 13 mm., .5 inch. Thickness, 8 mm. .34 inch.

CARPITES OVALIS, nov. sp.

Plate LXXVIII, fig. 86.

Fruit regularly oval, end rounded, surface with a few indistinct ribs. Length, 2 mm., .63 inch. Width, 11 mm., .37 inch.

CARPITES TRIGONUS, nov. sp.

Plate LXXVIII, fig. 87.

Fruit unsymmetrical in form, acuminate at the upper end, rounded below. Sharply triangular in section. Length, 17 mm., .7 inch. Width, 11 mm., .5 inch.

GENUS NYSSA, Gron.

The genus Nyssa appears to have been well represented in the forests which furnished the material for the lignite and several of the ancient species very closely resemble modern ones. Plate LXXIX is mostly occupied by species of this genus.

NYSSA SOLEA, nov. sp.

Plate LXXXIII, fig. 78.

This is a small fruit which appears to belong to this genus. Its general form is shown by the figure. At one end, the upper in the figure, there is a stem scar. The end opposite is thin and wedge shape. Length, 25 mm., .9 inch. Width, 12 mm., .45 inch. Thickness, 7 mm., .25 inch.

NYSSA MICROCARPA, Lx.

Plate LXXIX, fig. 90.

Nyssa microcarpa Lx. Am. Jour. Sci. Vol. XXXII. p. 361. 1861.
Nyssa microcarpa, Geology of Vermont, Vol. II. p. 717. Figured Vol. I, p. 231, fig. 154.

Lesquereux's description of this species is as follows: "Fruit oval, scarcely compressed, regularly ribbed, short." This is a description which would fit more than one of the Brandon species. The figure, too, is very poor. The specimen in the Am. Museum is the only one to be had at present. The figure, 90, referred to was made from a photograph of this specimen. The type is not "ribbed" but rather somewhat rugose or wrinkled. As a supplementary description, I may give the following: Fruit broadly oval. One end slightly acuminate the other obtuse, cross section cylindrical. Length, 10 mm., .4 inch. Width, 7 mm., .27 inch. With considerable doubt, I leave the species in this genus.

NYSSA CYLINDRICA, nov. sp.

Plate LXXIX, fig. 91.

In the Am. Museum collection received from Dr. Hitchcock there is a peculiar form of Nyssa which is labelled "Nyssa sp." Figure 91 is from a photograph of this specimen and I have ventured to add a specific name. The figure is somewhat larger than the actual specimen. This appears to have been the original of Hitchcock's figure, 155 Geol. Vt., Vol. I, but when he described others of the species which had been figured, Lesquereux seems to have passed this by. Very likely it was not sent with the others. The specimen figured has evidently been considerably compressed and it is somewhat broken, but it appears to have been cylindrical, regularly ribbed, tapering to a point at one end, blunt at the other. It is 10 mm., .4 inch long and 5 mm., .2 inch in diameter.

NYSSA LAMELLOSA, nov. sp.

Plate LXXIX, figs. 93, 94.

This is one of the rarest and most distinct species found in the lignite. A comparison of fig. 93 with 92 which is from a photograph of the fruit of the *Nyssa ogechee* now growing in the south, is sufficient to show the close resemblance of these two. This fruit is one of the largest yet found. As the figure shows, instead of the ribs which are common on the carpels of Nyssa,this species, like the modern one, bears numerous thin elevations or wings. These have been well preserved in the fossil and give it a very striking appearance. The species may be described as follows:

Carpel large, long oval, somewhat flattened, surface bearing

11 longitudinal wing-like lamellae. The highest of these is 7 mm., others are less in height, all are thin and sharp. Ends sharply pointed. Length, 37 mm., 1.45 inch. Width, 20 mm., .8 inch.

NYSSA ASCOIDEA, nov. sp.

Plate LXXIX, fig. 96.

This species much resembles the modern *N. caroliniana*, but it is larger. It also closely resembles the living *N. aquatica*, fig. 95. General form ovate, lower end rounded, upper showing a distinct stem scar. Surface smooth, evenly ribbed by 10 rather broad and rounded costae. Somewhat flattened, but probably cylindrical in section when fresh. The figure places the upper end at the bottom. Length, 16 mm., .65 inch. Width, 10 mm., .4 inch.

NYSSA CRASSICOSTATA, nov. sp.

Plate LXXIX, fig. 97.

The specimens figured in 97, 100, 103 are similar, but they present what seem to be real differences and therefore I have placed them in several species. These differences are more apparent in the specimens than in the figures. *N. crassicostate* is shorter, thicker and with heavier ribs than the others. It is somewhat assymmetrical, one side being more curved than the other,—more than is shown in the figure. The ends are blunt pointed, cross section nearly cylindrical. Length, 20 mm., .8 inch. Diameter, 10 mm., .4 inch.

NYSSA OVATA, nov. sp.

Plate LXXIX, fig. 98.

General form ovate, pointed, ribs numerous, but only slightly elevated. Fruit much flattened. Length, 15 mm., .6 inch. Width, 9 mm., .35 inch. This is shorter and broader than most of the species, in which characters it resembles *N. aquatica*, but it is flatter and the ribs are smaller and more numerous.

NYSSA LESCURII, C. H. HITCHCOCK.

Plate LXXIX, fig. 100.

Carpolithes Lescurii, Hitchcock, Portland Soc. Nat. Hist. Vol. I, p. 95, pl. I, fig. 5, 1862.

"Fruit oval, slightly compressed, about 1 inch long, 1-2 inch broad, slightly taper pointed at one end, but somewhat obtuse at the other, regularly 12 ribbed, with nearly equal ribs. Surface horizontally wrinkled. It is probably a capsular fruit with some affinity of general form to Aristolochia ringens but far different by the number and prominence of the ribs. It appears to have been enveloped in a hard, thick shell."

The length of the specimen figured, which corresponds with the type in the Am. Museum, is 22 mm., .85 inch, width, 10 mm. .4 inch.

NYSSA JONESII, nov. sp.

Plate LXXIX, fig. 101.

Fruit similar to the preceding, but the ribs are fewer and broader, and the form is more cylindrical and regular. Length, o mm., .8 inch. Width, 9 mm., .33 inch.

NYSSA ELONGATA, nov. sp.

Plate LXXIX, fig. 102.

This is more linear in outline than any of the others. How ong it is when perfect I cannot tell since no specimens have been found that had both ends complete. The ribs are distinct, egular equidistant. Length, probably about 30 mm. Width, 8 mm., .35 inch.

NYSSA MULTICOSTATA, nov. sp.

Plate LXXIX, fig. 103.

Fruit rather larger than the allied forms, ribs more numerous, inequilateral, both ends blunt pointed. Length, 24 mm., .95 inch. Width, 10 mm., .4 inch.

NYSSA EQUICOSTATA, nov. sp.

Plate LXXIX, 110.

Fruit of medium size, thin, flattened on both sides very inequilateral. Ribs small, regular. Length, 15 mm., .55 inch. Width, 7 mm., .3 inch.

NYSSA LAEVIGATA, lx.

Plate LXXIX, figs. 99, 109, 113, 114. x4.

Nyssa laevigata, Lx. Am. Jour. Sci. Vol. XXXIII, p. 361, 1861.
Nyssa laevigata, Lx. Geol. Vermont, Vol. I, p. 251, fig 156, Vol. II, p. 717.

Fruits small, cylindrical, more or less irregular, upper end somewhat abruptly cut off, lower rounded. At the upper end there is a distinct scar. Surface smooth or slightly rough. Length, 8-11 mm., .3-4 inch. Width, about 5 mm., .2 inch.

Of this and some of the other species, Lesquereux remarks, Am. Jour. Sci. XXXII, p. 361, "The positions of these fruits, as they are figured, and their form, recall immediately the general appearance of the fruits of *Nyssa multiflora*. The likeness is still greater in comparing the dry drupes with the fossil specimens. The thick putamen of some Nyssas is well adapted for preservation in the lignites. Though our fossil species is related to the living *Nyssa multiflora*, it differs by the size of the nutlets and the absence of striae."

NYSSA COMPLANATA, lx.

Plate LXXIX, fig. 112, x4.

Nyssa complanata Lx. Am. Jour. Sci. Vol. XXXII, p. 361.
Nyssa complanata, Lx. Geol. Vermont, Vol. I, p. 231. fig .153. Vol. II, p. 717, 1861.

The figure of this species in the Vermont Report is much better than those o most of the fruits there figured. Yet even this is inaccurate. The ends are never alike as the figure just mentioned shows them. As figure 112 shows the fruit is ribbed longitudinally. The form is ovate.

It is much more than "bicostate" as Lesquereux describes it. He calls attention to its "resemblance to *Nyssa vertumni*, Ung. from the lignites of the Rhine." The species varies considerably in size. The large specimens are 8 mm., .3 inch long, 5 mm., .2 inch wide and 3 mm., .1 inch thick. Others are less than this.

NYSSA CURTA, nov. sp.

Plate LXXIX, fig. 111, x3.

This species is much like the preceding except in form and may be only a shortened variety, but it has some marks of distinction.

Form short, broadly ovate, surface ribbed by low elevations, one side concave, opposite convex. Length 8 mm., .4 inch. Width, 6 mm., .45 inch. Thickness, 4 mm., .15 inch.

NYSSA EXCAVATA, nov. sp.

Plate LXXXI, fig. 166.

Fruit of medium size, pointed oval, convex on one side, excavated by a wide deep furrow on the other, that shown in the figure. Length, 17 mm., .65 inch. Width, 11 mm., .37 inch.

NYSSA CLARKII, nov. sp.

Plate LXXXI, fig. 167.

Fruit medium in size, longitudinally ribbed, general form pointed oval, ends blunt pointed, cross section oval. Length, 20 mm., .75 inch. Width, 13 mm., .5 inch.

GENUS CINNAMOMUM, Blume.

CINNAMOMUM OVOIDES, nov. sp.

Plate LXXIX, figs. 104, 107, x4.

Fruit regularly ovoid, surface smooth. There are no ribs but scattered and irregular corrugations. The upper end is marked by a depressed scar about the edge of which are a few short teeth, seen, though not very distinctly, in fig. 107. This figure also shows very well the character of the surface which is, under a glass, not unlike that of a cocoanut. The little fruits are somewhat flattened. Length, 7 mm., .25 inch. Width, 5 mm., .4 inch.

Cinnamomum corrugatum, nov. sp.

Plate LXXIX, fig. 105, x4.

Fruit less globular than the preceding, surface strongly irregularly ridged or corrugated, stem scar distinct. Length, 67 mm. Diameter, 5 mm., .2 inch.

Cinnamomum lignitum, nov. sp.

Plate LXXIX, fig 106, x4.

Fruit small, form ovate, surface smooth but furrowed by fine, irregular grooves, lower end rounded, upper with distinct and cup stem scar. Length, 10 mm., 4 inch. Diameter, 6 mm., 7 inch.

Cinnamomum, novae-angliae, Lx.

Plate LXXVI, fig. 82; LXXIX, fig. 108, x4.

Cinnamomum novae-angliae, Lx. Am. Jour. Sci. Vol. XXXII, p. 360.
Cinnamomum novae-angliae, Lx. Geol. Vermont. Vol. I, p. 231, fig. 148, Vol. II, p. 716.

Lesquereux's original description is as follows: Fruit small, one-sixth of an inch in diameter, globular, enlarged above, narrowed below to an obscurely costate point, apparently a broken pedicle, smooth.

I could not discover in the specimen the horizontal striae marked on the figure in the Vt. Report. The fruit is like that of Cinnamomum, a genus well represented in the different strata of the Tertiary of Europe. This genus is also represented in the Tertiary of America. When perfect the surface is smooth, but in most cases, the pericarp is gone leaving a roughened surface.

Genus APEIBOPSIS, Heer.

The genus Apeibopsis is thus defined by Heer. "Fructus capsularis, 5-16 valves, polyspermus, seminibus, rotundata, parvulis, in quovis locula biseriatis, folia palminerva. Nerva medio fortiore lateralibus camptodromis." Bowerbank, on the other hand, includes fruits like those which Heer calls Apeibopsis in the modern genus Cucumites and says "All parts of these fruits so closely resemble those of various members of the recent genus Cucumites both in their outward form and their internal structure that no reasonable doubt can remain of their being true Curcurbitaceae" (Fruits and Seeds of the London Clay, p. 90.) Heer declares that these fruits cannot be placed in any living genus and considers the characters such that they cannot be included in any of the Cucurbitaceae at any rate.

Apeibopsis Heerii, Lx.

Plate LXXX, figs. 118, 121, 124.

Apeibopsis Heerii, Lx. Am. Jour. Sci. Vol. XXXII, p. 358.
Apeibopsis Heerii Lx. Geol. Vermont. Vol. I, p. 230, figs. 132, 133, Vol. II, p. 716.

Lesquereux's description is as usual very brief. "Fruit globular, deeply grooved or rugose, distinctly marked by seven furrowed costae."

There are three specimens labelled as above in the Am. Museum and they are of much assistance in discovering just what Lesquereux had in mind when he described the species. It is the largest globular species found in the lignite. All the specimens are more or less compressed, so that the exact size cannot be made out. The diameter varies in different specimens from 15-20 mm., .6.75 inch.

Apeibopsis Gaudinii, Lx.

Plate LXXX, fig. 120, 128.

Apeibopsis Gaudinii, Lx. Am. Jour. Sci. XXXII, p. 358.
Apeibopsis Gaudinii, Lx. Geol. Vermont, Vol. I, p. 231, figs. 139, 140. Vol. II, p. 715, 1861.

This is quite like the preceding, but smaller and more abundant. Lesquereux's description is "Fruit smaller, oval, depressed on one side, costae are more numerous and less marked, surface nearly smooth."

As in the previous species, the specimens of this are all compressed so that none have the original globular form.

The diameter is on the average 15 mm., .6 inch, but the size of different species varies.

APEIBOPSIS PARVA, nov. sp.

Plate LXXX, figs. 148, 152.

Fruit small, globular, six costate, surface somewhat wrinkled. Diameter, 8 mm., .33 inch.

GENUS ARISTOLOCHIA, Linn. 1765.

ARISTOLOCHIA OBSCURA, Lx.

Plate LXXX, figs. 123, 125.

Aristolochia obscura, Lx. Am. Jour. Sci. Vol. XXXII, p. 359.
Aristolochia obscura, Lx. Geol. Vermont, Vol I, p. 231, figs. 137, 138, 141, Vol. II, p. 715.

I am inclined to think that this species should be placed in Apeibopsis, but on the whole I follow Lesquereux in placing it in this genus. Lesquereux's description is as follows: "Fruit capsular, small, one-third of an inch in diameter, six or seven costate, globular or a little flattened." Then he adds, "This species is uncertain. The specimens are not well preserved and I had not any for anatomical examination. I believe, nevertheless, that it is a specimen of this kind that Prof. Bailey has critically examined by a cross section. He found it a six valved pod, with seeds apparently flattened. This agrees with the structure of the fruit of Aristolochia." The specimens which I have examined are seven celled, surface roughened, average diameter, 10 mm., .4 inch.

GENUS ARISTOLOCHITES, Heer, 1866.

ARISTOLOCHITES RUGOSUS, nov. sp.

Plate LXXX, fig. 115.

Fruit six celled, oval, surface much corrugated, and there are six costae which do not show in the figure but on the end uppermost in the figure they are distinct. Length, 17 mm., .67 inch. Diameter, 12 mm., .47 inch.

ARISTOLOCHITES OVOIDES, nov. sp.

Plate LXXXI, figs. 136, 137.

Fruit ovoid, well preserved, surface smooth, scar at upper end elevated, opposite end slightly acuminate. Six celled, six indistinct costae. Length of 136, 14 mm., .53 inch, 12 mm., .45 inch.

ARISTOLOCHITES BRANDONIANUS, nov. sp.

Plate LXXX, fig. 138.

Fruit large, somewhat irregular, round oval, hilum raised and knob like, surface somewhat roughened, cross section flattened oval, probably due to compression. Length, 16 mm., .7 inch. Width, 15 mm., .6 inch. Thickness, 11 mm., .45 inch.

ARISTOLOCHITES APICALIS, nov. sp.

Plate LXXX, fig. 144.

Fruit quadrangular in section, upper end contracted to a blunt point, lower rounded, surface rough. Length, 17 mm., .67 inch. Width, 10 mm., 4 inch.

ARISTOLOCHITES ELEGANS, nov. sp.

Plate LXXX, fig. 145.

Fruit not large, somewhat closely resembles Lesquereux's *Aristolochia curvata*, but it is smaller and more cylindrical. It is six costate, ovoid. Length, 12 mm., .47 inch. Diameter, 8 mm., .5 inch.

ARISTOLOCHITES IRREGULARIS, nov. sp.

Plate LXXX, fig. 149.

Fruit small, cylindrical, pointed at one, square at the other, form irregular, six indistinct ribs. Length, 1 mm., .4 inch. Diameter. 6 mm., 25 inch.

ARISTOLOCHITES DUBIUS, nov. sp.

Plate LXXX, fig. 153.

This small species appears to belong with those which I have included in this genus, but its true affinity is not clear. It was probably more nearly globular when fresh than now. It has six not very distinct costae. Length, 9 mm., .35 inch. Diameter, 6 mm., .25 inch.

ARISTOLOCHITES CONIODEUS, nov. sp.

Plate LXXXI, fig. 154.

Fruit pyramidal at the upper end, more cylindrical below, strongly ribbed with deep furrows between the ribs. Length, 17 mm., .68 inch. Diameter, 9 mm., .35 inch.

ARISTOLOCHITES LATISULCATUS, nov. sp.

Plate LXXXI, fig. 155.

Fruit round oval, nearly as wide as long, ribs few and widely separated, rather thick. Length, 15 mm., .63 inch. Width, 12 mm., .5 inch.

ARISTOLOCHITES SULCATUS, nov. sp.

Plate LXXXI, figs. 156, 157.

General form oval or subquadrangular. Costae thin on the edges, prominent with wide and deep sulcations between. The costae are sharper and more conspicuous in this than in any other species. Length of 156, 3 mm. .5 inch. Width, 10 mm. .4 inch. Figure 157 was taken from a slightly larger specimen.

ARISTOLOCHITES CURVATA, (Lx.)

Plate LXXXI, fig. 158.

Aristolochia curvata, Lx. Am. Jour. Sci. Vol. XXXIII, p. 359.
Aristolochia curvata, Lx. Geol. Vermont Vol. I, p. 230, figs. 135, 136, Vol. II, p. 715, 1861.

This form seems to be most like the type of Lesquereux's species as represented in the Am. Mus., but it does not agree very well with Hitchcock's figure nor have I seen any specimen that does. Lesquereux's description, like most, is very brief, as follows:

"Fruit capsular, small, half an inch long, oval, pointed, marked with eight strong costae, somewhat curved on one side."

The specimen figured is a little larger than the above, but does not differ essentially. It is 15 mm., .6 inch long and 9 mm., .37 inch in diameter.

ARISTOLOCHITES ACUTUS, nov. sp.

Plate LXXXI, fig. 159.

Form ovate, pointed sharply at one end, blunt pointed at the other. This is the only species of these sulcated forms which is acute at each end. As the figures show, the rest are cut off more or less squarely at one end. Length, 17 mm., .65 inch. Diameter, 10 mm., .4 inch.

ARISTOLOCHITES EXCAVATUS, nov. sp.

Plate LXXXI, fig. 160.

Fruit variable in form, sometimes nearly orbicular, sometimes oval. Neither end is pointed, costae very widely separated, rather thick and heavy. Length, 13 mm., .5 inch. Width, 10 mm., .5 inch.

ARISTOLOCHITES CRASSICOSTATUS, nov. sp.

Plate LXXXI, figs. 161, 162, 165.

Fruit oval, rounded at each end, costae very thick, rounded, not widely separated. Length, 162, 17 mm., .65 inch. Diameter, 12 mm., .45 inch.

ARISTOLOCHITES CUNEATUS, nov. sp.

Plate LXXXI, fig. 163.

Fruit longer and narrower than most, blunt pointed at one end, broad and wedge shaped at the other, ribs not much elevated, few, somewhat quadrangular in cross section. Length, 17 mm., .65 inch. Diameter, 9 mm., .35 inch.

ARISTOLOCHITES MAJUS, nov. sp.

Plate LXXXI, fig. 164. Plate LXXX, fig. 134.

Fruit large, oval, ribs not elevated, rounded at each end, surface somewhat corrugated. Length, 20 mm., .75 inch. Diameter, 13 mm., .55 inch. This is the finest of the species and is not much flattened.

ARISTOLOCHITES GLOBOSUS, nov. sp.

Plate LXXX, figs. 129, 151.

Fruit small, globular, surface rough, not costate. Diameter, 10 mm., .4 inch.

GENUS SAPINDOIDES, gen. nov.

Plate LXXX, figs. 129, 151.

I have proposed this genus to include certain more or less globular or ovoid fruits which resemble some of those of Sapindus, but cannot be certainly determined as belonging to that genus. They appear to have been somewhat fleshy, or at least covered by a layer of fleshy material.

SAPINDOIDES VARIUS, nov. sp.

Plate LXXXI, figs. 116, 117. 122.

The specimens which I have referred to this species are much like the types of Lesquereux's *Aristolochia oeningensis* in the American Museum, but they are not at all like the figure given in the Vermont Report, Vov. I, p. 230, fig. 134, nor are the specimens so labelled in the Museum as mentioned above. I do not find any specimens that can be likened to the above mentioned figure.

The species may be described as follows: Fruit in general ovoid, but often quite irregular in form. Surface smooth. Length of 116, 20 mm., .75 inch. Diameter, 14 mm., .55 inch.

SAPINDOIDES PARVA, nov. sp.

Plate LXXX, fig. 126.

Fruit irregularly globular, small, surface roughened, somewhat flattened. Greatest diameter, 12 mm., .47 inch.

SAPINDOIDES MEDIUS, nov. sp.

Plate LXXX, fig. 130.

Fruit small, long oval, surface somewhat wrinkled. Length, 13 mm., .5 inch. Diameter, 10 mm., .4 inch.

SAPINDOIDES VERMONTANUS, nov. sp.

Plate LXXX, fig. 132, 135.

Fruit small, elongated, cylindrical, surface somewhat roughened, ends blunt. Length, 14 mm., .53 inch. Diameter, 6 mm., .25 inch.

SAPINDOIDES AMERICANUS, (Lx.)

Plate LXXX, fig. 119, 140.

Sapindus americanus Lx. Am. Jour. Sci. XXXII, p. 357.
Sapindus americanus Lx. Geol. Vermont. Vol. I. p. 231, fig. 142, 143. Vol. II. p. 715.

With some hesitation, I take this form out of Sapindus in which Lesquereux placed it because I cannot think that it belongs there. It has much resemblance to some of the fruits of Sapindus, as for instance, *S. marginalis*, but I am not able to make out the internal structure which it should have if Sapindus. I, therefore, prefer to place it in the new genus as above.

Lesquereux's description is as follows: "Fruit oval, reniform, either smooth or irregularly rugose, depressed or flattened on one side, about half an inch in its greatest diameter." It may be described as follows:

Fruit oval, more or less flattened, surface shining, but corrugated. Measurements, fig. 140. Length, 20 mm., .75 inch. Width, 14 mm., .53 inch. Thickness, 11 mm., .46 inch.

SAPINDOIDES CYLINDRICUS, nov. sp.

Plate LXXX, figs. 131, 139.

Fruit small, elongate, oval, cross section cylindrical, surface shining, somewhat corrugated. Length, fig. 131, 13 mm., .5 inch. Diameter, 9 mm., .37 inch.

SAPINDOIDES MINIMUS, nov. sp.

Plate LXXX, fig. 127.

Fruit very small, oval, surface wrinkled. Length, 8 mm., .37 inch. Width, 5 mm., .2 inch.

GENUS PRUNOIDES, gen. nov.

This genus is established to include several forms which are much like the stone of the fruits of the modern genus Prunus. This resemblance will readily be seen in the figures, 133, 141, etc.

PRUNOIDES BURSAEFORMIS (Lx.)

Plate LXXX, fig. 133.

Carpolithes pruniformis, Lx. Am. Jour. Sci. Vol. XXXII, p. 359.
Carpolithes pruniformis, Lx. Geol. Vermont, Vol. I. p. 231, figs. 146, 147, Vol. II, p. 715, 1861.

On the whole specimens like that shown in figure 133 are more like Lesquereux's species than anything I have seen and they are therefore referred to it. The original description is as follows: "Fruit narrowed at one end, where it bears a round small cavity, inflated and obtuse at the other end, a little curved on one side, smooth." The specimen figure is almost exactly equal in size to that figured in the Vermont Report. It is 114 mm., .55 inch long and 10 mm., .4 inch wide.

PRUNOIDES SEELYI, nov. sp.

Plate LXXX, fig. 141.

The resemblance of this specimen to a plum stone is apparent. It is not a common form in the lignite. The surface is smooth and shining in the center, somewhat rough on the edges. It is 15 mm., .65 inch long, 11 mm., .45 inch wide, and 7 mm., .27 inch thick in the middle.

GENUS PINUS, L.

From the presence of coniferous wood in the lignite it would be expected that fruits or seeds of such trees would occur also, but if they exist they have thus far almost entirely eluded the collector. A few of the lignite fossils appear to be seeds of pines or allied trees and it is not impossible that some of the others as figs. 137, 130 and others may be fruits of some juniper like tree. The specimens figured in 142, 143, 150 are like the seeds of some of the pines and it has seemed best to refer them to that genus.

PINUS CUNEATUS, nov. sp.

Plate LXXXII, fig. 142, 143.

Form triangular, wedge shaped, rather thick, surface rugose, 143, 16 mm., .65 inch. Width, 12 mm., .45 inch. Thickness, 7 mm., .27 inch.

PINUS CONOIDES, nov. sp.

Plate LXXXII, fig. 150.

Similar in form to the preceding, but more conoidal and much smaller, and less flattened, being nearly cylindrical in section. The figure is somewhat smaller than the specimen from which it was taken. Length, 11 mm., .43 inch. Width, 7 mm., .28 inch.

GENUS ILLICIUM, L.

ILLICIUM LIGNITUM, Lx.

Plate LXXX, figs. 146, 147.

Illicium lignitum, Lx. Am. Jour. Sci. Vol. XXXIII, p. 360.

Illicium lignitum, Lx. Geol. Vermont, Vol. I, p. 231, fig. 149, Vol. II, p. 716. As in other cases the figure in the Vermont Report and the type in Am. Museum do not agree, but as in other cases, we may follow the type. Figure 146 is from a photograph of the type specimen natural size and 147 is the same specimen taken so that it is enlarged about 4 times. Lesquereux's description is as follows: "Seed small, one-eighth of an inch long, oval, pointed, marked at the point by a small scar and by a ring on one side, very smooth and shining. I cannot but refer this seed to *Illicium*. It is a little thicker and more pointed than that of *Illicium anisatum* of China; but about the same size and the same form."

This seed seems to be very fragile. I have seen parts of several specimens but the only entire one that I know of is that figured. Its glossy surface is very noticeable since even when smooth none of the fruits possess so polished an exterior as does this. Length, 6 mm., .23 inch. Diameter, 4 mm., .15 inch.

GENUS DRUPA, Gop.

DRUPA RHABDOSPERMA, Lx.

Plate LXXXI, figs, 168, 169, 170, x5.

Drupa rhabdosperma, Lx. Am. Jour. Sci. Vol. XXXIII, p. 360.

Drupa rhabdosperma, Lx. Geol. Vermont, Vol. I, p. 231, fig. 150; Vol. II. p. 716, 1861.

This is one of the most attractive and abundant of the smaller species of the Brandon fossils. When magnified so that the beautifully corrugated surface is well seen it is very handsome. Lesquereux's description is: "Seed small, of the same form and size as the former, Illicium, oval, pointed, or slightly beaked, finely and deeply striated, marked under the point by a deep triangular scar. These seeds resemble those of *Pinus rhabdosperma* Heer from the miocene of Switzerland. The likeness is not enough to prove that our seeds are of the same species or even the same genus. Anolagous forms of such small seeds are found in different genera, putamen is pretty thick, very hard, bony, and in all the specimens that I have broken the kernel has been destroyed or the seed is empty. The kernel is covered with a brown skin, like that enveloping the albumen of the seeds of pines. However, the affinity of these seeds with those of pines is rendered doubtful by the absence of every trace of wing in all the specimens, six in number, that I have seen." The specimens vary somewhat in size but an average specimen is 5 mm., .2 inch long, 3 mm., .11 inch in diameter.

GENUS CUCUMITES.

CUCUMITES, LESQUEREUXII, Kn.

Figure VIII, Nos. 3, 4, 5.

In the Bulletin of the Torrey Botanical Club, Prof. F. H. Knowlton has described and figured the above species. The figures are from drawings furnished by Prof. Knowlton.

Knowlton's description and comments are as follows: "Among the fruits sent me by Professor Seely and which were afterwards sent to Lesquereux himself, was a single, small, nearly spherical fruit named *Carya globulosa* by Lesquereux himself. This was the first intimation of the existence of a species under this name, and for a time it proved a complete puzzle. Subsequently in looking over the collections of the United States National Museum I found a small box containing fruit under this name and in the catalogue the information that the species was unpublished.

"The fruit may be described as follows: Specimens are completely spheroidal in shape, being only slightly compressed at the apex. Some of the fruits have retained what seems to have been a thin outer covering or exocarp which entirely enveloped them. Through this thin exocarp the wrinkling or roughening of the true capsule is plainly discernible, and in this condition they really very much resemble some living species of *Juglans* or *Hicoria* which are provided with an indehiscent exocarp. When this outer covering is removed, several valves become apparent, and when the specimen has been macerated in the potash solution, may be very readily separated into six nearly equal valves. This shows that it cannot possibly belong to either *Hicoria* or *Juglans*, for which when still covered with an exocarp it might be mistaken.

"In its decorticated condition this capsule bears very strong resemblance to species of Cucumites detected in the London clay by Bowerbank, particularly the six valved form of his C. *variabilis*. It is also similar to what Lesquereux has called *Apeibopsis*, but, all things considered, it is probably best referred to the former genus. In view of the fact that the *Carya globulosa* was never actually published, it may be appropriate to name it in honor of Lesquereux, who first detected it. It may be called *Cucumites Lesquereuxii*." *

I cannot see any reason for separating this form from *Apeibopsis*. Either Lesquereux's species of *Apeibopsis* should all be placed in *Cucumites* or the latter, so far as Brandon fruits are concerned, should be transferred to *Cucumites*.

It may be remarked that the above characterizations of species have been made more brief than they would have been had the author not believed that the figures, all of which, as stated above, are from photographs taken directly from the specimens, give a more accurate idea of the form and appearance of the fossils than could be conveyed by any description however full.

*Bulletin Torrey Bot. Club. Vol. 29, pp. 640, 641.

FOSSILS

OF THE

BRANDON LIGNITE.

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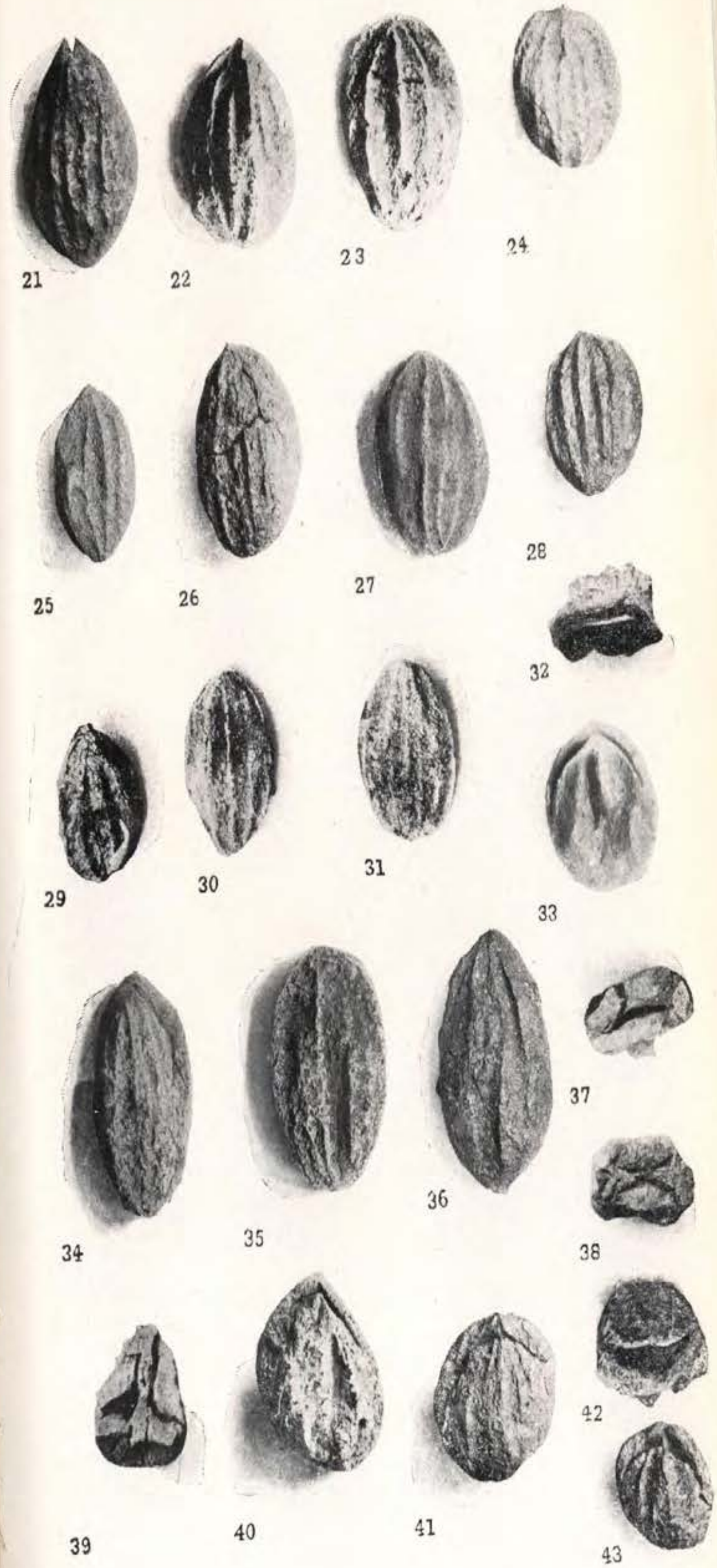
Figures Natural Size.

PLATE LXXV.

PLATE LXXVI.

Figures Natural Size.

PLATE LXXVI.



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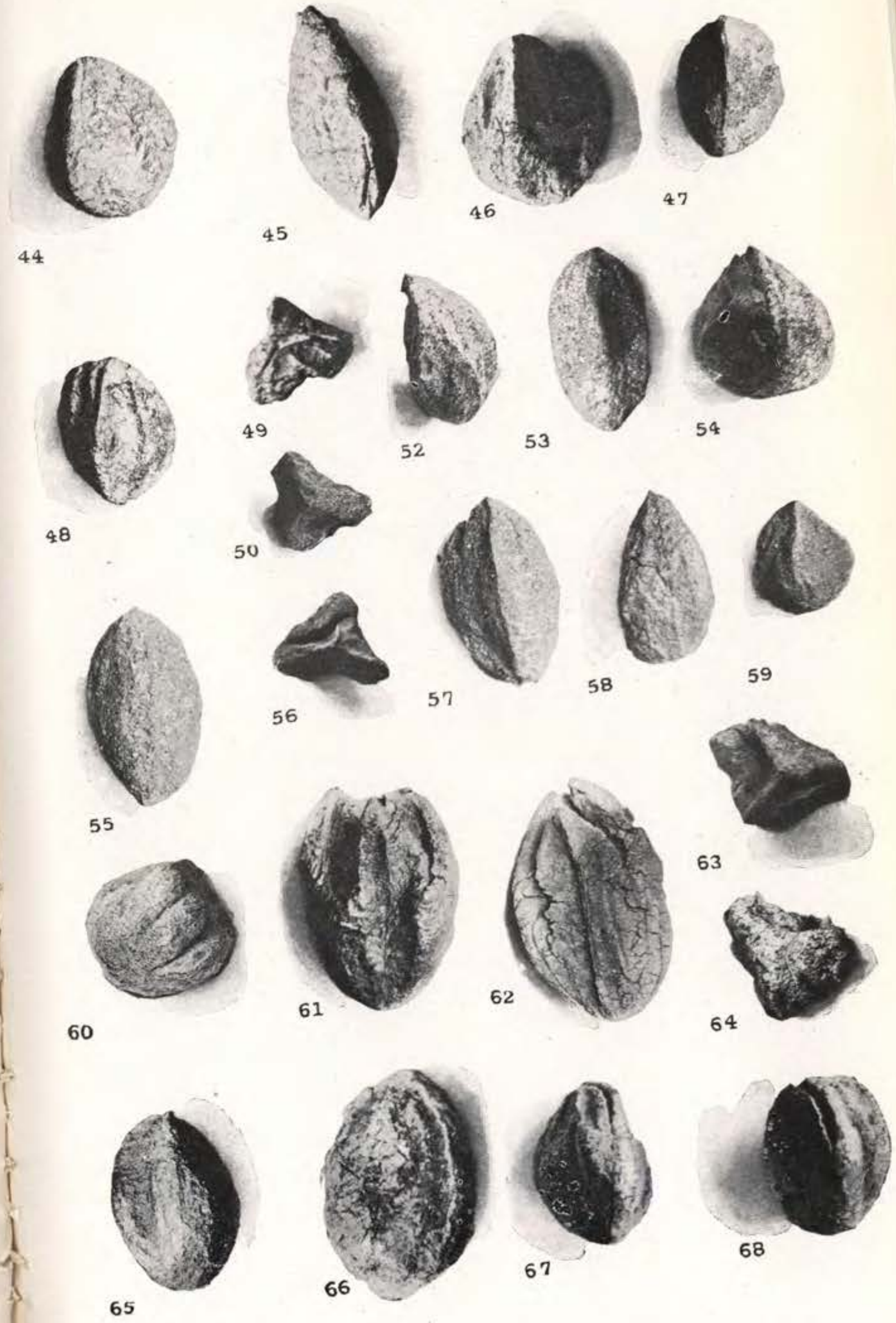

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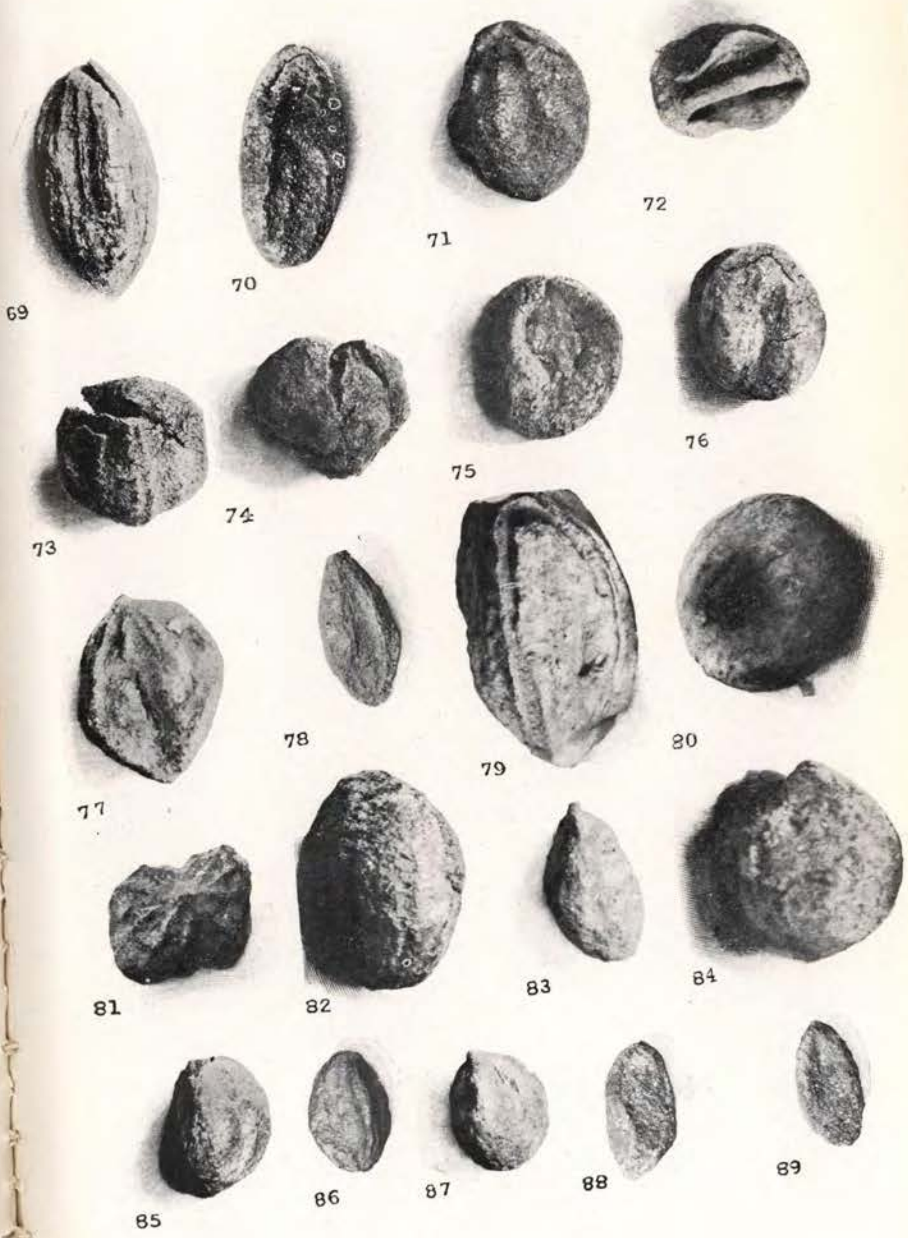

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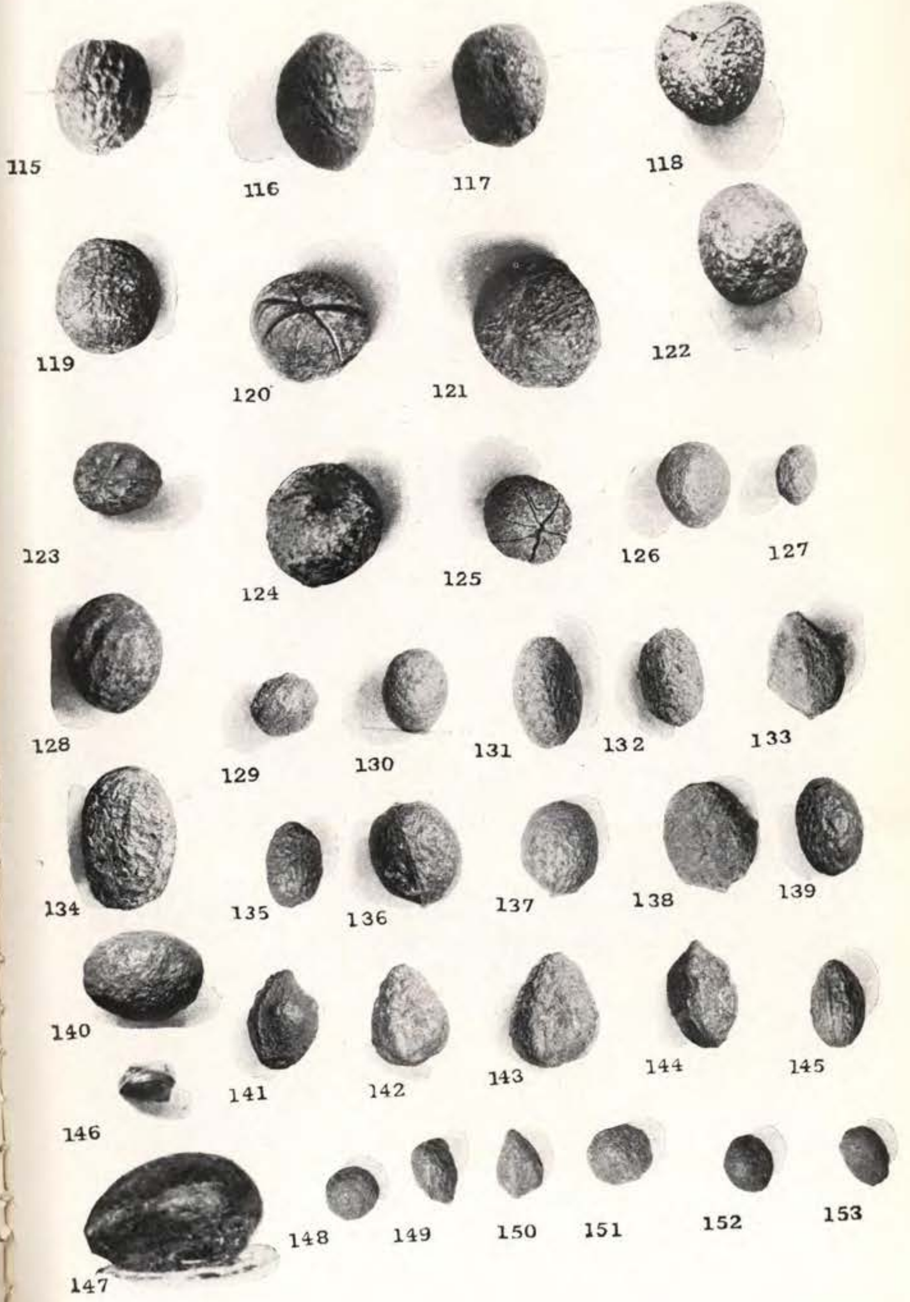

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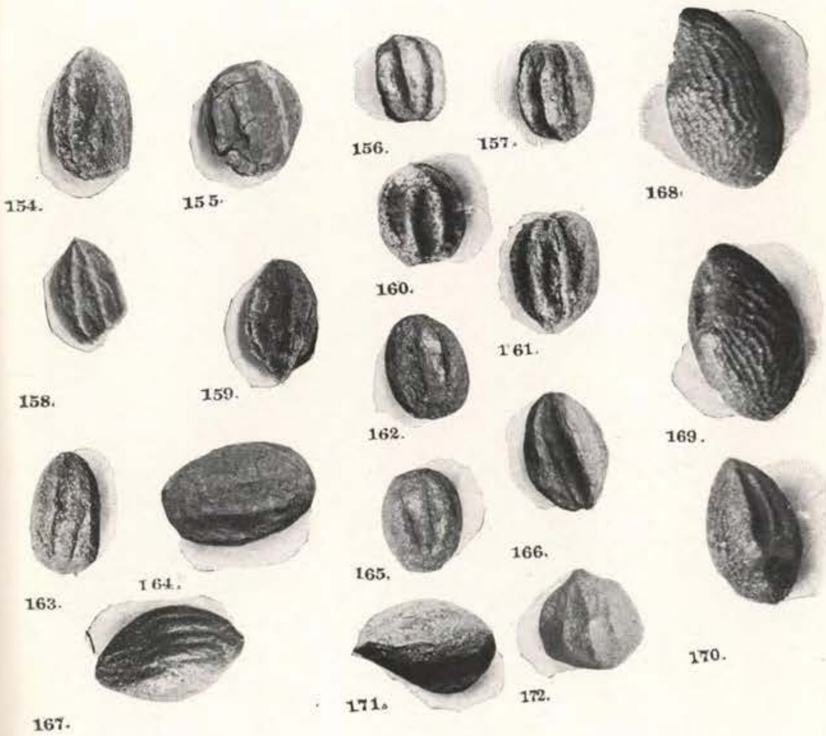

HYDROLOGY.

A SUMMARY OF INVESTIGATIONS UPON THE DRINKING WATERS OF VERMONT.

Early in 1903 the State Survey was invited by the U. S. Geological Survey to cooperate in a study of the underground waters of the United States and the State Geologist was appointed Hydrologist for Vermont to act in some measure under the direction and with the aid of the National Survey. In accordance with the wishes of the Washington Office, an investigation of the town and village supplies of water used for domestic purposes was undertaken in connection with a study of the general geology of different parts of the State. This work is as yet far from complete, but some report of progress may be made at this time.

Although of necessity, because of the very limited time at the disposal of the Geologist, the work has been far less extensive and thorough than it should be, yet it is believed that something of interest and value has been gained and it is hoped that further investigation may add to the importance of that which is here presented.

In this work I have been very greatly assisted by the suggestions of Mr. M. L. Fuller, Chief of the Eastern division of the Department of Hydrology of the U. S. G. S. and by the abundant supply of printed blanks and franked envelopes furnished by the Department. The assistance rendered by the Government has very materially diminished the cost of the investigation to this State, and has made possible a much more complete report than would otherwise have been practicable. In passing, the Geologist would like to say that neither his con-

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nection with the U. S. Survey nor the present investigation has terminated and he would be very glad to receive any corrections or additions which any of the citizens of the State who may read these pages are able to send him in order that they may be incorporated in a future report. It can hardly be expected that some errors have not found their way into the statistics which have been collected. Most of the larger towns have been visited by the writer and their water supply personally investigated, but, obviously, a personal inspection was only possible in a comparatively small number of towns and for information as to the larger number the writer has been entirely dependent upon information received in reply to the inquiry blanks sent out. The writer is under obligation to many of those who, having received the circulars, have returned them with valuable information as to the locality with which each was familiar. Some few have so evidently misunderstood the meaning of the inquiries as to declare that in their towns no water was used for any purpose.

It is scarcely necessary to call attention to the very great importance of an investigation of the source, quality, etc., of the drinking water of any locality. Only good, and it is believed great good, can result from such investigation. So far as possible, the people of the State want to know what they drink and those outside of the State who are thinking, more or less seriously, of locating here, are very likely to manifest great interest in the same question.

The results of this investigation may be anticipated so far as they are involved in the statement that no State in the Union is more abundantly supplied with pure water than is Vermont, in none is it more readily obtained for town supply, in none are the sources of water supply less likely to be contaminated and in none is there better provision for the analysis of the water used. Since the establishment of the State Laboratory we have not been left to conjecture as to the purity of our drinking water, we can have analyses and from them we may know with certainty that in general the water that is drunk in Vermont is of unusual purity. Whatever one's taste may incline him to drink, there is no possible excuse on the score of healthfulness for drinking anything but water in this State.

In WATER SUPPLY AND IRRIGATION PAPERS, *192, Contributions to the Hydrology of Eastern U. S. by M. L. Fuller,* the results of the work done in this State, as in several other eastern states, are published. In a somewhat different form and with less detail so far as some parts of the work is concerned these results are given in the following pages.

Circulars supplied by the U. S. Geological Survey were sent to every post-office in this State except those located in places where it was possible to make personal examination.

In response to these circulars, returns have been received from 248 towns out of 252 in the State. In most instances several replies have been obtained from the same town, especially where several post offices are included in the limits of a single town as is not infrequently the case.

All inhabitants of Vermont are familiar with the general topography of its area and are well aware that the Green Mountains form a watershed throughout the length of the State from which streams flow east into the Connecticut or west into the Champlain valley. The mountains and their foot hills occupy so much of the State that there is little room for level ground and it is comparatively rare. By far the greater part of the surface of Vermont is occupied by mountains and hills and the intervening valleys. Necessarily, this controls to a great extent the character of the water supply both above ground and below it. The mean annual rainfall is not large, 39 inches, the climate is not such as to cause great evaporation and the soil in most parts of the State is such that it retains what moisture it receives. As a result of these conditions, Vermont is probably as well watered as any part of the United States and far better than most.

Much of the surface is covered with glacial deposits which are usually underlaid by hard and insoluble rocks. Springs and streams of all sizes from the tiniest rivulet to the fully developed river abound everywhere. Because of this abundance of water sources and the ease with which they can be utilized, the greater number of families are provided with some sort of piped supply.

From the reports received, it appears that at least 65 towns use water from some kind of public system. In some of these the public supply is used by only a portion of the residents, but, so far as can be ascertained, in a majority of towns the public supply is that from which most of the families take water. There are also towns, as Barre, Montpelier and others, which have several, it may be a dozen, lines of pipes from as many different springs or groups of springs. Montpelier, for instance, has a public supply taken from Berlin Pond, and from this undoubtedly the greater part of the water supply of the city is taken, but in addition there are more than a dozen private systems each furnishing water from various privately owned springs to from two to fifty families. Barre has, besides the city supply, at least five smaller supplies which furnish from six to over two hundred families each. Few towns, however, are so lavishly supplied as these, but there are many that have several supplies which are more or less public.

There is at present no excuse which can be offered by any town authorities if the public supply is not properly examined chemically and biologically in order that its sanitary character may be known, for in 1898 a State Laboratory was established where samples of water may be examined without cost except for transportation, and it is the wish of the Laboratory authorities that the water of any supply which is used by a number of persons be analyzed four times yearly.

The sources from which water for domestic uses is obtained are as follows: Springs, Ordinary Wells, Deep and Artesian Wells, Lakes or Ponds, Streams, Cisterns.

SPRINGS.

Springs are most abundant in the mountain towns, but are found more or less commonly in all parts of the State. Of the

248 towns that have furnished reports, 190 are said to be either wholly or largely supplied with spring water. Many of these springs are large and nearly constant in temperature throughout the year. Many vary little from 45° F. and some are even colder. As the rocks of the State are largely crystalline and metamorphic they are not soluble and therefore do not affect the water, so that the spring water is soft and pure.

Reports from numerous towns state that every farm is supplied with springs and many of the larger farms have within their limits several. As many as twenty, thirty or even forty good springs have been reported as existing on a single farm.

The water supply of most towns having a public water system is taken either from one large spring or from several which have been so connected as to become practically one large one. Analyses of many of these springs could be given were there space. Nearly all of them, however, simply show pure water with no organic and very little solid matter and, as Vermont is for the most part not thickly settled, there are usually few or no sources of contamination. As an example of what I should regard as an average sample of Vermont spring water the following may be given. The sample was taken from a tap located at some distance from a reservoir supplied by springs. It is not the purest nor the worst.

	Parts in 100,000.
Total solids	4.04
Loss on ignition	0.32
Fixed solids	3.72
Free Ammonia	.0018
Albuminoid Ammonia	.0070
Chlorine	.04
Nitrogen as Nitrates	.0100
Nitrogen as Nitrites	0000
Hardness	3.1
Turbidity	none
Sediment	none
Color	none

MINERAL SPRINGS are found, though not in large number, in different parts of the state. Most commonly they are more or less sulphurous, but alkaline carbonated springs also occur.

The chief resorts on account of the water are at Alburg Springs, Highgate, Sheldon, Clarendon, Middletown and Brunswick. The springs at South Hero, Chelsea, Concord, Wolcott, Newbury, Warren and elsewhere are all of some repute. The Equinox spring at Manchester is not mineral as is often supposed. It is simply a very fine spring of pure water. The water of some of the deep wells is so strongly magnesian as to properly come under the class of mineral waters. As examples of these mineral waters the following analyses may be taken.

CLARENDON SPRING WATER.

	Grains per gallon.
Chloride of Sodium	0.1458
Sulphate of Potash	0.1155
Sulphate of Lime	0.4054
Bicarbonate of Lime	10.6578
Bicarbonate of Magnesia	2.1443
Chloride of Magnesium	0.0630
Bicarbonate of Iron	0.0692
Silica	0.6533
Alumina	0.0467

MISSISQUOI SPRING WATER.

	Contains in 1,000,000 parts.
Free Carbonic Acid	45.49
Sodium Chloride	0.38
Calcium Chloride	2.12
Magnesium Chloride	0.60
Sodium Sulphate	6.52
Calcium Sulphate	12.09
Aluminium Sulphate	2.70
Magnesium Sulphate	5.51

Sodium Phosphate	0.08
Sodium Bicarbonate	126.62
Magnesium Bicarbonate	72.19
Manganous Bicarbonate	1.40
Ferrous Bicarbonate	3.03
Silicic Acid	12.25
Crenic and Apocrenic Acid	Trace
Titanic Acid	Trace

ORDINARY WELLS.

As has been shown above, a large number of Vermont towns are so well supplied with pure springs that any other source of water is quite superfluous, hence wells are not dug. I have found many towns in which it was said no well was used if there were any to use.

In some of our towns, however, there are few springs, or those that exist are not conveniently located, and here wells have been dug and are generally used. There is little difficulty in finding water when a well is dug in most of the towns, though there are a few exceptions to this statement.

Throughout the State, wells yielding sufficient water can be dug in the drift which covers nearly the whole area of Vermont and they need not be deep. For the most part the wells now used are from 10 to 30 feet deep and only rarely does an ordinary well go into the rock underlying the drift, though many go to it. The well water is generally reported to be hard and analysis shows that in nearly all the cases well water contains a larger quantity of solids than spring water. From the reports, I should judge that wells are much more numerous in the Champlain valley than elsewhere in the State.

Usually the wells are of ordinary size, but in some places, as in Grand Isle, it has been found by experience better to dig large though not very deep wells in order to obtain a sufficient and permanent supply. Some of these are 12 to 16 feet in diameter and about the same in depth.

More water is obtained in such wells than by digging a smaller well deeper.

DEEP AND ARTESIAN WELLS.

These are found almost exclusively in the western part of Vermont. As has been stated, the water of ordinary shallow wells is hard as compared with spring water, though it would not be considered hard in many parts of the country, but when we examine analyses of the water of the deep wells we find a great increase in mineral content. The more common salts are those of lime and magnesia, especially the latter.

The water of these deep wells is, as would be expected, very cold and of nearly uniform temperature throughout the year. On this account they are often used at creameries.

Water is not invariably reached by deep boring. The deepest well in the State, which is reported to have been bored mainly for experimental purposes to a depth of 1400 feet, is useless as a water supply, although only a very short distance from the shore of Lake Champlain. Another well bored by the Burlington Rendering Company only a few rods from the lake found no water at a depth of 490 feet and water had to be supplied from outside for the drilling, as was also done in the deeper well.

In all, reports have been received from about one hundred deep wells, that is, those over 50 feet. Only a few of these are flowing wells. In most cases the water is pumped or forced by the Pohld air system, or some other means, from a greater or less distance below the surface. There are, however, a few wells that give a flow of from 4 to 18 feet above the top.

In and about Burlington there are eighteen deep wells varying in depth from 130 to nearly 500 feet. At least five of these supply water which is so strongly impregnated with lime and magnesia salts that it cannot well be used for steam as the precipitation of the mineral matter soon fills the pipes to a dangerous extent.

The water is clear, cold at all seasons, and is much liked by many for drinking. By some it is found beneficial in dyspeptic conditions. A well of this sort is used at the Van Ness House

and the water is very satisfactory to the guests. This well is 365 feet deep and the following analysis will serve for half a dozen or more located in the western part of the city.

	Parts per 100,000.
Solids	24.60
Loss on ignition	3.20
Fixed solids	21.40
Free ammonia	.0037
Albuminoid ammonia	.0062
Chlorine	.1800
Nitrites and Nitrates	.000
Hardness	.103

Water rises in this well to within 42 feet of the surface. At the Gas Works there is a flowing well. The mouth of this well is 8 feet above the mean level of Lake Champlain and the water rises 4 feet above the top of the well, i. e., 12 feet above the level of the Lake. Its uniform temperature is 42° F. and it flows 20,000 gallons in 24 hours. At the Venetian Blind Company's Mill there is another flowing well 138 feet deep, from which the water rises 18 feet above the mouth of the well. At Fort Ethan Allan, near Burlington, there are four wells having depths of 317, 320, 375, 496 feet respectively. The Pohld air system is used to raise the water, as in none of the four does the water come nearer the surface than 100 feet. In boring these wells, which are not far distant from each other, substantially the same strata were passed through. The following taken from the record of the first bored will suffice for all.

Sand, at first fine, then coarse	70 feet
Clay	1 foot
Clay and sand	30 feet
Blue clayey sand, water constantly in the pipe up to 100 feet	59 "
Pure, blue clay	21 "
Quicksand	60 "
Seams of soft rock changing to limestone	40 "

White limestone	30 feet
Fissures in limestone giving mud, large pebbles and sand	10 "
Solid limestone	24 "
Gravel, water worn pebbles	10 "
Clay stained by iron oxide	1 "
Coarse gravel and black sand with water worn pebbles mostly too large to come up in the sand pump	19 "
	375 feet

In boring most of the deep wells in the neighborhood of Burlington the first few or many feet, differing in each case, was through glacial drift and the rest through Cambrian sand-rock or limestone. The thickness of the drift is very variable. In one case it is 20 feet, in another 200. Elsewhere deep wells, as that at North Hero, have been bored in Utica shale and there may be others in different formations. So far as I can judge from the returns received most of the deep wells in the State are in Cambrian rock. In the slate region of western Vermont, which is all Cambrian, Mr. J. P. Hoadley, who has probably bored more deep wells than anyone else in the State, tells me deep wells are very numerous. In Poultney alone he has bored over fifty.

LAKES AND PONDS.

Naturally many who live near Lake Champlain take water from it, pumping it usually by wind mills. The city of Burlington takes its supply entirely from this source, pumping the water by steam power to two large reservoirs 400 feet above the Lake from which it is distributed. Montpelier, as has been noticed, has numerous supplies, but the main source is Berlin Pond. Brandon and a few other towns are supplied from ponds, but this source is not common in Vermont. The water of Lake Champlain, average of several analyses, is as follows:

	Parts in 100,000.
Total solids	7.41
Loss on ignition	1.80
Fixed solids	5.61
Free ammonia	.0035
Albuminoid ammonia	.0143
Chlorine	.065
Sediment very slight.	
Turbidity very slight.	
Hardness	4.3

STREAMS.

Only a very few of the Vermont towns take drinking water from the streams. There are several that collect the water of small brooks which are not far removed from the springs which give them rise, but such supply is essentially spring water. There are few that take water from larger streams, as for example Vergennes, Wells River, Chester, Readsboro, and very likely some others which have not reported.

It is probable that the water obtained from streams is less wholesome than that from any of the other sources.

CISTERNS.

On account of the abundance of good water from other sources, cisterns are not common in any part of the State. In a few localities, however, there are few springs and well water is very hard. Here cistern water is used for domestic purposes.

From the foregoing statements it is evident that the problem of water supply often so serious a one in many other states is not a problem in Vermont. In many towns large quantities of pure spring water run to waste because not needed.

In the next report it is the intention of the writer to discuss this whole matter much more fully.

The State Cabinet.

During the past two years the cases and collections in the main cabinet room have been entirely rearranged.

Shortly before his death the late Seargent-at-Arms, Mr. T. C. Phinney, ordered a new floor of red and white marble and other needed repairs including the painting and decorating of the two rooms used for the cabinet.

These improvements have been most satisfactorily completed and the appearance of both rooms, especially the north one, has been greatly bettered. Most of the cases in this room were reglazed with large glass and five new cases added. Nevertheless, to be well seen and properly displayed the various specimens need larger and better lighted quarters.

The present curator took charge of the cabinet in 1898. At first it was his plan to confine the collections, as had been done to a great extent in previous years, mainly to Vermont objects and this is still the plan, but as the collections are visited and studied by large numbers of school children, many of whom use the cabinet as a supplement to their nature study, it has been deemed advisable to introduce specimens of marine forms, and also animals, fossils, minerals, etc., not occuring in this State in order that a more complete idea of the various groups of natural objects may be gained than would be possible if the Museum were to include only Vermont species.

Anything like a full description of the collections now in the Cabinet is out of the question at this time, but a brief running account of the more important specimens will be of some interest, at least to those who may be able to visit these rooms.

Two rooms in the north-east corner of the Capitol building are assigned to the Cabinet. In the southern room are arranged

the Mammals and Birds. These include nearly all the species that have been known to live in the State or to pass through it in migration, during the last fifty years.

Of the Mammals (Quadrupeds) there are about fifty specimens which represent all the more common species and such uncommon ones as the Bear, Otter, Beaver, Catamount, both species of Lynx, Red Fox and the Cross, Silver and Black varieties, Harbor Seal (killed on the ice of Lake Champlain), etc. In addition there is the fine head of a Moose killed a few years ago in Wheelock and from the west, there are heads of the Bighorn, Blacktailed Deer, Antelope and Elk, gifts of Dr. W. S. Webb. There are four hundred and fifty specimens of Birds including a number of species extremely rare in this State. Nearly all of these mammals and birds are very good specimens and well set up.

In the north room the collections are of necessity more diverse.

In the corner on the right as one enters, is a case containing about a thousand specimens representing nearly three hundred and fifty species of birds eggs. Next is a similar case containing the more recent fossils, including a set of the Brandon lignite fruits described in this report. Beyond this is the case containing, perhaps, the greatest treasure of the Cabinet, a nearly complete skeleton of a fossil whale, or rather dolphin. This is thirteen feet long and the bones are in excellent preservation. It was found in Charlotte in a railroad cut in 1849, and is the only nearly entire skeleton of this animal ever found. Near it are two large elephant's tusks. One found in Brattleboro is four feet long, both ends being lacking: the other, found at Mt. Holly, is nearly six feet long. Though few, the fragments of tusks that have been found in Vermont in the later geological beds, prove conclusively that in those ancient times these animals roamed over our hills and through our forests.

The whale is the sole survivor of a time when what is now Lake Champlain was an arm of the then great St. Lawrence gulf.

On the North side of this room are several cases filled with fossils from the older geological formations of the State and it is expected that this series will be increased from year to year as the survey of the State progresses. The minerals and ores of this, and to some extent other regions, are represented by about a thousand specimens in cases on the North side of the room.

Running through the middle of this room are cases, one of which contains a small, but very excellent collection of corals and the other a fine series of tropical butterflies, showing most of the more brilliant and interesting species. There are some three hundred of these all mounted on Denton tablets. There are also in drawers about the same number of New England butterflies and several hundred insects of other orders.

South of these is a case arranged to show in epitome the groups of the animal kingdom, typical forms having been selected for the purpose. A careful study of this case will be well worth while to those interested in nature study. Several beautifully made papier mache models of some of the larger fishes, Dog fish, Mascalonge, Sturgeon, and Eel supplement this synoptical case.

In another case there is a very complete series of the building and ornamental stones of Vermont, Marbles, Granite, Slate, Soapstone, etc. Over fifty of these are in the form of eight inch cubes, the several faces being differently dressed. Besides these larger specimens, there are over a hundred smaller so that, while all the quarries now worked are not represented, most are, and anyone wishing to see what Vermont produces from its quarries can form a very good estimate from this collection. There is also a collection of Indian relics, some of them very fine and unique, a series of about a hundred crania of mammals and birds, an alcoholic collection of Reptiles and Batrachians and some other minor collections.

Near the case containing the fossil whale are several frames filled with photomicrographs of snow flakes, a hundred and fifty in all, taken by Mr. W. E. Bently, Nashville, Vt., directly from the objects. These are of great value as they show more

perfectly than any other illustrations, the true structure of the snow crystal.

A large collection of the rocks of Vermont is arranged in the gallery of this room. With very few exceptions, every town in the State is represented. Along the opposite side of the gallery are small cases containing shells. All of the collections above named have been considerably enlarged and newly labelled during the last year.

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