REPORT

OF THE

State Geologist

ON THE

MINERAL INDUSTRIES AND GEOLOGY OF CERTAIN AREAS

OF

VERMONT

1909-1910

SEVENTH OF THIS SERIES.

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STATE OF VERMONT.

OFFICE OF STATE GEOLOGIST.

BURLINGTON, VT., *October 1st, 1910.*

To His Excellency George H. Prouty, Governor of Vermont:

SIR: In accordance with Section 279, Statutes of 1900, I herewith present my Seventh Biennial Report as State Geologist.

A summary of the work carried on during the years 1909 and 1910 is given in the introduction. As in past years much important assistance has been afforded by several co-workers who have investigated the geology of different parts of the State.

Some of these gentlemen have been paid very moderately as assistants on the Survey, but some of the most valuable work has been done at little or no cost to the State. This refers especially to the investigations of Professor Seely, Dr. Raymond and Dr. Dale.

All of this work is of permanent value and the Geologist considers it extremely fortunate that its results can be included in this report. Aside from the field work which frequently requires attention, the preparation of reports, examination of a large number of samples of rocks, minerals and ores which are constantly coming into this office, a very large correspondence has been carried on with dealers in stone, contractors and others who have desired information as to the stone products of this State.

Very respectfully,

GEORGE H. PERKINS,

State Geologist.

Introduction.

As in previous reports, the following pages include a variety of articles prepared by different writers, which treat of the geology and mineral resources of Vermont.

The first article is intended to meet a long existing need for some guide and catalogue of the collections in the State Cabinet.

As a guide, it is hoped that it will prove of assistance to those visitors who may wish a more intimate acquaintance with the specimens exhibited than can be gained by a simple, unaided inspection. As a catalogue, it will serve, not only as a record of what is contained in the Cabinet rooms, but also as a source of information to scientists, wherever they may be, who desire to know what specimens the State has collected and something as to their character. Of course, a much greater number of illustrations would have accomplished this more completely and satisfactorily, but this was not praticable, and therefore only a few of what are considered as the more characteristically Vermont specimens have been figured. Most of these are stone implements left by the original inhabitants of the territory now forming the State, because it seemed most important that these objects which are of such general interest should receive especial attention.

The second paper, by Dr. T. N. Dale, altho already published by the United States Geological Survey, is of such great practical value to the granite industry of the State that, as is indicated later, it should be included in the permanent literature of Vermont geology. In the form in which it is here presented, it also is much more accessible to the people of this State than in the government publication. The paper by Professor Hitchcock on the surface features of parts of the State will be read with interest by all who are interested in Physiography.

The paper by Dr. P. E. Raymond, now of the Canadian Geological Survey, tho technical, is of much scientific value and the discussion of a very interesting group of fossils from a part of Vermont that has for many years been noted among geologists will, it is believed, be very welcome to all who are interested in the science.

The Geologist continues his study of Chittenden County in the article on the Burlington Quadrangle, which includes the south-western portion of the county. Naturally, following this is the very complete account of the Geology of Addison County by Professor Seely.

For many years Professor Seely has studied the geology of this county and it is exceedingly fortunate that so extensive a report of the results of long continued and skilfully carried on work can be put into permanent form. The article will be found to be a real and very valuable contribution to Vermont geology.

Very few localities have produced asbestos and the report by Dr. C. H. Richardson on the region about Belvidere Mountain and Lowell gives the results of a very careful and thorough investigation of a very interesting locality. The report on the Mineral Resources of the State has been placed last in this volume, as it probably will be hereafter, as this arrangement makes it possible to furnish later information.

A number of the plates have been furnished without expense to the State, as is noticed in each case.

History and Condition of the State Cabinet.

Brief reports of the State Cabinet and of additions to it have been made by different Curators during the sixty years since it was established. These reports, however, have been not only brief, but published at very irregular intervals and in different volumes of State publications where they cannot be found without considerable searching. None of them makes any attempt at giving an adequate idea of what the various collections are or of their importance. This will be attempted in the following pages and it is hoped that from them, those of the many visitors to the Cabinet who are especially interested in any department of natural history may find such guidance as shall make their examination of the specimens exhibited more profitable than would be possible otherwise. That is, it is the intention of the present Curator to provide a handbook of the collection that will give tolerably full statements of what it contains.

The idea of a State Museum appears to have been entertained by the first State Geologist very soon after his appointment in 1845. There was no place provided for some years after the appointment of Professor C. B. Adams by Governor Slade in accordance with an act passed by the Legislature late in the previous year in which specimens could be placed for exhibition.

In 1848 the Legislature passed a joint resolution which provided "That all collections of minerals, field notes and all preparations and materials amassed by the State Geologist for a final report be brought together by some suitable person to be appointed by the Governor and be deposited in the State House that nothing be lost and that the State may have the benefit of these collections whenever the State shall deem it expedient to prosecute the Survey to completion."

In accordance with the foregoing resolution, Professor Zadock Thompson was instructed to examine, collect and forward to the State House whatever material had been accumulated by the State Survey. Professor Thompson partly accomplished this work and made suggestion as to the arrangement of cases and display of specimens, but died before he had completed the task assigned to him.

Meantime, in 1855, the Legislature passed a joint resolution by which the Sergeant-at-Arms was directed to "Set apart and prepare room 14 for the use of the State Naturalist for the deposit and arrangement of the specimens collected and to be collected."

Not long after this we find that the Sergeant-at-Arms had fully complied with the above resolution in doing which he had followed "the advice and suggestions received from Professor Thompson in his lifetime."

Professor Adams had gathered a very creditable series of rocks and fossils as well as notes, instruments and other material, most of which appears to have been stored in what is called the "Geological Depot" in Burlington. As the room designated by the Legislature was ready to receive these specimens Mr. A. D. Hager, then assistant on the State Survey, forwarded them to Montpelier and shortly afterwards arranged such of them as were suitable in the cases, thus beginning the State Museum.

This was not, however, the beginning of the present Museum, for in less than a year fire broke out in the State House and destroyed a part of the building including the room that had received the geological collections. In a subsequent report, Professor Hitchcock declares that of the whole collection "not more than fifty specimens remain fit to take a place in the Cabinet."

The damaged portion of the State House being rebuilt as soon as possible, arrangements were at once made to form a new museum. Professor Edward Hitchcock was now State Geologist and he exercised great diligence during the next three or four years in collecting specimens of the rocks and fossils of Vermont. These specimens are still an important part of the collections in the Cabinet. For many years these specimens formed the major part of the collection and they are enumerated at length in the Geological Report of 1861. The collections made by Professor Thompson were bought by the State and added to the Cabinet. These included most of the specimens which are mentioned in the Natural History of Vermont and, besides some fossils, were largely zoological.

The following gentlemen have been Curators of the Cabinet as well as State Geologists, the law providing that the Geologist "shall also be Curator of the Cabinet." Indeed, between the years 1861 and 1896 the so called State Geologist was little more than Curator of the Cabinet as no appropriation was made to meet the expenses of the former office.

Of course there could be no Curator until there was a cabinet so Mr. A. D. Hager, who was acting Geologist was first Curator in 1856–57. Between 1857 and 1861 Professor Hitchcock had charge of the Cabinet, Mr. Hager acting as assistant, succeeded to the office in 1861. Mr. Hager continued in office until 1870. In 1871 Dr. H. A. Cutting was appointed Curator and continued to serve until 1886 when G. W. Perry followed him, continuing until 1898 when the present Curator took charge.

The writer is well aware that lists, or anything that approaches them, are usually tedious and that for this reason much of what is to follow will be of no great interest to a majority of those who see this report and yet it seems to be necessary to print somewhere pretty full lists of the various collections now having place in the Cabinet and, while it would obviously be a mistake to fill up this volume with complete catalogues of the various collections, it does appear to be eminently proper that so much of a catalogue as has already been indicated should be given here. In some cases a complete list will be given, but in others only a very general statement of what there is in the collection.

Not only are citizens of this State interested in what there is in the State Collections, but every now and then scientific workers in distant places are desirous to know where certain specimens or groups of specimens can be found.

As has been already intimated it is greatly to be regretted that the collections can not be displayed to better advantage both because of lack of room and, in one of the rooms, especially that in which the birds and mammals are placed, for want of light.

It need not be explained to people of this State that this is not because of any indifference on the part of those in authority, but because of the generally crowded condition of the State House.

Under these conditions the collections are as well treated as they possibly can be. Almost the last outlay upon the building that was authorized by the late Mr. Phinney as Sergeant-at-Arms was for refitting the room which had been long used for the Cabinet in the best possible manner and, so far as its space allows, this room is excellently adapted for its use. The other room was never designed as a Cabinet and is extremely bad in its lighting, but there is none better available and until more space is attainable through the enlargement of the building nothing better can be had.

Passing now to a consideration of the various collections which together make up the Cabinet we have the following, which altogether comprise between nine and ten thousand specimens.

MAMMALS AND BIRDS.

These collections are placed in a room formerly occupied by the Historical Society.

In 1886 the collection of this society was moved to a room in the second story of the addition built especially for the accomodation of the Supreme Court and the State Library.

Cases entirely covering the walls of this room, which is 30 feet long and 26 wide, are filled with the mounted specimens. All of the mammals and nearly all of the birds were taken in Vermont. The former are represented by examples of every species of quadruped that has been known to exist in the State during the last fifty years and therefore shows fully the mammalian fauna of Vermont.

MAMMALS.

There are about seventy specimens of Mammals in the collection, including the following species.

FELIS COUGAR, Kerr. *Panther, Catamount.*

The specimen of this animal in the State Collection is the very large individual which was killed in Barnard in 1881.

It is not as well mounted as could be desired, but presents a very good appearance. The Panther is very rarely found in this State, but once in a great while a specimen is seen and usually taken. So far as I know the only specimen taken before that at Barnard was caught in a trap in Bennington in 1850. This was sent to the University of Vermont. For many years before this no specimens are reported. It is said to have been not infrequent in the days of the early settlements.

LYNX CANADENSIS, Raf. *Canada Lynx.*

This and the following species are represented by several specimens. It is taken at infrequent intervals in the mountain towns and while very seldom seen, it does not appear to be quite extinct. Besides the two mounted specimens there is a very good skull.

LYNX RUFUS, Raf. *Bay Lynx. Wild Cat. Bob Cat.*

Not very uncommon in the sparsely inhabited parts of Northern Vermont. This smaller species is more like a large domestic cat than the preceding. It sometimes wanders into inhabited regions. In the winter of 1908 a half grown specimen was shot in a hen yard in Burlington. It was supposed to be a large cat, but, as it was rather singular in its appearance, the specimen was brought to me for examination. One mounted specimen. There is also a good skull.

VULPES FULVUS, Dekay. *Common Red Fox.*

Several specimens of this species are in the Museum, and also several skulls. The species does not appear to be extremely rare in Vermont, tho it cannot be called common.

Fine specimens of the variety known as the Cross Fox and the still more rare variety known as Silver Fox are also in the museum.

MUSTELA PENNANTI, Erx. *Fisher. Pekan.*

This is one of those fur bearing animals which, altho not yet extinct in Vermont, has become very rare. Two pairs were captured a few years ago and one pair is in the State Museum.

There are also the skulls of two others which were taken many years ago. The mounted specimens were taken in Bristol.

MUSTELA AMERICANA. Turton. *Pine Marten. American Sable.*

This species appears to be more rare than the preceding. At any rate, I have not known of the capture of any for many years. We have one mounted specimen and one skull.

PUTORIUS CICOGNANI, Rich. *Ermine. Little Weasel.*

It is probable that this little animal is more common than it appears to be since its small size, fleet running, and secretive habits keep it out of sight even when not very rare. Like the following, it is brown in summer and white in winter. Therefore it is when in the winter coats that they are Ermines.

PUTORIUS NOVEBORACENSIS, Dekay. *Weasel. Ermine.*

This species closely resembles the preceding except in its much larger size.

PUTORIUS VISON, Gapp. *Mink.*

This species is much more abundant than any other of our fur bearing animals and is not infrequently seen along the shores of Lake Champlain. Besides mounted specimens there are several skulls.

LUTRA CANADENSIS, Sabine. *Otter.*

This fine species is nearly extinct in Vermont. It is only at rare intervals that one is taken. We have but one specimen, a very good one and well set up. There is also the skull of another individual.

Thompson, writing in 1842, speaks of the Otter, Pine Marten and Fisher as being taken in considerable numbers, tho some of them were even then far less common than formerly.

MEPHITIS MEPHITICA, Baird. *Skunk.*

Of this very common animal there are several specimens in normal fur and two abnormal ones. One of these is a perfect albino and the other is apparently unique. It is white and brown, the latter color replacing the usual black. It is a very pretty specimen, the brown being of a handsome shade.

There are also two skulls.

PROCYON LOTOR, Storer. *Raccoon.*

This animal does not appear to be very uncommon in the mountain towns and less thickly settled parts of the state. There is but one specimen in the Collection and one skull.

URSUS AMERICANUS, Pallas. *Black Bear.*

This animal has always inhabited in greater or less numbers the Mountainous parts of the state.

PHOCA VITULINA, Linn. *Common Harbor Seal.*

It would hardly be supposed that any species of seal would be properly included in a list of Vermont mammals, but three specimens have been killed in the State during the century since 1810. Certainly this is not a very large number and the specimens are rather to be regarded as estrays than inhabitants. Whether any of these had spent any time in Vermont or were merely taking a trip through the State may not be known, but the fact that any of them were taken where they were is extraordinary

The first specimen of which there is any record was caught on the ice of Lake Champlain in February 1810. It was found, according to Thompson's record, "a little south of Burlington". What became of it is not stated. So far as I find any record, no other specimen was seen until February, 1846, when another was taken on the ice between Burlington and Port Kent. The animal was crawling over the ice which covered the lake. It was a female and weighed seventy pounds. This seal was brought to Burlington and mounted for the Museum of the University where it is still to be seen.

In August, 1876, a third specimen was shot in Otter Creek at Weybridge and is now in the State Collection.

As this species has always been common in the lower St. Lawrence it may be considered certain that these three individuals for some reason had left their kindred and made their way to the localities where they were found.

ODOCOILEUS VIRGINIANUS, Allen. *Common Deer.*

There is a fine buck well mounted in the collection with good antlers. There is a second head from another buck. A freak specimen is the head of a doe with rudimentary antlers in the velvet, tho the label states that the animal was shot in

October. She had two fawns with her at the time. The horns are unequal, the left being $5\frac{1}{2}$ inches long and the right 4 inches. The right horn is a simple spike, while the left does not taper towards the end, but rather grows thicker and at the end is somewhat forked as if branches were to grow out. A white fawn, apparently about five months old, was shot in Concord in 1907, and coming into the possession of the Fish and Game Commissioner, was mounted by his order and sent to the State Collection where it has attracted much attention and been greatly admired. It is pure white except on the outside of the ears and a row of small spots along each side of the middle of the back which are brown. There are also skulls of this species.

PARALCES AMERICANUS, Allen. *Moose.*

During the last fifty years or more, very few specimens of this species have been seen in Vermont. In 1900 a large male was shot in Wenlock and came into the possession of Mr. Thomas, Fish and Game Commissioner. Because of the crowded condition of the State Museum and the large size of the animal only the head was preserved and this is in the Collection. It is rereported on good authority that moose are occasionally killed in Ferdinand and other unsettled portions of the State.

CERVUS CANADENSIS. *Elk.*

No specimen of elk has been found living in this or the adjacent states since the coming of white men. That it did once live in this region, however, is conclusively proved by the horns which have been found in several localities. There is in the University Museum at Burlington a long, unbranched spike, 33 inches from base to tip, and in good condition. This was found in Grand Isle.

In the State Collection there is a similar antler, but with three tines, and several portions of larger and apparently, regularly branched antlers. There is also a part of a pelvic bone, including the acetabulum, which was found in Fletcher, and the label states that a fully developed set of antlers was found at the same time, but where they are I have not been able to discover.

RANGIFER CARIBOU, A & B. *Woodland Caribou.*

This animal has long been extinct in Vermont. Thompson does not mention it and yet it is strange that now and then a stray individual has not wandered hither from the Maine woods where it has been common until within comparatively few years. That the Caribou formerly did exist in the State is proved by a fully developed horn in the Collection which was found in Woodbury, seven feet below the surface of a peat bog. There is also a part of the upper jaw, including most of the side with five molars in place. The horn is the right antler. It measures forty-one inches from base to tip and is nearly complete. So far as I have information, these are the only remains of Caribou that have been found in the bogs of the State. It is unexpected that a greater number of Elk bones have been found.

Elephant.

Fossil bones of this species have been found in several parts of this state. There are in the State Collection portions of two tusks.

In 1848 workmen engaged in excavating on the line of the Rutland R. R., near the west end of the rock cut at Mt. Holly, came upon bones and tusks of an elephant. "Most of the bones, including a molar tooth, were taken by the workmen and others and carried out of the state. But one of the tusks, the most perfect one, was secured by Professor Thompson and is now lodged in the State Cabinet at Montpelier."

This specimen consists of the upper portion of a tusk, which, when complete, must have been of large size. The part in the Cabinet is eighty inches long following the outside curve, 3½ inches in diameter at one end and 4 inches at the other.

The original tooth went to the Museum of Comparative Zoology at Cambridge. It weighed eight pounds. A cast of it is in the State Collection. These were found in a bed of muck.

There is another portion of a tusk, probably of the same species, tho it is not so complete as to show whether it is the tusk of an Elephant or Mastodon, both of which inhabited Vermont in the latter part of the Pleistocene. This specimen was found at Bellows Falls. It is 46 inches long, following the outside, and 4 inches in diameter at the upper end and 7 inches at the other.

In the University Museum there is a portion of a tusk which was found in Richmond. Both ends are broken off. The piece remaining is thirty-one inches long, five inches in diameter at one end and three at the other.

CONDYLURA CRISTATA, Linn. *Starnosed Mole.*

This and most of the moles, shrews, bats and mice in the Collection were collected by Professor Thompson and still bear his labels made by his own hand. As such they are interesting as well as being those from which the figures and descriptions in the Natural History of Vermont were made. They are not regularly set up, but for the most part are merely sewed up skins.

We have three specimens of this species and one skull. It is not a common animal in this State.

PARASCALOPS BREWERI, Bach. *Shrew Mole.*

This is our most common mole. There are several specimens and one skull in the Thompson series.

BLARINA BREVICAUDA, TALPOIDES, Bangs. *Short-tailed Shrew.*

Apparently not very common, but like some other species of these little mammals which are habitually out of sight, it is more abundant than it seems to be. There are several specimens and one skull.

SOREX PERSONATUS, G. St. H. *Forsters Shrew.*

This tiny creature is rarely seen. When fully grown it is only a little more than two inches long, exclusive of the tail, which adds another inch or more, and as it runs thru long grass must usually be almost invisible.

SOREX HOYI. *Least Shrew.*

This species is very uncommon in Vermont, but does occur here.

LASIURUS CINEREUS, Baird. *Hoary Bat. Silver Bat.*

This is our largest species and is not as common as some of the other species. As stated, Professor Thompson's specimens of this and the following species are in our Collection.

LASIURUS BOREALIS, Mull. *Red Bat.*

This is not at all common in this state.

EPTISECUS FUSCUS, Baird. *Carolina Bat.*

Another rare species in this State. Perhaps the least common.

LASIONYCTERIS NOCTIVAGANS, LeConte. *Silver-haired Bat.*

More abundant than the preceding, but not very common.

MYOTIS LUCIFUGUS, LeConte. *Little Brown Bat.*

This is our most abundant species and occurs in some places in considerable numbers. It is also our smallest species.

SCIUROPTERUS VOLANS, Linn. *Flying Squirrel.*

This pretty animal is quite common, especially in the less inhabited parts of the State. Besides several normal specimens, there is one pure albino, which when living must have been a most charming little creature. There are also skulls.

SCIUROPTERUS SABRINUS MACROTIS, Mearns. *Northern Flying Squirrel.*

Less common and larger than the preceding.

SCIURUS HUDSONICUS, Allen. *Red Squirrel.*

Common all over the State. Besides several normal specimens, there is a perfect albino and skulls.

SCIURUS HUDSONICUS, Loquax. *Red Squirrel.*

This is reported from the southern part of the State and it may be that one of the specimens in our Collection is of this form.

SCIURUS CAROLINENSIS LEUCOTIS, Allen. *Gray Squirrel.*

Of the common form there are normal specimens and one entirely black. Also a skull.

TAMIAS STRIATUS LYSTERI, Mer. *Chipmuck. Striped Squirrel.*

Besides the ordinary form of this species there is an albino. There is also a skull.

CASTOR CANADENSIS, Kuhl. *Beaver.*

There is a specimen of this animal in the Collection, labelled "Loaned by Andrew J. Martin, North Calais." It is not certain that the specimen was taken in Vermont. According to Thompson: "The last of which I have any account was killed in Essex county 12 years ago." This being written in 1842 it follows that the beaver in question was killed in 1830. Neither label nor catalogue give information as to the locality from which our specimen came originally, but it is quite certain that the animal was formerly not uncommon all over Vermont. Here and there remains of old dams and sticks gnawed by them are still found and parts of skulls and various bones have been brought to me that were dug up at no great depth, usually near what appears to have been an Indian encampment. We also have accounts of early settlers concerning the presence of beaver in the State. Besides the mounted specimen there is one skull.

ARCTOMYX MONAX, Schr. *Woodchuck.*

Of this common animal we have several mounted specimens and several skulls.

PERIMYSCUS CANADENSIS, Bangs. *Field Mouse. White-footed Mouse.*

Common everywhere. We have Thompson's specimen of this species and also a skull.

PEROMYSCUS LEUCOPUS NOVEBORACENSIS, Mill. *Deer Mouse. Wood Mouse.*

Not very rare. One specimen in the Collection.

MICROTUS PENNSYLVANICUS, Rh. *Meadow Mouse.*

Not uncommon.

MUS MUSCULUS, Linn. *Common House Mouse.*

One specimen.

FIBER ZIBETHICUS, Cuvier. *Muskrat.*

This animal is still abundant in some of the reedy swamps. In the fall of 1907 several hundred were taken near the mouth of Malletts Creek. There is here a large bulrush swamp and for many years this has been inhabitated by hundreds of muskrats. There are other similar places in the State. There are several mounted specimens and skulls in the Collection.

ZAPUS HUDSONIUS, Coues. *Jumping Mouse.*

This is rather a rare or at least, rarely seen animal. There is one mounted specimen and one skull.

NAPEOZAPUS INSIGNIS, Miller. *Wood Jumping Mouse.*

One specimen of this not common species.

ERITHIZON DORSATUS, Cuvier. *Porcupine.*

Very common in the mountainous parts of the State. Besides several ordinary specimens, there is a very good albino, and also skulls.

LEPUS AMERICANUS VIRGINIANUS, Allen. *Northern Hare. Varying Hare.*

We have specimens of this animal in the gray summer fur, the white winter and one entirely black.

LEPUS FLORIDANUS TRANSITIONALIS, Allen. *Gray Rabbit.*

Several specimens and one skull.

In addition to the native species named, there are finely mounted heads of the following:

OVIS CANADENSIS, Shaw. *Bighorn.*

ANTILOCAPRA AMERICANUS, Ord. *Pronghorn*

CARIACUS MACROTIS. *Black-tailed Deer.*

CERVUS CANADENSIS, Erx. *Elk.*

These were obtained by Dr. Webb at Jacksons Lake, Wyo., and Dr. Webb had the heads mounted and presented them to the State Museum. There is also a pair of Koodoo horns from South Africa presented by Mr. C. O. Church of Whiting.

There are in all 380 specimens of mounted birds, most of them very well set up and in good plumage. I judge from his reports on the condition of the Museum that Dr. Cutting obtained and placed most of the birds. Most of the species likely to be found in Vermont are represented by at least one specimen and many by several specimens, showing the male and female plumage and sometimes also that of the immature bird. Such small gaps as there are will be filled as soon as possible so that the collection may give a complete series of not merely what may be considered our native birds, but also those that now and then at greater or less intervals visit the State

The following species are now in the cases.

PODILYMBUS PODICEPS, Linn. *Pied-billed Grebe.*
One specimen.

URINATOR IMBER, Gunn. *Loon. Great Northern Diver.*
One adult male. One fully grown, but in immature plumage.

UNA LOMVIA, Linn. *Brunnichs Murre.*
Sometimes this bird is very abundant in Lake Champlain and tributary streams, but usually it is rare. There are two specimens in the collection.

ALLE ALLE, Linn. *Dovkie. Sea Dove.*
Usually not seen in the State, but sometimes numbers are found in winter. There is a good pair of these birds.

LARUS ARGENTATUS, SMITHSONIANUS, Coues. *Herring Gull.*
Common on islands in Lake Champlain and occasionally seen inland. It breeds abundantly on the islands called the Four Brothers where Mr. Edward Hatch, owner of the islands, protects them.
Two in adult plumage.

OCEANODROMA LEUCORHOA, Vieil. *Leachs petrel.*
Occurs very rarely in Lake Champlain. Two specimens.

MERGANSER AMERICANUS, Cass. *Shelldrake Merganser.*
Common all over the State. Two specimens.

MERGANSER SERRATOR, Linn. *Red-breasted Merganser.*
Far less common than the preceding, but it is occasionally taken. One specimen.

LOPHODYTES CUCULLATUS, Linn. *Hooded Merganser.*
Not common. One male.

ANAS BOSCHAS, Linn. *Mallard Duck.*
Not very common.

ANAS OBSCURA, Gmel. *Black Duck.*
This is one of our most common species. One fine male. One female.

ANAS CAROLINENSIS, Gmel. *Green-winged Teal.*
Not common. One male.

ANAS DISCORS, Linn. *Blue-winged Teal.*
More common about Lake Champlain than the preceding. Two males.

SPATULA CLYPEATA, Linn. *Shoveller.*
Only occasinally seen. Two females.

DAFILA ACUTA, Linn. *Pintail.*
Uncommon. One male.

AIX SPONSA, Linn. *Wood Duck.*
This species, which is said to be growing very rare, is occasionally found in various parts of the State. Three males. One female.

AYTHYA AMERICANA, Eyt. *Redhead Duck.*
A good male.

AYTHYA AFFINIS, Eyt. *Little Bluebill. Little Blackhead.*
A good male.

CHARITTONETTA ALBEOLA, Linn. *Bufflehead. Butterball.*
Two specimens, males.

OIDEMIA AMERICANA, Eyt. S. & R. *American Scoter.*
Found only in the northern part of the State. One male

OIDEMIA PERSPICILLATA, Linn. *Surf Scoter.*
One specimen, male.

CLANGULA HYEMALIS, Linn. *South Southerly.*
Two males.

ERISMATURA RUBIDA, Wils. *Ruddy Duck.*
Not common. One male.

CHEN HYPERBOREA, Pall. *Lesser Snow Goose.*
Rare. One good specimen.

BRANTA CANADENSIS, Linn. *Canada Goose. Common Wild Goose.*
Two specimens.

BRANTA BERNICLA, Linn. *Brant.*
Rare. Two specimens.

BONAURUS LENTIGINOUS, Mont. *Bittern. State Driver.*
Common. Two specimens.

ARDETTA EXILIS, Gmel. *Least Bittern.*
Rare. Two specimens.

ARDEA HERODIAS, Linn. *Great Blue Heron.*
Not common. Two specimens.

ARDEA VIRESCENS, Linn. *Little Green Heron.*
Not very common, but more so than the other two. One specimen.

NYCTICORAX NYCTICORAX NAEVIUS, Bodd. *Night Heron.*
Usually rare. Two adult specimens and one young.

GRUS MEXICANA, Mull. *Sandhill Crane.*
The specimen of this bird very unusual in Vermont, was shot in the Connecticut River at Lunenburg. It is a large adult.

RALLUS LONGIROSTRIS, OREPITANS, Gmel. *Clapper Rail.*
Not common. Two specimens.

RALLUS VIRGINIANUS, Linn. *Virginia Rail.*
Not common. One specimen.

PORZANA CAROLINA, Linn. *Carolina Rail.*
Not common. One specimen.

FULICA AMERICANA, Gmel. *Mud Hen. Coot.*
Rare. One specimen.

CRYMOPHILUS FULICARIUS, Linn. *Red Phalarope.*
Rare. One specimen.

PHILOHELA MINOR, Gmel. *Woodcock.*
Becoming rare. There is a good pair in the Collection.

GALLINAGO DELICATA, Ord. *Wilsons Snipe.*
Not now common in most localities. There is a pair in the Collection.

LIMOSA HAEMASTICA, Linn. *Hudsonian Godwit.*
One fine specimen.

TOTANUS MELANOLEUCAS, Gmel. *Greater Yellowlegs.*
Not common. Three specimens.

TOTANUS FLAVIPES, Gmel. *Yellow Legs.* Rare.
One specimen.

TOTANUS SOLITARIUS, Wils. *Solitary Sandpiper.*
Not common. One specimen.

SYMPHEMIA SEMIPALMATA, Gmel. *Willet.*
One specimen.

BARTRAMIA LONGICAUDA, Bech. *Bartrams Sandpiper.*
Rare. One specimen.

ACTITIS MACULARIA, Linn. *Spotted Sandpiper.*
Common. One specimen.

NUMENIUS LONGIROSTRIS, Wils. *Long-billed Curlew.*
Not common. There is a fine pair in the Collection.

CHARADRIUS SQUATAROLA, Linn. *Black-bellied Plover.*
One good specimen.

CHARADRIUS DOMINICUS, Mull. *Golden Plover.*
Rare. We have a fine pair.

AEGIALITIS VOCIFERA, Linn. *Killdeer.*
Not common. One good specimen.

AEGIALITIS SEMIPALMATA, Bon. *Semipalmated Plover.*
Usually rare. Dr. Cutting reports it common about Groton Pond some years ago. One specimen.

AEGIALITIS MELODA, Ord. *Piping Plover.*
Rare. One specimen.

AEGIALITIS WILSONIA, Ord. *Wilsons Plover.*
Rare. One specimen.

COLINUS VIRGINIANUS, Linn. *Quail. Bob White.*
This species has been several times introduced as a game bird and has lived for several years, but it is not probably native to the State. One specimen.

DENDRAGACUS CANADENSIS, Linn. *Canada Grouse.*
Spruce Partridge.
Found sparingly in the northern part of the State. A fine pair.

BONASA UMBELLUS. *Common Partridge. Ruffed Grouse.*
One pair.

TETRAOGALLUS CAPERCAILLI. *Capercailli.*
There is a fine pair of this foreign species in the Collection. It finds a place among Vermont birds only because ten or twelve years ago it was introduced and pairs set free mostly on Dr. Webb's preserves in Shelburne, but also in several other localities, but the experiment was not successful as none were afterwards heard from.

PHASIANUS COLCHICUS. *European Pheasant.*
This species appears to have been more successfully introduced. Dr. Webb has had many living at Shelburne and estrays from this preserve have been shot in the adjoining region. There is a pair in the Collection.

ECTOPISTES MIG GRATORIUS, Linn. *Wild Pigeon.*
Formerly common, but now rarely seen. One specimen.

ZENAIDURA MACROURA, Linn. *Wild Dove. Mourning Dove.*
Rare.

CIRCUS HUDSONIUS, Linn. *Marsh Hawk.*
Not very common. Two specimens.

ACCIPETER VELOX, Wils. *Sharpshinned Hawk.*
Not common. Three.

ACCIPETER COOPERI, Bonap. *Coopers Hawk.*
Common. Two.

ACCIPITER ATRICAPILLUS, Wils. *Goshawk.*
Not very common, but more so than most of the hawks. Three.

BUTEO BOREALIS, Gmel. *Red-tailed Hawk.*
This and the following are our most common species. None of the others can be called abundant. Three specimens.

BUTEO LINEATUS, Gmel. *Red-shouldered Hawk.*
Rather common. Four specimens.

BUTEO SWAINSONI, Bonap. *Swainsons Hawk.*
Quite rare.

BUTEO LATISSIMUS, Wils. *Broad-winged Hawk.*
Rare. Three specimens.

ARCHIBUTEO LAGOPUS SANCTI-JOHANNIS, Gmel. *Black Hawk.*
Rare. Two specimens.

AQUILA CHRYSAETOS, Linn. *Golden Eagle.*
Rare in this State. For a long time none may be reported. Then for two or three years several are seen. We have three specimens.

HALIAETUS LEUCOCEPHALUS, Linn. *White-headed Eagle. Bald Eagle.*
This is our common species and in some parts of the State a few individuals may be seen at almost any time during the warmer parts of the year. As the young reach full growth in the brown plumage, they are often mistaken for the golden eagle. Two specimens.

FALCO PEREGRINUS ANATUM, Bonap. *Duck Hawk.*
Not common. One.

FALCO COLUMBARIUS, Linn. *Pigeon Hawk.*
Not uncommon in spring and fall. There are five specimens showing variation in plumage.

FALCO SPARVERIUS, Linn. *Sparrow Hawk.*
Common. Three.

PANDION HALIAETUS CAROLINENSIS, Gmel. *Fish Hawk. Osprey.*
Not common. One specimen.

ASIO WILSONIANUS, Less. *Long-eared Owl.*
Not common. One specimen.

ASIO ACCIPITRINUS, Pall. *Short-eared Owl.*
Not common. Two specimens.

SYRNIUM NEBULOSUM, Forest. *Barred Owl.*
Rather common. We have a fine pair of this species.

SCOTIAPTEX CINEREUM, Gmel. *Great Gray Owl.*
Usually very rare and it may not be seen in the State for years, then during several years a number of individuals are taken. It is not seen except in winter. We have a pair.

NYCTALA TENGMALMI RICHARDSONI, Bonap. *Richardsons Owl.*
Rare winter visitor. Two specimens.

NYCTALA ACADICA, Gmel. *Saw Whet Owl. Acadian Owl.*
Sometimes common, especially in the northern part of the State.

MEGASCOPS ASIO, Linn. *Screech Owl.*
Common.

BUBO VIRGINIANUS, Gmel. *Great Horned Owl. Cat Owl.*
Somewhat common. Two specimens.

NYCTEA NYCTEA, Linn. *Snowy Owl.*
Usually rare, but once in a while during a severe winter this species is unusually abundant in the northern part of the State. Two specimens.

SURNIA ULULA CAPAROCH, Mull. *Hawk Owl.*
Not common. Two specimens.

CONTOPUS BOREALIS, Swains. *Olive-sided Flycatcher.*
Not uncommon. Two specimens.

EMPIDONAX FLAVIVENTRIS, Baird. *Yellow-bellied Flycatcher.*
Rare. One specimen.

EMPIDONAX MINIUM, Baird. *Least Flycatcher.*
Common. A good pair.

OTOCORIS ALPESTRIS PRATICOLA, Hens. *Prairie Horned Lark.*
Common. Two specimens.

CYANOCITTA CRISTATA, Linn. *Blue Jay.*
Common away from habitations. Three in adult and three in immature plumage.

PERISOREUS CANADENSIS, Linn. *Canada Jay.*
Found chiefly in the northern part of the State. Two specimens.

CORVUS CORAX PRINCIPALIS, Ridg. *Raven.*
Found in the extreme north of the State. Two good specimens.

CORVUS AMERICANUS. *Common Crow.*
Very abundant. Two specimens.

DOLICHONYX ORYZIVORUS, Linn. *Bobolink.*
Common. There is a good pair in the Collection.

MOLOTHRUS ATER, Bodd. *Cowbird.*
Not rare. A pair.

AGELAIUS PHENICEUS, Linn. *Red-winged Blackbird.*
Common. Male and female.

STURNELLA MAGNA, Linn. *Meadow Lark.*
Not uncommon in some parts of the State. Two good specimens.

ICTERUS SPURIUS, Linn. *Orchard Oriole.*
Not common. Male and female.

ICTERUS GALBULA, Linn. *Baltimore Oriole.*
Common. Two males.

SCOLEPHAGUS CAROLINUS, Mul. *Rusty Blackbird.*
Not common. Three specimens male and two females.

QUISCALUS QUISCULA, Linn. *Purple Grackle, Blackbird.*
Not as common as the next. One specimen.

QUISCALUS QUISCULA AENEUS, Ridg. *Bronze Grackle Blackbird.*
The common blackbird in this region. Three specimens.

PINICOLA ENUCLEATOR, Linn. *Pine Grosbeak.*
Variable, being common during some winters and rare during others. A male and two females.

CARPODACUS PURPUREUS, Gmel. *Purple Finch.*
Common. Two males and two females.

PASSER DOMESTICUS, Linn. *English Sparrow.*
Very common. One specimen.

LOXIA CURVIROSTRA MINOR, Brehm. *Crossbill.*
Not usually very common. Four specimens.

LOXIA LEUCOPTERA, Gmel. *White-winged Crossbill.*
Rare. Two species.

ACANTHIS LINARIA, Linn. *Redpoll.*
Two specimens.

SPINUS TRISTIS, Linn. *Goldfinch. Yellowbird.*
Common. One male.

SPINUS PINUS, Wils. *Pine Siskin.*

AMMODRAMUS SANDWICHENSIS SAVANNA, Wils. *Savannah Sparrow.*
Not common. One fine specimen.

AMMODRAMUS SAVANNARUM PASSERINUS, Wils. *Grasshopper Sparrow.*
Not common. One specimen.

AMMODRAMUS CAUDACUTUS, Gmel. *Sharp-tailed Finch.*
Not common. Three specimens.

ZONOTRICHIA LEUCOPHRYS, Forst. *White-crowned Sparrow.*
Common. Fine pair.

ZONOTRICHIA ALBICOLLIS, Gmel. *White-throated Sparrow.*
Rather common. Two specimens.

SPIZELLA MONTICOLA, Gmel. *Tree Sparrow.*
Not usually common. One specimen.

SPIZELLA SOCIALIS, Wils. *Chipping Sparrow.*
Very common. One specimen.

SPIZELLA PUSILLA, Wils. *Field Sparrow.*
Common. One specimen.

JUNCO HYEMALIS, Linn. *Junco. Black Snowbird.*
Common. Two specimens.

MELOSPIZA FASCIATA, Gmel. *Song Sparrow.*
Very common. Three specimens.

MELOSPIZA GEORGIANA, Lath. *Swamp Sparrow.*
Not common. Two specimens.

PASSERELLA ILIACA, Merr. *Fox Sparrow.*
Not common. A migrant. Two specimens.

PIPILIO ERYTHROPHTHALMUS, Linn. *Chewink. Ground Robin.*
Not very common. Two specimens.

CARDINALIS CARDINALIS, Linn. *Cardinal.*
It may be doubted that the specimen of this southern species was taken in the State, but the bird is seen here, tho very rarely. One specimen.

HABIA LUDOVICIANA, Linn. *Rose-breasted Grosbeak.*
Not uncommon. Three males.

PASSERINA CYANEA, Linn. *Indigo Bunting.*
Not very common. One specimen, male.

PIRANGA ERYTHROMELAS, Viell. *Scarlet Tanager.*
Not very common. Male and female.

PYRANGA RUBRA, Linn. *Summer Tanager.*
Not common. Male and female.

PROGNE SUBIS, Linn. *Purple Martin.*
Not common. Found in only a few localities in the State. One specimen.

PETROCHELIDON LUNIFRONS, Say. *Cliff Swallow.*
Common. One specimen.

CHELIDON ERYTHROGASTER, Bodd. *Barn Swallow.*
Common. One specimen.

TACHYCINETA BICOLOR, Viell. *Tree Swallow.*
Rather common. Two specimens.

CLIVICOLA RIPARIA, Linn. *Bank Swallow.*
Common.

STELGIDOPTERMX SERRIPENNIS, Aud. *Rough-winged Swallow.*
Not common.

AMPELIS CEDRORUM, Viell. *Cedar Bird. Waxwing.*
Common. Several specimens in the Collection.

AMPELIS GARRULUS, Linn. *Bohemian Waxwing.*
Rare, but sometimes seen. There is a good pair in the Collection.

LANIUS BOREALIS, Viell. *Northern Shrike. Butcher Bird.*
Not very common. Three specimens.

LANIUS LUDOVICIANUS, Linn. *Loggerhead Shrike.*
Quite rarely seen.

VIREO OLIVACEOUS, Linn. *Red-eyed Vireo.*
Common. Two specimens.

VIREO FLAVIFRONS, Viell. *Yellow-throated Vireo.*
Tolerably common. One specimen.

VIREO NOVEBORACENSIS, Gmel. *White-eyed Vireo.*
Rarely seen. One specimen.

VIREO SOLITARIUS, Wils. *Solitary Vireo.*
Rare. One specimen.

MNIOTILTA VARIA, Linn. *Black and White Creeper.*
Common. One specimen.

HELMINTHOPHILA PINUS, Linn. *Blue-winged Warbler.*
Rare. One.

HELMINTHOPHAGA CHRYSOPTERA, Linn. *Golden-winged Warbler.*
Rare. One.

HELMINTHOPHAGA RUFICAPILLA, Wils. *Nashville Warbler.*
Rare. One.

HELMINTHOPHAGA PEREGRINA, Wils. *Tennessee Warbler.*
Rare. One specimen.

COMPSOTHLYPIS AMERICANA, Linn. *Parula Warbler.*
Common. A pair.

DENDROICA TIGRINA, Gmel. *Cape May Warbler.*
Rare. One.

DENDROICA AESTIVA, Gmel. *Yellow Warbler.*
Common. One.

DENDROICA CAERULESCENS, Gmel. *Black-throated Blue Warbler.*
Not uncommon in the northern part of the State. Two.

DENDROICA CORONATA, Linn. *Myrtle Warbler.*
Common as a migrant. One.

DENDROICA MACULOSA, Gmel. *Magnolia Warbler.*
Not common. One.

DENDROICA PENNSYLVANICA, Linn. *Chestnut-sided Warbler.*
Quite common. One.

DENDROICA CASTANEA, Wils. *Bay-breasted Warbler.*
Not common. One.

DENDROICA STRIATA, Forst. *Blackpoll Warbler.*
Somewhat common. Three specimens.

DENDROICA BLACKBURNIAE, Gmel. *Blackburnian Warbler.*
Common. Two.

DENDROICA VIRENS, Gmel. *Black-throated Green Warbler.*
Common. Two specimens.

DENDROICA VIGORSII, Aud. *Pine Warbler.*
Rare. One specimen.

DENDROICA PALMARUM, Gmel. *Palm Warbler.*
Rare. One.

DENDROICA PALMARUM HYPOCHRYSIA, Ridgw. *Yellow Palm Warbler.*
Rare. One specimen.

SEIURUS AUROCAPILLUS, Linn. *Oven Bird.*
Rather common. Two specimens.

SEIURUS NOVEBORACENSIS, Gmel. *Water Thrush.*
Not common. One.

GEOTHLYPIS AGILIS, Wils. *Connecticut Warbler.*
Rare. One.

GEOTHLYPIS PHILADELPHIA. Wils. *Mourning Warbler.*
Rare. Spring visitor. One specimen.

GEOTHLYPIS TRICHAS, Linn. *Maryland Yellowthroat.*
Common. A pair.

ICTERIA VIRENS, Linn. *Yellow-breasted Chat.*
Very rare. One.

SYLVANIA MITRATA, Gmel. *Hooded Warbler.*
Rare. Two.

SYLVANIA CANADENSIS, Linn. *Canadian Warbler.*
Rare.

SETOPHAGA RUTICILLA, Linn. *Redstart.*
Common. Two.

ANTHUS PENNSYLVANICUS, Lath. *Titlark. Pipit.*
Rare. One.

MIMUS POLYGLOTTUS, Linn. *Mockingbird.*
There is in the Collection a pair of this species that came to Lunenburg and nested. I have no record of others.

GALEOSCOPTES CAROLINENSIS, Linn. *Catbird.*
Common. Three specimens.

HARPORHYNCHUS RUFUS, Linn. *Brown Thrasher. Brown Thrush.*
Not usually very common. Two specimens.

TROGLODYTES AEDON, Viell. *House Wren.*
Common. Two specimens.

TROGLODYTES HIEMALIS, Viell. *Winter Wren.*
Not common. Fine pair.

CERTHIA FAMILARIS AMERICANA, Bonap. *Brown Creeper.*
Not common. One specimen.

SITTA CAROLINENSIS, Lath. *White-breasted Nuthatch.*
Not common. One pair.

SITTA CANADENSIS, Linn. *Red-breasted Nuthatch.*
There is a pair of these in the Collection. Not as common as the preceding.

PARUS ATRICAPILLUS. *Chickadee. Titmouse.*
Very common. One pair.

PARUS BICOLOR, Linn. *Tufted Titmouse.*
Not common. One.

Regulus satrapa, Licht. *Golden-crowned Kinglet.*
Pair. Sometimes quite common. Often rare.

Regulus calendula, Linn. *Ruby-crowned Kinglet.*
More common than the preceding. One specimen.

Turdus mustelinus, Gmel. *Wood Thrush.*
Not very common. One.

Turdus fuscescens, Steph. *Wilsons Thrush.*
Not common. One.

Turdus aliciae, Baird. *Gray-cheeked Thrush.*
Rare. One.

Turdus Ustulatus swainsoni, Cab. *Swainsons Thrush.*
Not very common. One specimen.

Turdus aonalaschke pallasi, Cab. *Hermit Thrush.*
Common. Pair.

Merula migratoria, Linn. *Robin.*
Common. Pair adult, one young.

Sialia sialis, Linn. *Bluebird.*
Not usually common. Three specimen.

In addition to those species enumerated in the foregoing list the following are to be seen in the collection. Most of these have not been found in Vermont.

Podiceps holbelli, R. *Red-necked Grebe.*
One specimen.

Rissa tridactyla, Linn. *Kittawake Gull.*
Two specimens.

Larus marinus, Linn. *Great Black-backed Gull.*
There is one specimen in fine mature plumage and one in inmature.

Glaucionetta islandica, Gmel. *Barrows Golden-eye.*
Three male specimens.

Oidemia fusca. *Velvet Duck.*
One specimen.

Histrionicus histrionicus, Linn. *Harlequin Duck.*
One fine male.

Somateria dresserii, Sharpe. *Eider Duck.*
A very fine pair.

Macrohampus griseus, Gmel. *Red-breasted Snipe.*
A good pair.

Numenius hudsonicus, Lath. *Hudsonian Curlew.*
A good pair.

Dendroica discolor, Viell. *Prairie Warbler.*
One male.

Cistothorus stellaris, Licht. *Short-billed Marsh Wren.*
A fine pair.

REPTILES AND BATRACHIA.

The collection of these animals is not very extensive and many of the specimens have been many years in alcohol and are more or less faded. As will be seen from the following lists, nearly all the species that have been found in Vermont are represented by some sort of a specimen. In the reptiles these are better than in the batrachians. Some of the examples of the former are very good but many of the latter need renewing.

REPTILES.

Chelydra serpentina, Sch. *Snapping Turtle.*
There are two large carapaces of this species in the Collection. It is nowhere very common. It grows to a much greater size than any other of our species.

Chelopus insculptus, Gray. *Wood Tortoise.*
This species is more terrestrial than the others. It is not common.

Chrysemys picta, Gray. *Painted Tortoise, Terrapin.*
Although not very abundant, this is our most frequently seen species.

Malacoclemys geographicus, Cope. *Geographic Turtle.*
Not at all common.

Trionyx spinifer, Lesq. *Soft-shelled Turtle.*
Not common.

Diadophis punctatus, B. & G. *Ring-necked Snake.*
Not very rare, but not often seen on account of its disposition to remain hidden.

Cyclophis vernalis, Cope. *Green Snake.*
This snake is not very common.

ZAMENIS CONSTRICTOR, Bonl. *Black Snake.*
Found only in the southern part of the State and not common there.

LAMPROPELTIS DOLIATAUS TRIANGULAUS, Cope. *Milk Snake. Chicken Snake.*
Common in some places, but not generally. It is one of the larger species sometimes reaching a length of five feet.

NATRIX FASCIATA SIPEDON, Cope. *Water Snake.*
Common in coves, etc., of Lake Champlain, but rarely seen far from water.

STORERIA DEKAYI, B. & G. *Brown Snake.*

STORERIA OCCIPITOMACULATA, B. & G. *Spotted-necked Snake.*
One of the smaller snakes. Common, especially in late summer.

THAMNOPHIS SAURITA, B. & G. *Garter Snake. Striped Snake.*
This is more slender and smaller than the following, which it somewhat resembles. It is also less common.

THAMNOPHIS SIRTALIS, Cope. *Striped Snake.*
This is the common species and also a larger form than the above.

THAMNOPHIS SIRTALIS ORDINATA, Cope. *Brown Snake. Grass Snake.*
This little snake is not often seen except late in the season.

ANCISTROMA CONTORTRIX, Baird. *Copperhead.*
Found formerly very rarely and only in a few limited localities, and very probably extinct in the State, tho still found at Split Rock and other places just across the lake.

CROTALUS HORRIDUS. *Banded Rattlesnake.*
The only locality in which this species is now found in Vermont is on Skitchawaug Mt., in Springfield, where a number of good sized specimens are killed every season.

BATRACHIA.

NECTURUS MACULATUS, Raf. *Menobranchus. Necturus.*
Found now and then in Lake Champlain and its tributaries.

AMBLYSTOMA PUNCTATUM, Baird. *Spotted Salmander.*
Not common.

AMBLYSTOMA JEFFERSONIANUM, Baird.
Rare.

AMBLYSTOMA TIGRINUM, Green. *Tiger Salamander.*
Rare.

PLETHODON CINEREUS, Cope. *Gray Salamander.*
Woods and damp places. Not very common.

PLETHODON CINEREUS ERYTHRONOTUS, Cope. *Red-backed Salamander.*
Not very common.

PLETHODON GLUTINOSUS, *Slimy Salamander.*
Very rare.

GYRINOPHILUS PORPHYRITICUS, Cope. *Purple Salamander.*
Not common.

SPELERPES BILINEATUS, B. *Striped Salamander.*
Rare.

DESMOGNATHUS FUSCA, Baird. *Brown Salamander.*

DIEMYCTYLUS VIRIDESCENS, Hall. *Common Salamander. Newt.*
Our most common species in ponds and ditches. This species is badly named, for its general color is red brown with bright red spots along the sides.

DIEMYCTEIUS MINIATUS, Har. *Red Salamander.*
Not common.

BUFO AMERICANUS, Cope. *Common Toad.*

HYLA PICKERINGII, Leconte. *Tree Toad. Tree Frog.*
Common. Because of its ability to change color and thus closely resemble its surroundings this little animal is not seen as often as might be expected.

HYLA VERSICOLOR, Leconte. *Tree Toad.*
Common.

RANA PIPIENS, Gmel. *Leopard Frog.*
Common.

RANA PALUSTRIS, Leconte. *Pickerel Frog.*
Common in meadows and swamps.

RANA CLAMATA, Daud. *Green Frog.*
This is the common pond frog.

RANA CATESBIANA, Shaw. *Bull Frog.*
This is our largest species.

RANA SYLVATICA, Leconte. *Wood Frog.*
Common in meadows and moist woods. Often seen at considerable distance from water.

Next north of the room in which the Mammals and Birds, as enumerated, are shown, is the room which at first was set apart for the reception of the Cabinet. In this room, which is about thirty feet square, the other collections are placed. As has been intimated, there is not room sufficient for properly displaying the excellent collections which have accumulated. All that can be done until far more space is available for cases is to make the best of the conditions existing. There is reason to hope that in the not distant future additional space may be given. As has been noticed, the north, or old Cabinet, room is well lighted and fitted with cases as well as it can be and the collections which it contains, together with those already enumerated, are such as no Vermonter need be ashamed of.

Obviously, a State Collection should primarily exhibit the resources of the state in which it is located and originally it was intended that the Vermont Cabinet should contain mainly, if not solely, Vermont specimens. This was the plan of the writer when twelve years ago he took charge of the Cabinet. A few months' experience and observation convinced him that, while certainly our own State should be well represented, even to showing so far as possible its entire natural history, this would not be sufficient if the collections were to accomplish the utmost for the education of the many visitors. There are large and important groups in the animal kingdom which are not represented in this State and there are peculiar forms of others found only in distant localities. On this account and because not only the general public in large numbers visit the rooms, but also hundreds of pupils from the schools, it has been thought best to so arrange and extend the collections that they may represent in some measure the whole animal kingdom. Properly all groups that can be fairly represented by Vermont specimens need not be illustrated by those from other localities and always the natural history of this State is to be kept prominent. The chief object of the Collections is and always should be to show as clearly as possible the resources of this State.

As supplementary to the other Collections and also for the purpose of giving a comprehensive view of the animal kingdom, altho necessarily a very restricted one, the Curator has arranged one of the large cases as a "Synoptical Case". While this is arranged especially for the use of pupils in the schools in con-

nection with their nature study. It will be found generally instructive. It would be needlessly tedious to mention all the specimens contained in this case. It must suffice to say that not only are all of the great sub divisions of the animal kingdom represented by a number of specimens, but many of the larger sub-groups as Mollusca, Coelenterata, Insecta, etc. There are also a few models of animals not so well shown in any other manner and a series of most useful preparations illustrating the development from the egg of different animals. Altho outside of this case on the front of the gallery, the large papier mache models of the Dogfish, Maskalonge, Sturgeon and Eel belong to this series. The Synoptical Case contains about three hundred and fifty specimens and models.

CORALS are shown in the case just mentioned, but the more important specimens are arranged in one of the two table cases in the center of the room. This collection is small, including only eighty specimens, but these have been selected from as many different genera as possible and many are fine examples of their kind. Together, they make a very attractive case. There are twenty-five genera and sixty species shown in the case.

MOLLUSCA. No attempt has ever been made to secure a large series of shells even of those that are native, but all the varieties found in Vermont are represented and many marine forms. In all there are not less than a thousand specimens. All are not shown in open cases, but for the present must be stored in drawers.

INSECTS. This Group is well shown by not far from a thousand specimens. There are several hundred specimens of the Moths and Butterflies which are mounted in the Denton tablets. All the species, except Microlepidoptera, which occur in Vermont are shown as well as other New England species and there are three hundred tablets of tropical butterflies showing the brilliant coloring, remarkable examples of mimicry, or resemblance found in these insects. None of the other groups of insects are so largely represented as are the butterflies, but there are small series of each of the orders. The tropical butterflies and those illustrating mimicry are shown in one of the table cases in the center of the room, but the rest of the insects are in drawers.

BIRDS EGGS. There is in one of the table cases on the south side of the room a series of nearly a thousand eggs from 346 species of birds. Most of these are eggs of Vermont birds, but there are a few, as ostrich, some marine species, etc., from outside of the State.

ROCKS OF VERMONT. Arranged in the gallery cases and in drawers there are over two thousand specimens of the rocks of Vermont; substantially all the varieties found in the State are shown and many of them by several specimens from different localities. The larger part of this collection of rocks was made by the earlier State Survey under Dr. Edward Hitchcock. The labels are copies of those attached by the members of that Survey. Nearly every town in the State furnished specimens for this series and the rocks are arranged by towns rather than by species. Since the former Survey the study of rocks has developed until it is essentially a different science and, of course, the nomenclature is correspondingly different now from that when these specimens were labelled.

During the past five years, Dr. C. H. Hitchcock and Dr. C. H. Richardson, in connection with their work on the present Survey, have collected series of rock specimens from the areas over which they have worked and these, amounting thus far to nearly five hundred specimens, trimmed to as nearly uniform size, 3x4 inches, as possible, have been labelled according to modern ideas.

It is not possible to state exactly the number of species found in the rocks of Vermont, but there are several hundred, including numerous varieties. Naturally some of these, as granite, hornblende, schist, quartz, limestone, etc., are very commonly disstributed, while others are found only in a few or perhaps but one locality.

The collection now at Montpelier is fairly complete, but it cannot be claimed that it contains all the varieties existing and as the territory of the State is more carefully explored other species are likely to be found. While nothing can take the place of field work, collecting and studying the rocks as they occur in different localities, yet it is intended that the collection at Montpelier shall be so complete that any one interested in the study of our rocks may gain a fair conception of what there is in the State by examining the Montpelier specimens. Indeed, one object of the following list is to show, especially to those who cannot study our rocks in place, what we have.

While any collection of rocks is less attractive to the average observer than most collections, the value and usefulness of such a collection needs no proof.

The hundreds of rock specimens collected by the older Survey, sets of which were distributed to the higher educational institutions in the State, were catalogued in the Report published in 1861, and will not be repeated here. All of the specimens catalogued below have been collected, as mentioned, by the members of the present Survey. The list of the rocks collected and distributed by the former Survey will be found on pp. 594-690, of Volume II.

Amygdaloidal Diabase, Westmore.
Aplitic Granite, Newport.
Amphibolite, Burke Mountain.
Actinolite schist, Walden
Amygdaloidal Diabase, Newark.
Basalt, Troy.
Biotite Granite, Coventry.
Biotite Granite, Blue Mt., Ryegate.
Bradford Schist, Kirby Mountain.
Bradford Schist, West Concord.
Bradford Schist, Hereford, P. Q.
Bradford Schist, Canaan Heights.
Biotite Granite, Newport.
Basalt, A. Troy.
Biotite Granite, Kirby Mountain
Biotite Granite, Cabot.
Bradford Schist, West of Barnet.
Bradford Schist, West of Paquetteville.
Bradford Schist, Averill Line.
Biotite Gneiss, North Concord.

Biotite Granite, Westmore
Biotite Granite, Concord.
Biotite Schist, Barton.
Calcareous Chlorite Schist, Newbury.
Camptonite, Crane Ledge, Danville.
Chlorite Schist, Hartford.
Chlorite Schist, Lebanon.
Chlorite Schist, Lunenburg.
Chlorite Schist, East Concord.
Chlorite Schist, Hardwick.
Chloritic Grit, Norwich.
Clay Slate, Canaan.
Clay Slate, East Montpelier.
Clay Slate, Cabot.
Clay Slate, Albany.
Chromite, Jay.
Conglomerate, Irasburg.
Camptonite, North Newport.
Camptonite, East Barnet.
Chorite Schist, White River Junction.
Chlorite Schist, Norwich.
Chlorite Schist, McIndoes Falls.
Chlorite Schist, Lower Waterford.
Chlorite Slate, Wells River.
Chloritic Grit,
Clay Slate, Newport.
Clay Slate, Woodbury Mountain.
Clay Slate, West Calais.
Clay Slate, Paquetteville, P. Q.
Compact Slate, Newport.
Contact, Granite and Fibrolite Schist, Burke Mountain, Top.
Conglomerate, Cornish.
Contact, Limestone and Quartz, Westmore.
Coos Mica Schist, Norwich.
Curved Strata, Mica Schist, White River
Crumpled Phyllite Schist, Irasburg.
Dark Limestone, Irasburg.
Decomposing Limestone, Barton.
Diabase, Miles Pond.
Diabase, Norwich.
Diabase, Queechee Gulf.
Diabase, Dike, Hartland.
Diabase, Altered, Waterford Mt.
Diabase, Newport.
Devonian Limestone, Owls Head.
Diabase, Owls Head
Diabase, Hartford.
Diabase Schist, Hartford Village.
Diabase, Crafts Hill, Lebanon.
Diabase, Westmore.
Diabase, Coventry.
Diorite, North Troy.
Diorite, Newport.
Diorite Porphyra, Concord.
Fibrolite Schist, Concord.
Ferruginous Schist, Hartford.
Fibrolite Schist, Burke Mountain.
Fibrolite Schist, Miles Mountain.
Foliated Hornblende Schist, Wilder.
Garnetiferous Mica Schist, Barnet.
Gabbro, East Barnet.
Gneissoid Granite, Newport.
Gneiss, Coventry.
Gabbro Porphyra, Newport.
Granite, Cabot.
Granite, Concretionary, Craftsbury.
Granite, Coventry.
Granite, West Hill, Hardwick.
Granite, Nortons Mills.
Granite, Westmore.
Graptolitic Limestone, Brownington.
Graptolitic Limestone, Coventry.
Gabbro, Lunenburg.
Gabbro Porphyra, Waterford.
Gabbro Diorite, North Troy.
Granite, Pomfret.
Granite, Irasburg.
Granite, Woodbury Mountain.
Granite, North Derby.
Granite, Salem Mountain.
Granite, Waterford Mountain.
Graptolitic Slate, Canada.
Greenish Sandstone, Hartford.
Hornblende, Stannard.
Hornblende Granite, Westmore.
Hornblende Schist, Norwich.
Hornblende Schist, Lebanon.
Hornblende Schist, Poor Farm, Norwich.
Hornblendite, Lebanon.
Hornstone, White River Junction.
Hornblende Schist, Wilder.
Hornblende Schist, Norwich.
Hornblende, Granite, Kirby Line.
Hornblende Schist, White River Junc.
Hornblende Schist, Pomfret.
Hornblende Schist, East Barnet.
Hornblende Schist, Thistle Hill, Norwich.
Hydromica Schist, North Troy.
Hurosian Rock, West Hill, Hardwick.
Indurated Chloritic Schist, Wells River.
Kirbyrite, Kirby Mountain.
Labradorite, Lunenburgh Village.
Limestone, Magoons Point.
Limestone, Barton.
Limestone, East Coventry.
Limestone, Brownington.
Limestone, Wheelock Mountain.

Limestone, White River Junction.
Limestone, Seaver Hill.
Limestone, Hartford-Hartland Line.
Limestone, Georgeville, P. Q.
Limestone, Barton Landing.
Limestone, West Derby.
Limestone, Irasburg.
Limestone, Metamorphic, Bear Mountain, Newport.
Limestone, Newport.
Limestone, Quechee Gulf.
Limestone, Quechee Summit.
Limestone, Cornish.
Newgintus Grit, Hartford.

Magnetite, Troy.
Metadiabase, Newport.
Metamorphic Breccia, Newport.
Metamorphic Schist, Concord.
Mica Schist, altered, Lebanon.
Mica Schist, Granby Mountain.
Mica Schist, Quechee Village.
Mica Schist, Hartford.
Mica Schist, Pomfret.
Mica Schist, Troy.
Micaceous Quartzite, Pomfret.
Micaceous Limestone, St. Johnsbury.
Muscovite Biotite Granite, Groton.
Metadiabase Newport Center.
Metamorphic Schist, Waterford Mt.
Metagabbro, North Troy.
Metamorphic Limestone, Newport.
Mica Schist, Quechee Gulf.
Mica Schist, Farnum Hill, Lebanon.
Mica Schist, Quechee-White River Junc.
Mica Schist, Crafts Hill, Lebanon.
Mica Schist, Black Hills, Newport.
Micaceous Qnartzite, South Newport.
Micaceous Quartzite, Hardwick.
Muscovite, Granite, Cabot.
Ottrelite Schist, Irasburg.
Olivine Diabase, Dike, Quechee Gulf.
Phyllite Schist, St. Johnsbury.
Phyllite Schist, Cabot.
Phyllite Schist, Stannard.
Phyllite Schist, Wheelock Mountain.
Phyllite Schist, Barnet.
Phyllite Schist, Woodbury.
Phyllite Schist, Plainfield.
Phyllite Schist, Salem Mountain.
Phyllite Schist, Kirby Mountain.
Phyllite Schist, Coventry.
Porphyritic Peridotite, South Troy.
Protogene Granite, Lebanon.
Pyritiferous Limestone, Coventry.
Pyritiferous Slate, Coventry.
Phyllite Schist, Barnet.
Phyllite Schist, Bradford.
Phyllite Schist, East Haven.
Phyllite Schist, Burke Mountain.
Phyllite Schist, East Lyndon.
Phyllite Schist, Marshfield.
Phyllite Schist, Concord.
Phyllite Schist, Holland.
Phyllite Schist, Irasburg.
Phyllite Schist, North Troy.
Porphyritic Granite, Northern Newport.
Porphyritic Diorite, Concord.
Protogene, Hartford.
Pyritiferous Mica Schist, Troy.
Quartz, Milky, East Coventry.
Quartz, Pomfret.
Quartzite, Sheared, Waterford.
Quartz, Norwich.
Quartz, Coventry.
Quartzite, Quechee Village.
Quartz Vein, St. Johnsbury.
Sandstone, Norwich.
Serecite Schist, Granby.
Serecite Schist, North Troy.
Serecite Schist, South Troy.
Serecite Schist, Barnet.
Serpentine, Troy.
Sheared Andesite, North Newport.
Slate, White River Junction.
Slate, Hartford.
Slate, Coventry.
Slate, North Troy.
Slate, Kirby
Sodalite, Granite, Newport.
Staurolite Mica Schist, Cabot.
Shale, East Coventry.
Serecite Schist, Woodbury.
Serecite Schist, Coventry.
Serecite Schist, Newport Center.
Shale, East Coventry.
Serpentine, North Troy.
Shale, Coventry.
Slate, Norwich.
Serecite, Schist.
Slate, North Hartford.
Slate, Irasburg.
Slate, Newport.
Slate, West Derby.
Siliceous Magnetite, South Troy.
Steatite, Troy.
Veined Limestone, Barton.
Washington Limestone, Cassville, P. Q.
Washington Limestone, Apple Grove, P. Q.
Washington Limestone, Derby.
Washington Limestone, Plainfield.
Washington Limestone, Peacham.
Washington Limestone, Danville.
Washington Limestone, Walden.
Washington Limestone, Burke Mt.
Washington Limestone, Waits River.
Washington Limestone, Hardwick.
Washington Limestone, Canaan.
Washington Limestone, Derby.
Washington Limestone, West Coventry.
Washington Limestone, Sutton.
Washington Limestone, Lyndonville.
Washington Limestone, Wayville, P. Q.
Washington Limestone, North Barre.
Washington Limestone, West Barnet.
Washington Limestone, South Ryegate.
Washington Limestone, Wheelock Mt.
Washington Limestone, East St. Johnsbury
Washington Limestone, Cabot.
Washington Limestone, Woodbury.
Washington Limestone, Holland.
Washington Limestone, Salem Mt.
Washington Limestone, Craftsbury.
Washington Limestone, East Lyndon.
Washington Limestone, East Calais.

MINERALS.

It may not be out of place in a popular Report, such as this is designed to be, to notice that while all scientific works make a distinction between rocks and minerals, and while this distinction is often very evident, it is also often true that the two are identical. For example, quartz is classed with both, so hornblende and other sorts. These are really minerals, but they are as often treated as rocks. Technically, a rock is any part of the earth's mass. It may be made up of a number of minerals and usually this is the case, but it may be only one mineral, as quartz, feldspar, etc. Granite, for instance, is a rock made up, usually, of quartz, mica and feldspar, each of which is a mineral. A rock therefore is usually a mechanical mixture of minerals, while a mineral is made of less complex substances, chemically mixed. This is the main distinction but, as noticed, the two may be indentical in some cases.

The following list of Vermont Minerals is given not only because the varieties are in the State Collection, but quite as much because the list shows what varieties of minerals are found in the State. Not all the localities in which a given species of mineral has been found are given, but usually only the principal ones.

It may also be well to notice that in a few cases minerals formerly found in a certain town are no longer to be found there, as for instance, the fine specimens of rutilated quartz found many years ago in Waterbury. None, so far as I can learn, have been seen there for a long time. The arrangement of species in the list below is that of Dana's smaller Mineralogy.

Molybdenite.—Cuttingsville, Brighton. Only in small quantity.

Graphite, *Plumbago*.—Found in many parts of the State, but is almost always quite impure. There is a mass weighing in the Collection, labelled "Chelsea, Vt." but I cannot ascertain the exact locality. It is very pure.

Gold.—This occurs in many parts of the State, having been reported from over fifty towns and has been mined in quite a number, especially at Plymouth and Bridgewater. It has never been profitable mining, however.

Silver.—No silver ore has ever been found in Vermont except Galenite. Specimens of this have been found which, besides the lead, has given a very small per cent of silver, but there is so little Galenite in the State that even if burdened with silver it would be of no appreciable value. Silver is also found in the Chalcopyite at South Strafford in small amount.

Platinum.—In the Fourth Report of the State Geologist there is a quotation from W. L. Hinchman of Rutland in which is the statement that analysis showed that in some of the rock bearing Copper sulphide at Plymouth "unmistakable signs of metallic platinum" were noticed. Samples of this rock submitted to others for assay and examination have shown that the rock does contain a very small amount, one-fourth ounce to the ton, of platinum.

COPPER.—Native Copper is reported in the 1861 Report as having been found at Strafford and Vershire, but only in small pieces.

CHALCOPYRITE.—This is the common ore of copper in Vermont and the only ore that has been taken out in quantity. It is mostly a low grade ore and this has greatly interfered with profitable mining at Vershire, Strafford and Corinth. Chalcopyrite has also been found in Waterbury, Brighton and other places, but not in large deposits.

BORNITE.—This ore of copper is not common in this State. So far as I know it has been found only at Enosburg.

MALACHITE.—This occurs in small amount at Vershire.

CHRYSOCOLLA.—This is found sparingly in Ira forming thin layers on the layers of schist.

GALENITE.—*Lead Ore.*—This is found of very good quality but in very small quantity in Brandon, Bridgewater, Thetford and a few other localities. As has been noticed, in some cases it carries a small amount of silver, but not always.

SPHALERITE.—*Blende, Zinc Sulphide.*—This mineral occurs only very sparingly in Vermont. It has been found in Thetford and Bridgewater.

RUTILE.—This is never found in large masses, but small quantities have been obtained in more than a dozen localities. Very fine specimens of rutillated quartz were formerly found in Waterbury, but none for a long time. There are several of these in the state Collection. The needle-like crystals of Rutile are beautifully seen running in every direction thru the clear quartz. Rutile has been found in Corinth, Newfane, Dummerston and elsewhere.

ZARATITE.—*Emerald Nickel.*—This has been found in South Troy.

PIMELITE.—This is a compound of Nickel and Silica. Reported from Newfane.

PYRITE.—This is one of the most widely distributed of our minerals. Its yellow color and bright surface often leads the unwary astray and raises false hopes as to the possibility of a gold mine.

PYRRHOTITE.—This is a less common form of Iron Pyrites. It occurs in connection with Chalcopyrite in the copper mines and in a few other localities.

ARSENOPYRITE.—Arsenical Iron Pyrites. This occurs in a number of places in Vermont. Brookfield, Waterbury, Vershire, etc.

HEMATITE.—*Specular Iron.*—This is not a common form of iron in Vermont, but it occurs in small quantity in Berkshire, Milton, Wardsboro and a few other localities.

Micaceous Iron.—This occurs in Jamaica.

Red Hematite.—This is found in Fairfield and a few localities.

MENACCANITE.—*Titanic Iron.*—This is an ore of iron which never occurs in large masses. It is found in various parts of the State in thin plates. Localities in which it has been found are Troy, Norwich, Bethel, Newfane, etc.

MAGNETITE.—*Black Iron Oxide.*—This is a widely distributed ore of iron in this State, tho it does not occur in large beds nor is it as abundant as Limonite. It is found in Cavendish, South Troy, Wolcott, Norwich and elsewhere.

CHROMITE.—*Chromic Iron.*—This ore is found in a few localities. Most of that in the Cabinet is from Troy. It was formerly also mined in Jay and Westfield. Specimens have also been obtained in Roxbury.

LIMONITE.—*Brown Hematite, Brown Iron Oxide.*—This is the common ore of iron in Vermont and beds, usually not large ones, have been mined from time to time, but none for many years. Our best specimens are from the Brandon beds but there are specimens from Colchester, Wallingford, Tinmouth and elsewhere. Brown Ochre, Bog Ore are varieties of this ore.

MELANTERITE.—*Copperas.*—Many years ago quite extensive works for the manufacture of this substance were carried on at what is now the Elizabeth Copper mine in South Strafford. Altho for the most part manufactured from pyrite, copperas or Green Vitriol is found where it has been produced by the natural decomposition of pyrite at Strafford and elsewhere.

SIDERITE.—*Iron Carbonate.*—The only locality in which this ore of iron exists in any quantity is at Tyson Furnace in Plymouth where it was worked for a time and where most of our specimens came from. Siderite is also found in South Troy, Lowell, Chittenden, Highgate, Swanton and several other places.

PYROLUSITE.—*Black Oxide of Manganese.*—This ore occurs in quite a number of localities as Brandon, Chittenden, Bennington, Monkton, South Wallingford, etc. It is more widely distributed in the State than the other ores of Manganese.

PSILOMELANE.—*Manganese Dioxide.*——This less common manganese ore is often found with the preceding at Brandon, Bennington, Bristol, Wallington, Chittenden, etc., but may occur by itself.

BRAUNITE.—*Manganese Oxide.*—This is still less abundant and occurs in but few localities. Most of these are those in which the other manganese ores are found, as Brandon, Bennington, etc. but also Plymouth and some few other places where it is the only manganese ore. It is only found in small quantities.

WAD.—*Bog Manganese.*—This useless ore is widely distributed in small quantities, often in nodules in the soil not far below the surface. Our specimens are from Highgate, Warren, St. Albans and Woodbury.

SPINEL.—*Automolite.*—The only variety of Spinel found in Vermont appears to be the blue, or Automolite. This has been found in Bridgewater, whence our specimens came.

ALUNITE.—*Native Alum.*—This occurs only as a coating on rocks. As such it has been found at Bethel, Colchester, Halifax and Newfane.

WAVELLITE.—This is a rare mineral here and the only locality reported is Bellows Falls.

FLUORITE.—*Fluor Spar.*—This is also found only in one locality, Putney.

GYPSUM.—This mineral, common elsewhere, is very rare in Vermont. It has been found in the soil in Orwell and in the form of Alabaste at Middlebury.

CALCITE.—*Calc Spar.*—In one form or another this mineral is found all over the State, usually in seams and veins in other rock. In some localities very good crystals have been found. Elsewhere it is more massive or rather less evidently crystalline, but in all the crystalline structure is more or less seen when the rock is broken. Finely colored crystals have been found in Townshend, and on Grand Isle there are several localities, especially near Ladd Point, where opaque white or black and white crystals of good form and size are abundant. A few good localities are Essex, Roxbury, Bennington, Cavendish, Bridgewater, etc.

DOLOMITE.—*Magnesian Limestone.*—Pure Dolomite is not common, but there are large deposits of more or less magnesian limestone in different parts of the State. In crystals, as Rhomo Spar, Bitter Spar, Dolomite occurs in Roxbury, Middlebury, Athens, Newfane, Bethel, etc.

BARITE.—*Heavy Spar.*—This is found in small quantity in Richford.

QUARTZ.—Calcite and Quartz are our commonest minerals as they are in many other regions. Both appear in many forms and varieties. Probably there is not a town in the State in which Quartz in some form does not occur.

ROCK CRYSTAL.—*Quartz Crystal.*—In this form it is often found and in a few localities very large and fine specimens have been found. Usually our crystals are small, but one found in Waterbury is twenty four inches long, eighteen inches in diameter and weighs 175 pounds, another in the Middlebury College Collection found in Roxbury is 20 inches long and 11 inches in diameter. In the State collection is a crystal found in the soil in Moretown which is 8 inches long and 8 inches in diameter. Besides the above mentioned localities good specimens have been found in Corinth, Alburg, Grafton, Chester, Hartford, etc.

Smoky Quartz.—Some very pretty specimens of this variety have been found in Waterbury, Plymouth, Windham, Strafford and Shrewsbury.

Milky Quartz.—This is the most abundant variety. It occurs in large veins in some places especially in the mountains.

PRASE.—*Green Quartz.*—Small specimens of this have been found in Newfane.

DRUSY QUARTZ.—This is found in many parts of the State at Newfane, Halifax, etc.

CHALCEDONY.—This occurs not commonly, but in several places, especially at Newfane.

CHRYSOPRASE.—This is reported from Newfane and the only specimens in the cabinet are so labelled.

JASPER.—This in both the red and yellow varieties is found in different localities. The yellow is rare, but the red is sometimes found in veins and quite large boulders.

PYROXENE.—This mineral is found in greater or less quantity in many places in the State. Good specimens have come from Newfane, Chester, Norwich, Corinth, Strafford, etc.

Coccolite.—This variety of Pyroxene occurs in Charlotte, but in boulders.

Malacolite.—*White Augite.*—This form of Pyroxene is found in Whitingham.

Diallage.—Found only in Newport.

Picrosmene.—This mineral, altered Pyroxene, is found in Jay, Lowell, Troy, etc., but is not common.

RHODONITE.—*Manganese Spar.*—This is not a common mineral, but it is found in Coventry, Irasburg, Topsham.

SPODUMENE.—So far as I know, this has only been found in Brattleboro.

AMPHIBOLE HORNBLENDE.—This occurs in several varieties and in many localities. It is very often found in place and also in boulders. It also occurs as an ingredient of Syenite and other massive rocks.

Tremolite.—This variety often of very pure white is found in Cavendish, Strafford, Rochester and other localities. A very fibrous form is often called Asbestos and may be used as such.

Actinolite.—Some very good specimens of this mineral have been obtained in several localities, as Bethel, Cavendish, Moretown, Waterville, Windham, Roxbury, Poultney, etc.

Asbestos.—Some of the fibrous varieties of Amphibole are found in the State and is of excellent quality for commercial uses, but most of the Asbestos mined in this State is fibrous Serpentine and will be noticed in its proper place.

Mountain Cork.—This is a curious Hornblendic mineral tho with little appearance of rock. It has been found in Swanton.

Hornblende.—That form of Pyroxene commonly called Hornblende is found in many of the rock masses and boulders and often occurs in large masses and as clear black crystals in quartz. It is, or has been, found in good specimens in Ludlow, Walden, Windham, Townshend, Holland and Chester, etc.

ANTHOPHYLLITE.—This variety is not common in Vermont. It has been found in Grafton and Plymouth.

CHRYSOLITE.—This is not a common mineral here and is found only in Cavendish and Thetford.

GARNET.—In small crystals this is not very uncommon. It is found in Cabot, Cavendish, Chester, Grafton, Peacham, Royalton, Windham, Bethel, etc., etc.

PYROPE.—This variety is found in granite in Rockingham.

ZIRCON.—This mineral has only been found in Middlebury.

EPIDOTE.—There are several localities in which this mineral has been found, as Chester, Berkshire, Wardsboro, Woodstock, etc.

ZOISITE.—This has been found in quite a number of localities, Newfane, Woodstock, Dummerston, Roxbury, etc.

IOLITE, *Pinite.*—This mineral has been sparingly found in some of the Gneisses at Chittenden and Rockingham.

MUSCOVITE.—*White Mica.*—This variety of Mica is found in small scales in a number of localities. The largest pieces that I have seen were in Sherburne. It also occurs in Cabot, Bellows Falls and other places. At Grafton the plumose variety has been found.

BIOTITE.—*Black Mica.*—This is more common than the preceding, tho in small flakes. It is found in most of our granites. Good specimens have been obtained in Ryegate, Craftsbury, Bethel, Middlebury, Townshend, etc., usually in Granite.

SCAPOLITE.—This is not a common mineral in Vermont. It has been found in Marlboro, Guilford, Brattleboro.

LABRADORITE.—This variety of Feldspar is much less common than others, but it has been found in Weybridge and it is common at Port Henry and along the New York shore of the lake.

ALBITE.—This Feldspar occurs in Castleton, Cabot and in some other localities.

ORTHOCLASE.—This is in most regions the common Feldspar. In this State good specimens are obtained in Corinth, Strafford, Chester, Jay, etc.

ADULARIA.—This variety of Orthoclase occurs in Bellows Falls.

TOURMALINE.—The black variety of Tourmaline is fairly common in Vermont, but others occur here. The jet black polished crystals are often seen in white quartz making very attractive specimens. These are found in Bellows Falls, Brattleboro, Cavendish, Grafton, Hartford, Lowell, Newfane, etc. At South Strafford some of the wall rock in the copper mine is thickly covered with very pretty, tho small, crystals of brown Tourmaline.

Rubellite.—Red Tourmaline.—This variety of Tourmaline has been found at Bellows Falls.

Indicolite.—Blue Tourmaline.—This has also been found at Bellows Falls.

ANDALUSITE.—This curious mineral has been found in Vernon, Saxtons River, Bloomfield and elsewhere, but is not common.

CHIASTOLITE.—This variety occurs in Bellows Falls.

FIBROLITE.—This has been found only in Saxtons River.

KYANITE.—This handsome stone is found sometimes in very good specimens, in Hartford, Thetford, Bellows Falls, Chester, Grafton, Norwich.

STAUROLITE.—*Staurotide.*—This mineral is widely distributed over the State. Often the crossing of the crystals is imperfect, but sometimes very excellent specimens are found. It occurs in Cabot, Chester, Saxtons River, Bellows Falls, Victory and many other places.

TITANITE.—*Sphene.*—This is rarely found in Vermont, but specimens have been found in Hornblende Schist in Marlboro.

PREHNITE.—This has, so far as I know, been found only in Bellows Falls and Vernon.

SCOLECITE.—This has been found in Gneiss in Westminster.

STILBITE.—This has been found only in Rockingham.

TALC.—Talc is common in larger or smaller masses in many parts of the State. It has been mined in a number of places and at present a good many tons are annually sold. Specimens have been collected in over thirty towns. It is mined at present in Granville, Rochester, Windham, Johnson, Moretown and perhaps elsewhere. Very handsome foliated Talc is found in Rochester, Stockbridge and elsewhere.

Steatite or Soapstone.—Quarries of Soapstone have been worked to some extent ever since the first settlement of the State. This variety of Talc occurs in many places and is worked especially in Chester, Athens, Weathersfield.

SERPENTINE.—This rock is found often in considerable deposits, especially in the mountain region. The only quarry at present worked is in Roxbury where the Barney Marble Company get out large blocks.

ASBESTOS.—There are several varieties of this mineral, or at least that are called Asbestos. That which is best for commercial purposes is a fibrous Serpentine and this, called Chrysotile, is found in large number of small veins on Belvidere Mountain, where it has been mined and separated from the enclosing rock for some time. At present the only openings worked are on the Tucker property and we have a full series of specimens from this locality. Chrysotile Asbestos is also found in Moretown, Stowe, Roxbury, Troy and many other places in the State. The silky variety, Amianthus also occurs in most of these localities.

KAOLINITE.—*Kaolin.*—This clay-like substance is the result of the decomposition of Feldspar, and also to a less extent, of allied minerals. There are several large beds of this in Vermont. Long and widely famous is that at Forestdale, where there is a fine mill for working it and separating the silicious sand and other impurities. At Monkton there is a large and thick deposit, and there are others of less importance in other parts of the State.

PINITE.—*Iolite.*—This is found in Chittenden and Rockingham.

LIGNITE.—*Brown Coal.*—This substance is found at Forestdale and at different times many tons have been taken out. The beds are now wholly covered by surface soil, etc.

BUILDING AND ORNAMENTAL STONE.

It is not the intention of the Curator to give place in the Museum to any specimens that have not value, either because representing and illustrating the natural history of the locality from which they came or because of the instruction to be gained from them or both, but it is probable that no specimens in the cases have as great practical value or are as important as those which show the very unusual resources of Vermont in the deposits of useful stone which exist within its borders.

It is not unlikely that many of those who see what an array of marbles, granites and slates is exhibited are astonished at their number and variety as well as their beauty. And really, it is in these products more than from anything else that the future wealth of this State is to come. And in order that these most valuable assets of our State may be shown to the fullest extent it is the desire of those interested in the Collections that all the active quarries in the State be well represented and specimens from them be as well displayed as the space at command permits. As far as possible, all specimens that have been sent to the Museum have been and will be placed where they can be seen to best advantage. Unfortunately, as things now are, this is not possible in all cases.

There are in the Museum not less than 150 varieties of marble, granite and slate—mostly marble, since here, as everywhere, this stone occurs in very much greater variety than any other. A few of the samples are from old and abandoned quarries and cannot be duplicated, or at least not without much trouble and consequent expense, but by far the larger part of these on exhibition are kept in stock by one or another of the companies operating in the State, and such stone can be ordered at any time. Hence an excellent general idea of what Vermont produces in varieties of stone can be gained from an examination of the series in the State Collection. Vermonters may well take pride in the showing which these blocks and slabs make for it is quite safe to say that no other state in the Union, nor any other country anywhere can make so varied and attractive an exhibition. If the very small area of the portions of the State from which all these kinds of stone come be taken into account, the display seems the more remarkable.

Marble.

In the previous Report a full list of all the marbles now quarried and sold in the State was given and a brief description of each followed its name. To this those interested are referred. In all there are about 150 samples of marble on exhibition. Nearly all of them show at least one polished surface and one unpolished. All of the building marbles are shown in cubes (eight inch) and these allow several different faces, rough, coarse hammered, fine hammered, and polished, in this way showing the stone as it appears when differently treated. The finer grades, such as are mostly used for interior finish or for monuments, are shown in slabs a foot square or one foot wide and two feet long. Attention may properly be called to the floor of this room, for it shows the use of some of the marble in both the reds and whites. The following varieties are now in the cases, the names, of course, are simply those given by the selling firms for trade purposes and have no other significance. They are arranged alphabetically. The name of the company selling the variety is also given.

Light Marbles.

Best Light Cloud Rutland, Vermont Marble Company, Proctor.
Blue Building, Rutland Florence Company, Fowler.
Brandon Italian, Brandon-Italian Marble Company, Middlebury.
Brandon Italian, High Street Variety Company, Middlebury.
Broccadillo, Vermont Marble Company.
Dorset Dark Green Vein, Norcross-West Marble Company, Dorset.
Dorset White, Norcross-West Marble Company.
Dove Blue Rutland, Vermont Marble Company.
Florence, Rutland-Florence Marble Company.
Gray Building, Vermont Marble Company.
Italio, Vermont Marble Company.
Light Cloud Rutland, Vermont Marble Company.
Light Columbian Building, Vermont Marble Company.
Light Florence, Rutland-Florence Marble Company.
Light Green Cloud, Norcross-West Marble Company.
Light Sutherland Falls, Vermont Marble Company.
Listavena, Sutherland Falls, Vermont Marble Company.
Mountain White, Sutherland Falls, Vermont Marble Company.
Pittsford Italian, Rutland-Florence Marble Company.
Pittsford Valley First Quality, Vermont Marble Company.
Pittsford Valley Second Quality, Vermont Marble Company.
Plateau White, Norcross-West Marble Company.
Riverside, Vermont Marble Company.
Rutland Building, Vermont Marble Company.
Rutland Statuary, Vermont Marble Company.
Second Statuary, Vermont Marble Company.
White Rutland Building, Vermont Marble Company.
Dark Marbles.
Black, Barney Marble Company, Swanton.
Dark Florence, Rutland-Florence Marble Company.
Dark Vein Esperanza, Vermont Marble Company.
Dark Vein True Blue, Rutland-Florence Marble Company.
Extra Dark Mottled True Blue, Rutland-Florence Marble Company.
Extra Dark Royal Blue, Vermont Marble Company.
Extra Dark Vein True Blue, Rutland-Florence Marble Company.
Florentine Blue, Rutland-Florence Marble Company.
Highland Blue, Brandon-Italian Company.
Livido, Vermont Marble Company.

Fancy Marbles.

Aeolian, Norcross-West Marble Company.
American Pavonazzo, Vermont Marble Company.
American Yellow Pavonazzo, Vermont Marble Company.
Columbian Listavena, Vermont Marble Company.
Dark Pink Shell, Rutland-Florence Marble Company.

Gray Shell, Rutland-Florence Marble Company.
Light Pink Shell, Rutland-Florence Marble Company.
Moss Vein, Rutland-Florence Marble Company.
Olivo, Rutland-Florence Marble Company.
Pink Listavena, Rutland-Florence Marble Company.
Rosaro, Rutland-Florence Marble Company.
Rubio, Rutland-Florence Marble Company.
Verdosa, Rutland-Florence Marble Company.
Verdura, Rutland-Florence Marble Company.
Verde Antique, Barney Marble Company.

Red Marbles.

Jasper, Barney Marble Company, Swanton.
Lyonnaise, Barney Marble Company.
Olive, Barney Marble Company.
Oriental, Barney Marble Company.
Royal Red, Barney Marble Company.
Ruvaro, Vermont Marble Company.

Granite.

Necessarily, the exhibition of specimens of this stone is much less attractive to the usual visitor than that of marble, because there is so little variety in the general appearance of granites, little of the lightness and delicacy in shading and variety in marking so abundantly seen in our marbles. Nevertheless, to anyone interested in building materials, our collection of granites will be found very suggestive.

Inasmuch as granite is commonly used in blocks, either for building or monuments, our specimens are mostly eight inch cubes, the different faces differently treated—that is, one face is polished, one rock faced and the rest hammered in various degrees of fineness. The granite quarries are far more numerous than those of marble, but the products of different quarries may often closely resemble each other and only an expert can tell the differences between them. On this account the number of specimens of granite shown is comparatively small, only about 40 in all. In addition to the cubes mentioned, a few firms wished to show larger surfaces and have sent slabs two feet by one foot by three inches.

The following varieties of granite are shown:

Extra Dark Barre, Jones Brothers Granite Company, Barre.
Dark Barre, Boutwell-Mine-Varnum Granite Company, Barre.
Dark Barre, Moore Brothers, Barre.
Dark Barre, E. L. Smith and Company, Barre.
Dark Barre, Consolidated Granite Company, Barre.
Medium Barre, Barclay Brothers Granite Company, Barre.
Medium Barre, Wetmore and Morse Granite Company, Montpelier.
Medium Barre, Granite City Quarry Company, Barre.
Medium Gray Granite, Newport Granite Company, Albany, N. Y. Quarry, Derby.
Medium Gray Granite, G. E. Lyon Company, Dummerston.
Medium Gray, Patch & Company, Montpelier.
Gray Granite, Woodbury Granite Company, Hardwick.
Gray Granite, Arnold Ledge, Hardwick.

Light Gray, Randolph, A. H. Beedle.
Light Medium Barre, Jones Brothers Granite Company, Barre.
White Barre, Jones Brothers Granite Company, Barre.
White Barre.
White Bethel, Woodbury Granite Company, Hardwick.
Windsor Green Granite, Enright Granite Company, Windsor.
Green Granite, Norcross Green Granite Company, Windsor.

In addition to specimens of stone, there are twenty-five large photographs of quarries sent by some of the above named firms.

Slate.

Our Collection contains examples of all the varieties of slate found in Vermont and also of the red slate which occurs in several places just across the state line in Washington County, N. Y. As some of these deposits of red slate are only a few feet beyond the Vermont border and as not a single bed of the sort has been found on our side of the line, it seems proper to include it among the varieties from this State. And these varieties are only a very few at most. There are blocks and slabs and roofing plates of green, purple and variegated slate from the main slate belt of Rutland County, black from Northfield and Benson and red from Granville, N. Y. There is also a dark gray from Poultney. These colors may differ more or less in different quarries, but in general the above are all the main varieties we have.

There are at present in the Museum the following specimens of slate.

Black Slate, Vermont Black Slate Company, Northfield.
Black Slate, Benson.
Purple Slate, eight-inch cube, Poultney.
Sea Green Slate, Poultney.
Unfading Green Slate, Fair Haven, Vermont Unfading Green Slate Company; assortment of roofing slates and blocks of various sizes.
Marbleized Slate, four small slabs, Vermont Unfading Green Slate Company.
Sea Green Slate, West Pawlet, Rising and Nelson Slate Company.
Green and Roofing Slate, also Purple Roofing Slate, Poultney, Matthews Slate Company.

FOSSILS.

While not larger in actual number of specimens, the collection of fossils is very much greater in number of species than that of rocks and minerals. For this reason it is impracticable to publish a list of different species except to a limited extent.

Geologists will welcome a fairly complete list of the Vermont species in the Museum, such as can be used for comparison with other regions. So far as the different formations recognized in Geölogy are represented in the Vermont rocks, few fossils from outside of the State have been placed in the cases, but, with the exception of the Tertiary of Brandon and the Pleistocene of the glacial clays, we have no rocks later than the Utica Shale at the top of the Ordovician. It is true that there is a little patch of Devonian just on the Vermont and Canada line at Owls Head, and another little bit of Silurian at South Vernon, but these are scarcely enough to make exception to the above statement.

In making the collection of fossils there is no attempt to show a large number of specimens, but rather to show as complete a series as seemed necessary to illustrate the different species, storing duplicates as compactly as possible. Even under this arrangement, it has not been feasible to exhibit our fossils as fully as we hope to do when more space is available.

In addition to the Vermont fossils, there are others from the west which not only represent formations not found in this State, but also groups of animals and plants not existing in the older rocks.

In all, the Collection contains not far from 3000 specimens of fossils, and as exploration of the State is carried on, both fossils and rocks are added to the series already in the Museum.

The different groups of fossils contained in the Museum will be considered with something of detail under the various ages to which they belong and therefore need not be specifically noticed here. Naturally, the first aim has been to show what fossils are to be found in Vermont and our Collection now contains a large proportion of all the species that have been found in the State.

In the northern and western parts of Vermont there are interesting beds of Lower and Middle Cambrian. Some of these are type localities from which several paleontologists, notably Billings, Hall, and especially Walcott, have described important species. The Vermont species are supplemented by some fine specimens of Cambrian trilobites and brachiopods from other localities and these, with the Vermont specimens, give a very excellent series of Cambrian fossils, that is, of the lower beds.

The following list is not designed to show what species are found in Vermont, but those which have been collected and placed in the cases or stored at Montpelier, if there could not be places made for them in the cases. The list does, however, include all that are common in our fossil localities and many that are only seldom met with. The localities in which the specimens were found are given for the guidance of collectors. In many cases, the same species are to be found in other localities in the State, but some have not been found elsewhere than at the place named.

LOWER CAMBRIAN.

Trilobites.

Bathynotus holopyga, Hall. Georgia.
Mesonacis vermontana, Hall, Georgia, Parker Ledge.
Microdiscus parkeri, Georgia, Swanton.
Olenellus thompsoni, Hall, Georgia, Parker Ledge, Swanton, Colchester.
Olenoides marcoui, Whitf. Swanton.
Protypus desideratus, Wall, Georgia.
Protypus hitchcocki, Whitf. Georgia.
Protypus senectus, Bill. Georgia.
Protypus senectus, var. parvulus, Bill. Georgia.

Ptychoparia adamsi, Bill. Georgia, Highgate, Swanton, Colchester.
Ptychoparia miser, Bill. Georgia.
Ptychoparia miser, var. A. Walc. Georgia.
Ptychoparia arenaria, Bill. Georgia.
Ptychoparia teucer, Bill. Georgia.
Ptychoparia vulcanus, Bill. Georgia.

Brachiopoda.

Iphidea labradorica, swantonensis, Walc. Swanton, Georgia.
Kutorgina, cingulata, Bill. Georgia, Swanton.
Lingulepis acuminata, Conr. Swanton.
Nisusia festinata, Bill. Swanton, Georgia, Colchester.
Proterthis wingi, Walc. Highgate, Swanton.
Scenella varians, Walc. Georgia.
Rustella edsoni, Walc. Swanton, Georgia.

Miscellaneous.

Hyolithes communis, Bill. Colchester.
Hyolithes sp? Colchester.
Saterella pulchella, Bill. Swanton, Colchester.
Stenotheca rugosa, Hall, Georgia.
Dactyloides asteroides, Walc. Swanton, Georgia.
Planolites congregatus, Hall, Swanton, Georgia.
Planolites virgatus, Hall, Swanton, Georgia.
Cruziana sp? Colchester.
Slabs with worm tracks, etc., etc. Colchester.

The middle Cambrian is not extensively exposed in Vermont and such specimens as have been found have not been fully determined. In the Intraformational Conglomerate of St. Albans and Swanton the following genera have been determined by Dr. Walcott, viz: Paradoxides, Agnostus, Agraulos, Menocephals, Ptychoparia, Anomocare, Hyolithes, Obolus, Lingulella, Leperditia and perhaps some others. Most of these will be represented in the State Collection as soon as they can be fully located.

BEEKMANTOWN.

The rocks of this period are not very extensively displayed in Vermont, but there are a few localities, notably that at Fort Cassin, which have yielded a considerable number and variety of exceedingly interesting fossils. The Fort Cassin beds have afforded a remarkable series of cephalopods as well as other species. Most of these are finely figured and described by Dr. Whitfield in Bulletin, Am. Museum Natural History, N. Y., Vols. I, II, III and IX. And most of the typical forms are figured on Plates LIII to LXII of this Report.

Fortunately, there is a very good set of the fossils of the Beekmantown in the Museum. Dr. Rudemann of the New York Geological Survey has revised the cephalopods of the Champlain Valley in Bulletin 90 of that Survey, and as most of the names have been changed, I have given in the following list the later name first and that by which the species was first known below it in those cases in which there has been change.

While by far the most interesting and numerous fossils in our collection were obtained at Fort Cassin, there are some from Providence Island and a few from other localities.

Trilobites.

Asaphus canalis, Conrad, Fort Cassin, Providence Island.
Bathyurus conicus, Fort Cassin.
Bathyurus perkinsi, Whitf. Fort Cassin.
Bathyurus seelyi, Whitf. Fort Cassin.
Bolbocephalus, seelyi, Whitf. Fort Cassin.
Bolbocephalus truncatus, Whitf. Fort Cassin.
Harpes cassinensis, Whitf. Fort Cassin.
Nileus striatus, Whitf. Fort Cassin.

Cephalopoda.

Apetoceras farnsworthi, Bill. Phillipsburg, P. Q.
Lituites farnsworthi.
Cameroceras brainerdi, Whitf. Fort Cassin.
Orthoceras brainerdi, Whitf.
Cyclostomiceras cassinense, Whitf. Fort Cassin.
Cyclostomiceras minimum, Whitf. Fort Cassin.
Gomphoceras cassinense, Whitf.
Gomphoceras minimum, Whitf.
Cyrtoceras acinacellum, Whitf. Fort Cassin.
Cyrtoceras confertissimum, Whitf. Fort Cassin.
Endoceras montrealense, Bill. Fort Cassin.
Orthoceras sordidum, Bill.
Eurystomites kelloggi, Whitf. Fort Cassin.
Nautilus kelloggi, Whitf.
Orygoceras cornu-oryx, Whitf. Fort Cassin.
Orthoceras cornu-oryx, Whitf.
Piloceras explanator, Whitf. Fort Cassin.
Protocycloceras whitfieldi, Rued. Fort Cassin.
Orthoceras bilineatum, Whitf.
Schroederoceras cassinense, Whitf. Fort Cassin.
Lituites cassinense, Whitf.
Schroederoceras eatoni, Whitf. Fort Cassin.
Lituites eatoni, Whitf.
Tarphyceras champlainense, Whitf. Fort Cassin.
Nautilus, champlainensey, Whitf.
Tarphyceras perkinsi, Whitf. Fort Cassin.
Nautilus perkinsi, Whitf.
Tarphyceras seelyi, Whitf, Fort Cassin, Providence Island.
Lituites seelyi, Whitf.
Trocholites internastriatus, Whitf. Fort Cassin.
Lituites internastriatus, Whitf.

Gasteropoda.

All these are from Fort Cassin.
Bellerophon cassinensis, Whitf.
Calaurops lituiformis, Whitf. F.C.P.I.
Clisospira lirata, Whitf.
Ecculiomphalus compressus, Whitf.
Ecculiomphalus triangulus, Whitf.
Ecculiompalus volutatus, Whitf.
Euomphalus circumliratus, Whitf.
Euomphalus perkinsi, Whitf.
Helicotoma similis, Whitf.
Holopea arenaria, Billings.
Holopea cassina, Whitf.
Lophospira cassina, Whitf.
Maclurea acuminata, Whitf.
Murchisonia cassina, Whitf.
Murchisonia obeliscus, Whitf.
Murshisonia prava, Whitf.
Maclurea Affinis, Whitf.
Pleurotomaria difficilis, Whitf.
Pleurotomaria etna, Billings.
Rhaphistoma compressum, Whitf.
Straparollina minima, Whitf.
Subulites obesus, Whitf.
Tryblidium conicum, Whitf.
Tryblidium ovale, Whitf.
Tryblidium ovatum, Whitf.
Tryblidium simplex, Billings.

Brachiopoda.

Hemipronites apicalis, Billings, Fort Cassin.
Orthis evadne, Bill. Fort Cassin.
Protorthis cassinensis, Whitf. Fort Cassin.
Protorthis minimum, Whitf. Fort Cassin.
Streptorhynchus primordalis, Whitf. Fort Cassin.
Triplesia lateralis, Whitf. Fort Cassin.

Miscellaneous.

Cryptozoon perkinsi, Seely, Isle La Motte.
Cryptozoon proliferum, Seely, Little Falls, N. Y.
Cryptozoon saxiroseum, Seely, East Beekmantown, N. Y.
Crptozoon steeli, Seely, Shoreham.
Cryptozoon wingi, Seely, Mt. Independence.
Isochilina gregaria, South Hero, Phelps Point.
Isochilina cristata, Whitf. Fort Cassin.
Isochilina seelyi. Whitf. Fort Cassin.
Rhinopora prima, Whitf. Fort Cassin.
Ribieria compressa, Whitf. Fort Cassin.
Ribieria ventricosa, Whitf. Fort Cassin.
Wingia congregata, Seely, Balls Bay, Ferrisburg.
Wingia discoidea, Seely, Balls Bay.
Wingia lapilla, Seely, Balls Bay.

CHAZY.

There is considerable Chazy material in the Museum which has not been as yet studied and undoubtedly when this has been gone over the list of species will be materially increased.

Trilobites.

Amphion canadensis, Billings, Isle La Motte.
Ceraurus pleurexanthemus, Green, Isle La Motte.
Cheirurus prolificum
Glaphurus pustulatus, Walc. Isle La Motte.
Arionellus pustulatus Walc.
Harpes ottawaensis, Bill.
Illaenus crassicauda, Hall, Isle La Motte.
Illaenus erastusi, Raymond.
Illaenus ovata, Conrad. Isle La Motte.
Illaenus incerta.
Isotelus angusticaudum, Raymond, Isle La Motte.
Isotelus harrisi, Raymond, Isle La Motte.
Lonchodoma halli, Bill. Isle La Motte.
Ampyx halli, Bill.
Platymetopus minganensis, Bill. Isle La Motte.
Lichas champlainensis, Whitf.
Placoparia multicostata, Isle La Motte.
Pseudosphaerexochus vulcanus, Bill. Isle La Motte.
Cheirurus vulcanus, Bill.
Remipleurides schlotheimi, Bill. Isle La Motte.
Sphaerexochus parvus, Bill. Isle La Motte.
Thaleops ovata, Conrad.

Cephalopoda.

Cameroceras curvatum, Rued. Isle La Motte.
Cameroceras tenuiseptum, Hall, Isle La Motte.

Orthoceras tenuiseptum, Hall.
Cyrtinactinoceras boyci, Whitf, Isle La Motte.
Cyrtoceras boyci, Whitf.
Ooceras perkinsi, Rued., Isle La Motte.
Ooceras seelyi, Rued,, Isle La Motte.
Ooceras lativentrum, Rued., Isle La Motte.
Orthoceras modestum, Rued., Isle La Motte.
Orthoceras vagum, Rued., Isle La Motte.
Spyroceras clintoni, Miller, Isle La Motte.
Tarphyceras multicameratum, Rued., Isle La Motte.
Vaginoceras oppletum, Rued., Isle La Motte.

Gasteropopoda.

Maclurea magna, LeSeur., Isle La Motte.
Bucania sulcatum, Isle La Motte.
Metopoma simplex, Isle La Motte.
Rhaphistoma stamineum, Isle La Motte.
Raphistoma planistriae, Isle La Motte.
Raphistoma lamottense, Isle La Motte.

Brachiopoda.

Camerella breviplicata, Bill. South Hero.
Orthis costalis, Hall, South Hero.
Orthis platys
Orthis porcia, Bill. Isle La Motte.
Orthis pervacta O. dorsalis.
Orthis gibbata.
Lingula limitaris, Seely, South Hero.
Lingula huronensis.
Lingula perryi, Bill, South Hero.
Leptaena fasciata.
Rhynchonella plena, Hall, South Hero.
Strophomena aurora, Bill., South Hero.
Strophomena camerata, Bill., South Hero.
Zygospira acutirostrata, Hall, South Hero.

Corals, Sponges and Bryozoa.

Columnaria parva, Bill., Isle La Motte.
Eospongia varians, Bill., South Hero.
Monticulapora insularis, Seely, South Hero.
Prasopora hero, Seely, South Hero.
Protarea patella, Seely, South Hero.
Solenopora compacta, Seely, South Hero.
Strephochetus brainerdi, Seely, South Hero.
Strephochetus occellatus, Seely, South Hero.
Strephochetus eccles.
Strephochetus prunus, Seely, Isle La Motte.
Stromatocerium eatoni, Seely, Isle La Motte.
Stromatocerium var cinetosum and var oceulinus.
Stromatocerium lamottense, Seely, Isle La Motte.
Stromatocerium lamottense var. chazianum, Seely, Chazy, N. Y.
Stromatocerium var. sullcatum.

Besides smaller specimens there are larger pieces of rock in which fossils are preserved in unusual abundance, as the dove limestone of Isle La Motte filled with cephalopods and pieces of the Rhynchonella limestone of South Hero.

BLACK RIVER.

Only a small number of species are found in the Black River limestone in this State. As a rule, the fossils are large and very sparsely distributed thru the strata.

Corals and Sponges.

Columnaria alveolata, Goldf. South Hero, Button Bay Island.
Strephochetus atrata, Seely, South Hero.
Stromatocerium rugosum, Hall, South Hero, Button Bay Island.
Tetradium fibratum, Saff., South Hero.

Trilobites.

Calymene senaria, Conr., South Hero.
Ceraurus pleurexanthemus, Green, South Hero.
Leperditia fabulites, Button Bay Island.

Molluscs.

Lituites undatus, Emm.
Maclurea logani, Salter, South Hero.
Dalmanella testudinaria, South Hero, Isle La Motte.
Hormatoma gracilis, Hall, South Hero.
Platystrophia biforata, Schl., South Hero, Isle La Motte.
Plectambonites sericea, Sowb., South Hero.
Rafinesquina alternata, Conr., South Hero.
Rhynchotrema inequivalve, Castl., South Hero, Isle La Motte.
Streptorhynchus filitextum, Hall, Button Bay Island.
Zygospira recurvirostra, Hall., South Hero.

TRENTON LIMESTONE.

The rocks of this age are more widely distributed over western Vermont than the Black River and in many places are much more fossiliferous and the number of species is much larger. This formation is therefore much more extensively represented in the Collection than others.

Trilobites.

Isotelus gigas, DeKay, South Hero.
Calymene senaria, Conrad, South Hero.
Trinucleus concentricus, Eaton, South Hero, Chimney Point.

Cephalopoda.

Endoceras proteiforme, Hall, South Hero, Larabees, Chimney Point.
Orthoceras amplicameratum, Hall, South Hero.
Orthoceras junceum, Hall, South Hero, Chimney Point.
Orthoceras olorus, Hall, South Hero.
Orthoceras strigatum, Hall, South Hero.
Trocholites ammonius, Conrad, South Hero.

There are several fine specimens of Endoceras proteiforme, one from South Hero is nearly perfect and is 44 inches long and 6 inches diameter at the base, or outer end.

Gasteropoda.

Bucania punctifrons, Emm., South Hero.
Bucania expansa, Hall, South Hero.
Bellerophon bilobatus, Sow., South Hero, Liospira americana, South Hero.
Liospira americana, South Hero,
Murchisonia bellicincta, Hall, South Hero, Chimney Point.
Murchisonia gracilis, Hall, South Hero.
Murchisonia milleri, Hall, South Hero.
Subulites elongatus, Emmons, South Hero.

Lamellibrachs.

Ambonychia undata, Emmons, Chimney Point, South Hero.
Ambonychia orbicularis, Emmons, South Hero.
Cuneamya truncata, South Hero.
Modiolopsis mytilloides, Hall, South Hero, Chimney Point.
Pterinea demissa, Con., South Hero.
Tellinomya nasuta, Hall, South Hero.
Conularia trentonensis, Hall, South Hero.

Brachiopods.

Dalmanella testudinaria, Dalman, South Hero, Chimney Point.
Dinorthis pectinella, Emmons, Chimney Point, South Hero.
Delthyris lynx., Eich., Chimney Point, Larabees, South Hero.
Hormotoma gracilis, H., South Hero.
Lingula curta, Conr., South Hero, Chimney Point.
Lingula quadrata, Eichw., Chimney Point, South Hero.
Orthis macrata, South Hero.
Hebertella occidentalis, Hall, South Hero, Chimney Point.
Orthis subquadrata, Hall, South Hero, Chimney Point.
Parastrophia hemiplicata, South Hero.
Plectambonites sericeus, Sow., South Hero, Chimney Point, Larabees.
Platystrophia biforata, Schl., South Hero, Chimney Point.
Protowarthia cancellata, Hall, South Hero, Chimney Point.
Rafinesquina alternata, Emmons, South Hero, Chimney Point.
Rhynchonella plena, Hall, South Hero, Chimney Point.
Schizocrania filosa, Sow., Chimney Point, South Hero.
Strophomena rugosa, Bl., South Hero, Chimney Point.
Zygospira exigua, South Hero.
Zygospira recusvirastra, South Hero.

Corals.

Prasopora lycoperdon, Say., Chimney Point, South Hero, etc.
Protarea vetusta, Hall, South Hero.
Streptelasma corniculum, Hall, South Hero.

UTICA.

The Utica rocks, which are mostly shale, are abundantly exposed in the western border of Vermont along Lake Champlain. They are not usually fossiliferous and in all contain only a small number of species.

The following are in the Collection.

Climacograptus bicornis, H. South Hero, Alburg.
Diplograptus pristis, H. South Hero.
Isotelus gigas, DeKay, South Hero.

Schizocrania filos, H. South Hero, Alburg, North Hero.
Orthoceras coralliferum, Hall, South Hero.
Triarthrus beckii, C. South Hero, North Hero, Alburg.
Trinucleus concentricus, E. South Hero.

With the Utica the Vermont formations stop for a long period. In other parts of the country, even those as near as New York, there are beds of Silurian, Devonian, Carboniferous, and elsewhere numerous later formations, none of which are represented in Vermont. There is a specimen of Devonia limestone in the Collection from Owls Head, but it probably came from just over the line in Canada. In South Vernon there is also a very small patch of Silurian rock, but these are scarcely enough to form an exception to the rule. For the sake of completeness, small series of fossils of those formations not found in Vermont are placed in the cases.

Were there room for them, it would be very much more satisfactory to any student of Geology if these series were much more extensive.

In a few characteristic specimens the life of each age is in some measure represented so that, altho meagerly in some cases, all the great subdivisions of geological time may be studied.

Obviously an enumeration of these specimens from without the State would be misplaced here and the simple mention of their presence in the Museum must be sufficient. An additional word as to some of the fossils will be helpful to anyone who may wish to examine the specimens with care. Passing the earlier groups, there will be found among the Cretaceous fossils some very interesting skulls, bones and teeth of fish and reptiles, some of them very perfect. Most of these are from the Chalk of western Kansas. There is also a very excellent set of over a hundred specimens of leaves of plants from the same formation.

These Kansas specimens were obtained from Mr. C. H. Sternberg, who for many years has collected fossils in the west. For the present, much of this collection must be placed in drawers, but they can all be examined and make a very interesting exhibition of both the plant and animal life of the chalk age.

Following the Cretaceous age is the Triassic and this is found over a very limited area in Forestdale, two and a half miles east of Brandon Station.

The area of undoubtedly Tertiary in Forestdale is very small, but it has afforded a most interesting group of fossils.

As the following list shows, many species occur and most are very well preserved so that their characters are clearly shown.

A full account of these is given in the last two Reports, fifth and sixth of this series, and nearly all the different forms are figured on the plates. There is little doubt that the Tertiary rocks are more widely distributed in Vermont than the above statement indicates, but they have been deeply covered everywhere by the gravels, sands, etc., of the Pleistocene and because of this it is quite impossible to know how extensively the Tertiary was originally distributed over the surface of the State. In the Geology of Vermont, published in 1861, both in the text and on the geological map of the State, the Tertiary is given a much greater area than seems to be warranted by such evidence as can be obtained. Well borings and any other operations by which the beds underlying the surface are reached may, and probably will, add to our knowledge of this matter. Indeed, this has already come to pass, for lignite indentical with that found in Forestdale was brought up in boring a well in Waltham, some twenty-five miles north, showing the existence there of a bed of this material.

It is remarkable that no fossils have been found in the lignite except nuts, fruits, etc., and the more or less altered wood and that all of these are peculiar to this one locality. Heer has described from Tertiary beds at Œningen in Switzerland, fossil fruits, some of which are similar to our Vermont specimens. Bowerbank also has figured some specimens from the London Clays of the Isle of Sheppy, which are not unlike some of the Forestdale farms, and especially like our species are some of those described by Von Muller from New South Wales.

Plates I and II are reproduced from the fourth Report in order that a better idea of these singular fossils may be gained. As is fitting, by far the most complete collection of the Brandon (Forestdale) fossils is in the State Cabinet. A few fragmentary specimens of leaves have been found and there are over a hundred microscopic sections of the lignite, prepared with great skill by Dr. E. C. Jeffrey of Harvard. The types of all the species described in Reports four and five are in the State Collection.

LIST OF SPECIES DESCRIBED FROM THE BRANDON LIGNITE AND IN THE STATE COLLECTION.

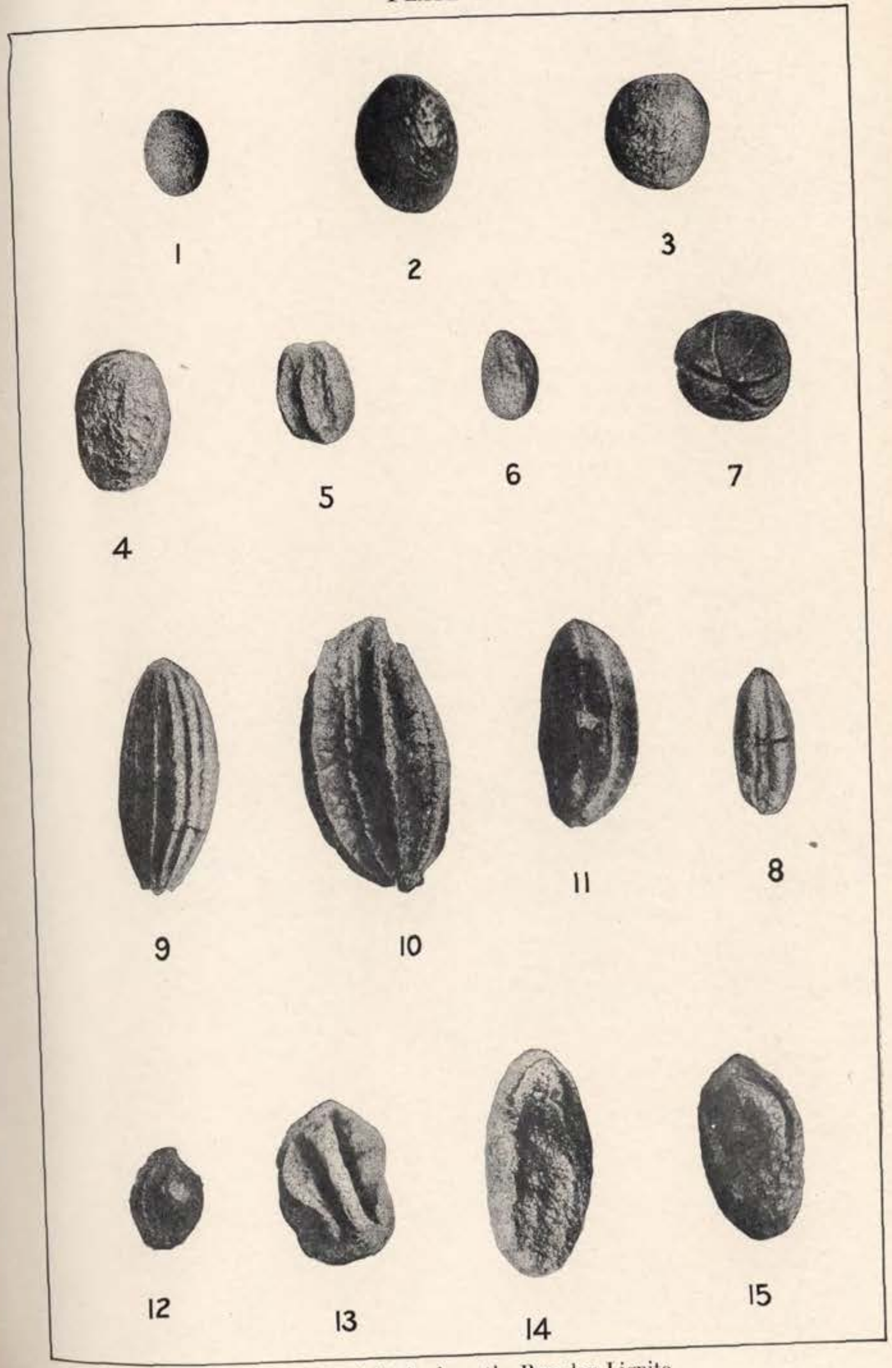
Apeibopsis gaudinii, Lesq. Am. Jour. Science, XXXII, page 358, Geol. Vt. 1861, p. 715.
Apeibopsis heeri, Lesq. Am. Jour. Science, XXXXII, p. 358, Geol. Vt. 1861, p. 716.
Apeibopsis parva, Perkins, Fourth Rep. Geol. Vt. 1904, p. 202, Pl. LXXX, figs. 148, 152.
Aristolochia obscura, Lesq. Am. Jour. Science, XXXII, p. 359, Geol. Vt. 1861, p. 715.
Aristolochites acutus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 202.
Aristolochites apicalis, Perkins, Fourth Rep. Geol. Vt. 1904, p. 203.
Aristolochites brandonianus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 205.
Aristolochites conoideus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 203.
Aristolochites crassicostatus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 205.
Aristolochites cuneatus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 206.
Aristolochites curvatus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 205.
Aristolochites dubius, Perkins, Fourth Rep. Geol. Vt. 1904, p. 204.
Aristolochites elegans, Perkins, Fourth Rep. Geol. Vt. 1904, p. 203.
Aristolochites excavatus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 205.
Aristolochites globosus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 206.
Aristolochites irregularis, Perkins, Fourth Rep. Geol. Vt. 1904, p. 204.
Aristolochites latisulcatus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 204.
Aristolochites majus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 206.
Aristolochties ovoides, Perkins, Fourth Rep. Geol. Vt. 1904, p. 203.
Aristolochites rugosus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 203.

Plate I.

EXPLANATION OF PLATE I.

Figure 1. *Sapindoides medius*, Perkins.
Figure 2. *Sapindoides varius*, Perkins.
Figure 3. *Sapindoides americanus*, Lesquereux.
Figure 4. *Aristolochites majus*, Perkins.
Figure 5. *Aristolochites sulcatus*, Perkins.
Figure 6. *Aristolochites elegans*, Perkins.
Figure 7. *Apeibopsis gaudinii*, Lesquereux.
Figure 8. *Nyssa jonessi*, Perkins.
Figure 9. *Nyssa lescurii*, C. H. Hitchcock. (Enlarged about twice.)
Figure 10. *Nyssa lamellosa*, Perkins.
Figure 11. *Nyssa crassicostata*, Perkins. (Enlarged one and one-half times.)
Figure 12. *Prunoides seelyi*, Perkins.
Figure 13. *Bicarpellites knowltonii*, Perkins.
Figure 14. *Bicarpellites rugosus*, Perkins.
Figure 15. *Glossocarpellites parvus*, Perkins.

PLATE I.

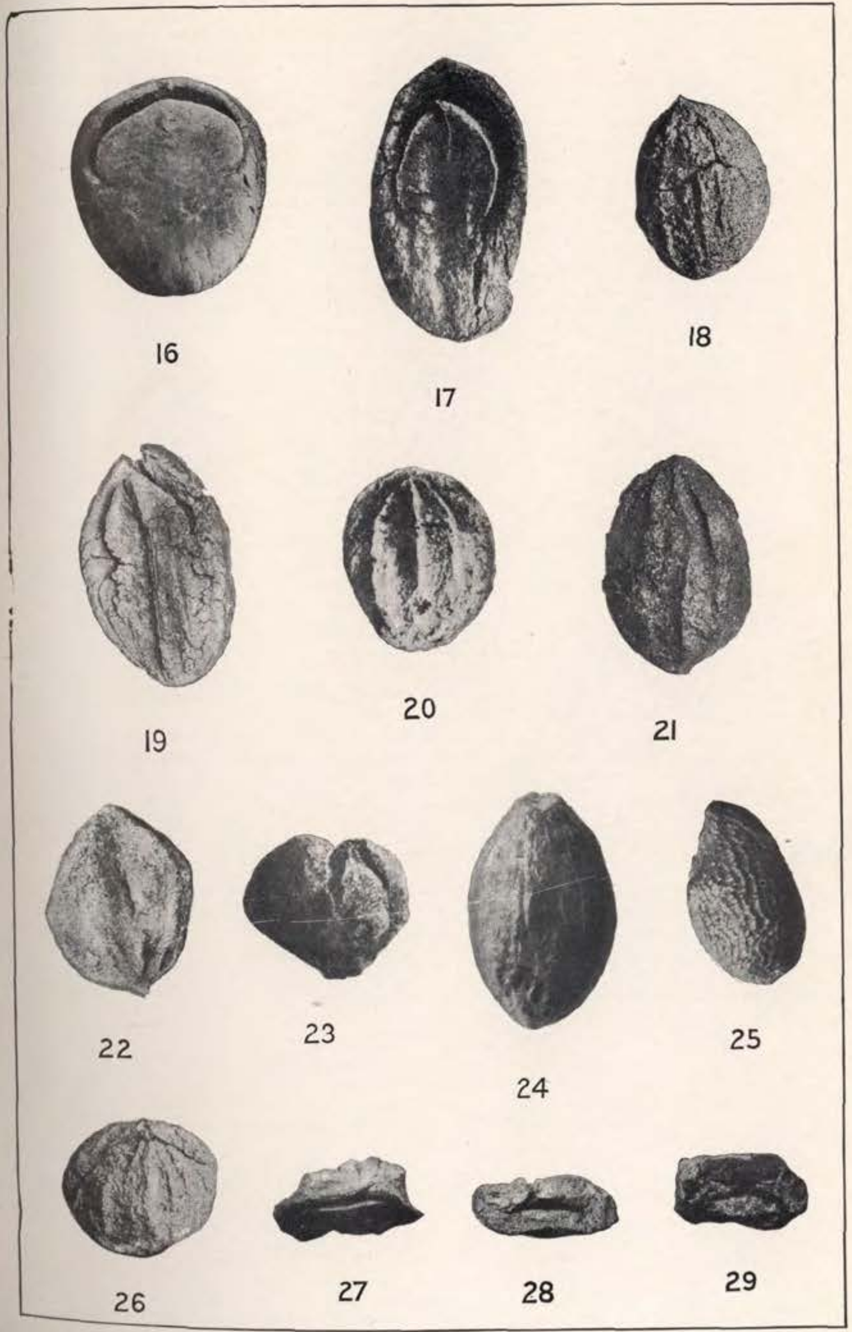


Fossil Fruits from the Brandon Lignite.

Plate II.

EXPLANATION OF PLATE II.

Figure 16. *Glossocarpellites obtusus* (Lesq.), Perkins.
Figure 17. *Glossocarpellites elongatus* (Lesq.), Perkins.
Figure 18. *Monocarpellites gibbosus*, Perkins.
Figure 19. *Tricarpellites fissilis*, Lesquereux.
Figure 20. *Monocarpellites sulcatus*, Perkins.
Figure 21. *Juglans brandonianus*, Perkins.
Figure 22. *Hicoria biacuminata*, Perkins.
Figure 23. *Brandonia globulus*, Perkins.
Figure 24. *Cinnamomum lignitum*, Perkins. (Enlarged three times)
Figure 25. *Drupa rhabdosperma*, Lesquereux. (Enlarged five times.)
Figure 26. *Hicoroides ellipsoideus*, Perkins.
Figure 27. *Hicoroides angulata*, Perkins.
Figure 28. Cross-section of Monocarpellites.
Figure 29. Cross-section of Bicarpellites.



Fossil Fruits from the Brandon Lignite.

Aristolochites sulcatus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 204.
Bicarpellites abbreviatus, Perkins, Fifth Rep. Geol. Vt. 1906, p. 209.
Bicarpellites attenuatus, Perkins, Fifth Rep. Geol. Vt. 1906, p. 210.
Bicarpellites bicarinatus, Perkins, Fifth Rep. Geol. Vt. 1906, p. 210.
Bicarpellites brevis, Perkins, Fifth Rep. Geol. Vt. 1906, p. 213.
Bicarpellites carinatus, Perkins, Fifth Rep. Geol. Vt. 1906, p. 210.
Bicarpellites crassus, Perkins, Fifth Rep. Geol. Vt. 1906, p. 211.
Bicarpellites crateriformis, Perkins, Fifth Rep. Geol. Vt. 1906, p. 211.
Bicarpellites grayana, (Lesq.) Perkins, Fourth Rep. Geol. Vt. 1904, p. 190.
Bicarpellites inequalis, Perkins, Fifth Rep. Geol. Vt. 1906, p. 211.
Bicarpellites knowltoni, Perkins, Fourth Rep. Geol. Vt. 1904, p. 191.
Bicarpellites lanceolatus, Perkins, Fifth Rep. Geol. Vt. 1906, p. 211.
Bicarpellites major, Perkins, Fifth Rep. Geol. Vt. 1906, p. 212.
Bicarpellites medius, Perkins, Fifth Rep. Geol. Vt. 1906, p. 212.
Bicarpellites minimus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 192.
Bicarpellites obesus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 191.
Bicarpellites ovatus, Perkins, Fifth Rep. Geol. Vt. 1906, p. 213.
Bicargellites papillosus, Perkins, Fifth Rep. Geol. Vt. 1906, p. 213.
Bicarpellites parvus, Perkins, Fifth Rep. Geol. Vt. 1906, p. 214.
Bicarpellites quadrangularis, Perkins, Fifth Rep. Geol. Vt. 1906, p. 214.
Bicarpellites quadratus, Perkins, Fifth Rep. Geol. Vt. 1906, p. 214.
Bicarpellites rotundus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 191.
Bicarpellites rugosus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 191.
Bicarpellites solidus, Pekins, Fifth Rep. Geol. Vt. 1906, p. 215.
Bicarpellites sulcatus, Perkins, Fifth Rep. Geol. Vt. 1906, p. 215.
Bicarpellites vermontanus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 192.
Brandonia globulus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 192.
Carpites inequalis, Perkins, Fourth Rep. Geol. Vt. 1904, p. 193.
Carpites ovalis, Perkins, Fourth Rep. Geol. Vt. 1904, p. 194.
Carpites trigonus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 194.
Cinnamomum corrugatum, Perkins, Fourth Rep. Geol. Vt. 1904, p. 200.
Cinnamomum lignitum, Perkins Fourth Rep. Geol. Vt. 1904, p. 200.
Cinnamomum novæ-angliæ, Lesq. Am. Jour. Sci. XXXII, p. 360, 18.
Cinnamomum ovoides, Perkins, Fourth Rep. Geol. Vt. 1904, p. 199.
Cucumites lesquereuxii, Knowlton, Bull. Torrey Bot. Club, XXIX, p. 641, 1902.
Drupa rhabdosperma, Lesq. Am. Jour. Sci. XXXXII, p. 360, 1861.
Glossocarpellites (Carpolithes) brandonianus, (Lesq.) Am. Jour. Sci. XXXII, p. 356, 1861.
Glossocarpellites (Carpolithes) elongatus, Perkins, Fourth Rep. Geol. Vt. 1904.
Glossocarpellites (Carpolithes) emarginatus, Perkins, Fourth Rep. Geol. Vt. 1904.
Glossocarpellites (Carpolithes) grandis, Perkins, Fourth Rep. Geol. Vt. 1904, p. 178.
Glossocarpellites (Carpolithes) hitchcocki, Perkins, Fourth Rep. Geol. Vt. 1904, p. 179.
Glossocarpellites (Carpolithes) mucronatus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 179.
Glossocarpellites (Carpolithes) obtusus, (Lesq.) Perkins, Fourth Rep. Geol. Vt. 1904, p. 177.
Glossocarpellites (Carpolithes) ovatus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 178.
Glossocarpellites (Carpolithes) parvus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 179.
Glossocarpellites (Carpolithes) simplex, Perkins, Fourth Rep. Geol. Vt. 1904, p. 178.
Glossocarpellites (Carpolithes) solidus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 179,
Glossocarpellites (Carpolithes) vermontanus, Perkins, Fourth Rep. Geol. Vt. 1904. p. 179
Hicoria biacuminata, Perkins, Fourth Rep. Geol. Vt. 1904, p. 193.
Hicoroides angulata, Perkins, Fourth Rep. Geol. Vt. 1904, p. 183.
Hicoroides ellipsoidea, Perkins, Fourth Rep. Geol. Vt. 1904, p. 184.
Hicoroides globulus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 184.
Hicoroides levis, Perkins, Fifth Rep. Geol. Vt. 1906, p. 217.
Hicoroides parva, Perkins, Fourth Rep. Geol. Vt. 1904, p. 184.
Hicoroides triangularis, Perkins, Fourth Rep. Geol. Vt. 1904, p. 183.
Illicium lignitum, Lesq. Am. Jour. Sci, XXXII, p. 360, 1861.
Juglans brandonianus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 182.

Lescuria attenuata, Perkins, Fifth Rep. Geol. Vt. 1906, p. 220.
Monocarpellites amygdaloidus, Perkins, Fifth Rep. Geol. Vt. 1906, p. 181.
Monocarpellites elegans, Perkins, Fourth Rep. Geol. Vt. 1904, p. 181.
Monocarpellites gibbosus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 181.
Monocarpellites hitchcockii, Perkins, Fourth Rep. Geol. Vt. 1904, p. 182.
Monocarpellites irregularis, Perkins, Fourth Rep. Geol. Vt. 1904, p. 181.
Monocarpellites medius, Perkins, Fourth Rep. Geol. Vt. 1904, p. 182.
Monocarpellites multicostatus, Perkins, Fifth Rep. Geol. Vt. 1906, p. 208.
Monocarpellites orbicularis, Perkins, Fourth Rep. Geol. Vt. 1904, p. 181.
Monocarpellites ovalis, Perkins, Fourth Rep. Geol. Vt. 1904, p. 182.
Monocarpellites pruniformis, Perkins, Fifth Rep. Geol. Vt. 1906, p. 208.
Monocarpellites pyramidalis, Perkins, Fourth Rep. Geol. Vt. 1904, p. 180.
Monocarpellites sulcatus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 180.
Monocarpellites vermontanus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 182.
Monocarpellites whitfieldii, Perkins, Fourth Rep. Geol. Vt. 1904, p. 180.
Nyssa acuticostata, Perkins, Fifth Rep. Geol. Vt. 1906, p. 218.
Nyssa ascoidea, Perkins, Fourth Rep. Geol. Vt. 1904, p. 196.
Nyssa clarkii, Perkins, Fourth Rep. Geol. Vt. 1904, p. 199.
Nyssa complanata, Lesq. Am. Jour. Sci. XXXII, p. 361, 1861.
Nyssa crassicostata, Perkins, Fourth Rep. Geol. Vt. 1904, p. 196.
Nyssa curta, Perkins, Fourth Rep. Geol. Vt. 1904, p. 199.
Nyssa cylindrica, Perkins, Fourth Rep. Geol. Vt. 1904, p. 195.
Nyssa elongata, Perkins, Fourth Rep. Geol. Vt. 1904, p. 197.
Nyssa equicostata, Perkins, Fourth Rep. Geol. Vt. 1904, p. 198.
Nyssa excavata, Perkins, Fourth Rep. Geol. Vt. 1904, p. 199.
Nyssa jonesii, Perkins, Fourth Rep. Geol. Vt. 1904, p. 197.
Nyssa lamellosa, Perkins, Fourth Rep. Geol. Vt. 1904, p. 195.
Nyssa lescurii, C. H. Hitchcock, Portland Soc. Nat. Hist. I, p. 95, 1862.
Nyssa levigata, Lesq. Am. Jour. Sci. XXXII, p. 361, 1861.
Nyssa microcarpa, Lesq. Am. Jour. Sci. XXXII, p. 361, 1861.
Nyssa multicostata, Perkins, Fourth Rep. Geol. Vt. 1904, p. 197.
Nyssa ovalis, Perkins, Fifth Rep. Geol. Vt. 1906, p. 218.
Nyssa ovata, Perkins, Fourth Rep. Geol. Vt. 1904, p. 196.
Nyssa solea, Perkins, Fourth Rep. Geol. Vt. 1904, p. 194.
Pinus conoides, Perkins, Fourth Rep. Geol. Vt. 1904, p. 209.
Pinus cuneatus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 209.
Prunoides bursæformis, Perkins, Fourth Rep. Geol. Vt. 1904, p. 208.
Prunoides inequalis, Perkins, Fifth Rep. Geol. Vt. 1906, p. 221.
Prunoides seelyi, Perkins, Fourth Rep. Geol. Vt. 1904, p. 209.
Rubioides lignita, Perkins, Fourth Rep. Geol. Vt. 1904, p. 193.
Sapindoides americanus, Lesq. Am. Jour. Sci. XXXII, p. 357, 1861.
Sapindoides cylindricus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 208.
Sapindoides medius, Perkins, Fourth Rep. Geol. Vt. 1904, p. 207.
Sapindoides minimus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 208.
Sapindoides parva, Perkins, Fourth Rep. Geol. Vt. 1904, p. 207.
Sapindoides urceolatus, Perkins, Fifth Rep. Geol. Vt. 1906, p. 220.
Sapindoides varius, Perkins, Fourth Rep. Geol. Vt. 1904, p. 206.
Sapindoides vermontanus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 207.
Staphidoides ovalis, Perkins, Fifth Rep. Geol. Vt. 1906, p. 223.
Staphidoides venosus, (Lesq.) Am. Jour. Sci. XXXII, p. 223, 1861.
Tricarpellites acuminatus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 190.
Tricarpellites amygdaloidus, Perkins, Fourth Rep. Geol. Vt. 1904. p. 188.
Tricarpellites carinatus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 186.
Tricarpellites castanoides, Perkins, Fourth Rep. Geol. Vt. 1904, p. 187.
Tricarpellites contractus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 189.
Tricarpellites curtus, Perkins, Fifth Rep. Geol. Vt. 1906, p. 216.
Tricarpellites dalei, Perkins, Fourth Rep. Geol. Vt. 1904, p. 186.
Tricarpellites elongatus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 186.
Tricarpellites fagoides, Perkins, Fourth Rep. Geol. Vt. 1904, p. 188.
Tricarpellites fissilis, Lesq. Am. Jour. Sci. XXXII, p. 356, 1861.
Tricarpellites hemiovalis, Perkins, Fourth Rep. Geol. Vt. 1904, p. 190.
Tricarpellites lignitus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 186

PLATE III.

Delphinapterus vermontanus, Thompson. Anterior part of skeleton. *About one-seventh natural size.*

PLATE IV.

Delphinapterus vermontanus, Thompson. Cranium. *Reduced to one-third natural size.*

Tricarpellites major, Perkins, Fourth Rep. Geol. Vt. 1904, p. 189.
Tricarpellites obesus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 188.
Tricarpellites ovalis, Perkins, Fourth Rep. Geol. Vt. 1904, p. 187.
Tricarpellites pringlei, Perkins, Fourth Rep. Geol. Vt. 1904, p. 189.
Tricarpellites rostratus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 187.
Tricarpellites rugosus, Perkins, Fourth Rep. Geol. Vt. 1904, p. 187.
Tricarpellites seelyi, Perkins, Fourth Rep. Geol. Vt. 1904, p. 189.
Tricarpellites triangularis, Perkins, Fifth Rep. Geol. Vt. 1906, p. 216.

In addition to the fossil plants mentioned in the above list there are in the Collection some very good vertebrate remains from the Florida phosphate beds.

THE PLEISTOCENE or *Quaternary*, the last of the great divisions of geological time is represented by some very interesting specimens. Some of these have already been mentioned in the list of mammals, viz: The two elephant's tusks and the tooth. There are also teeth and a few parts of bones from another species of elephant from Kansas and, most valuable of all our specimens, the nearly complete skeleton of a small whale. This is fully described and illustrated in the Sixth Report. It is the only specimen of the sort that has been found in the United States, tho several, more or less complete, have been found in Canada. The accompanying plates, III and IV, show this specimen as it is mounted for exhibition in the Museum.

Everywhere in the State the Pleistocene clays contain fossil shells and other animal remains of which the following is a list.

Spines of Euryechinus drobachensis?
Ophioglypha sarsii, Lut. Mallets Bay.
Helix, striatella, Malletts Bay.
Nucula abyssicola, Malletts Bay.
Nucula tenuis, M., Malletts Bay.
Nucula expansa, Reeves, Malletts Bay.
Leda minuta, Fab., Malletts Bay.
Leda arctica, Malletts Bay.
Cryptodon gouldii, Ph., Malletts Bay.
Leda arctica var. intermedia, Malletts Bay.
Macoma balthica, L. Burlington, Colchester, etc.
Macoma calcarea, Chemn., Malletts Bay.
Mya arenaria, L., Providence Island, Colchester.
Mytillus edulis, L., Isle La Motte.
Saxicava rugosa, Linn., Colchester, Burlington.
Saxicava arctica.
Yoldia obesa, St. Albans, Colchester.
Yoldia siliqua, R., Colchester.
Lepralia, Malletts Bay.
Tethea, Colchester.
Spicules, etc., Colchester.

Most of the above are found in what Dr. Dawson called Leda Clay. The above list will undoubtedly be increased as the Pleistocene clays are further studied.

INDIAN RELICS.

While the collection of Indian Relics is not as large as it should be it is yet fairly representative of the different forms that have been found in the State and contains some very excellent and finely made specimens. If those who have in their possession a few of these objects would contribute them to the State Collection they would be far more useful, because more accessible to those wishing to study them and a large number of specimens from the same region are much more instructive when seen together than they can be if divided into small lots which are more or less widely separated.

There are undoubtedly many of stone implements scattered about the State which are for the most part unknown to archeologists and which must continue hidden so long as they are distributed, a few on one farm and a few on another, but which would add materially to our knowledge of ancient Vermont if they could be placed together where they could be readily seen and studied. For this reason I am tempted to use this opportunity to urge all who have any such relics to deposit them in the State Museum, if they are not willing to give them or sell them. Setting aside the rudest and less perfect specimens, of which there are a good many, we have some three hundred and fifty good specimens from Vermont and a few from other states. These latter are mostly exceptionally good specimens. There are among them some mining hammers from the copper mines of Lake Superior, a few perfect pieces of pottery from mounds in Ohio, polished celts, amulets, etc., from other parts of the United States.

Of the Vermont specimens, some are quite peculiar to this region, others are similar to those found in the west.

Those special localities, such as mounds, graves, caches, village sites, etc., which in other parts of the country have afforded such large collections of prehistoric objects, are almost wholly lacking in Vermont as they are in most parts of the eastern United States. Still there are one or two places from which many and very interesting objeets have been taken.

The most notable of these is an ancient burial ground not far north of the railroad station at East Swanton. As a considerable number of the most valuable objects obtained at this place are now in the State Collection, a somewhat detailed account of it will not be out of place here.

In the *Proceedings of the American Association for the Advancement of Science, Volume XXII*, the writer published the first account of this very interesting site. This article was accompanied by several plates illustrating the specimens found and those who may care to see a more full account than can be given here are referred to it. The main facts, however, are given here.

The locality is a sand ridge, which appears to have been covered by a forest of Norway pines. About fifty years ago, after a portion of the trees had been cut off, and the sand blown away in places, it was discovered that the ground on which the trees had been growing was once used as a burial ground, for a number of graves were found and examined. If, as was stated by some of those who found implements there, some of them were taken from beneath large stumps, it must have been long since the graves were made, for it must have been before the forest had begun to grow.

At the time when Europeans came into the region, the Indian occupants were Algonkins and a tribe of these, the St. Francis, had a village four or five miles down the Mississquoi, which they occupied until comparatively recent times, that is, until the Revolution.

It is said that these St. Francis Indians had no knowledge of the ancient burial ground and if we may judge from the objects found, the people who used it were not Algonkins, or at least not like those who came later.

These had a burial ground farther down the river, which I have examined. In the old cemetery which, as has been stated, was not suspected until the wind had driven off a part of the sand and disclosed some of the graves, or at least some of the implements, thus leading to the discovery of the graves. At least twenty-five graves have been found. Those first opened by Mr. Elliot Frink, from whom most of the Montpelier specimens came, were six feet below the surface, but some of those since investigated were not more than two feet from the top of the ground because of the removal of the surface sand by the wind.

The sand in which the graves were dug is of a light brown color, but in some cases, perhaps all except two, the sand immediately about the bodies was stained a deep red brown. There were two graves, however, in which the sand at the bottom was black. The finding in one of the graves of a piece of red hematite, which is in the case at Montpelier, explains the red color. Apparently, the sand was colored, perhaps as a part of the funeral rites, by pouring over it a mixture of hematite and water. This appears the more likely since many of the stone objects found in the graves are stained so that, apparently, the grave had received the body and such objects as were to be buried with it before the coloring fluid was poured over the whole.

Most of the bones found in these graves were badly decayed. So far as I know, only a femur, a radius and about half of a skull are all that were rescued. These were stained green in parts by copper carbonate, which came from the copper implements found with them.

The portion of a skull from one of these graves is quite perfect, tho the bones are much discolored and as has been stated stained greenish by copper carbonite. Nearly all of the right half is preserved. It is of a medium sized adult. No teeth remain and only five alveoli. The condyles and foramen are entire.

None of those who examined these graves can give much information as to the position of the skeletons in the graves, whether horizontal or, as was not uncommon among the aborigenes, in a sitting posture, but from such facts as it has been possible to obtain it seems probable that the latter was the case.

Mr. Frink stated that he opened one grave in which the skeleton was in a vertical position, head down, and that in this grave nothing except a few arrow heads was found. If this body was buried in this position it is a very unusual case. It seems more likely that the body was buried sitting and had at some time, either during the excavation or before, fallen over and the skull, dropping down between the feet, would seem to have been placed originally below the rest of the body.

In all I have seen about a hundred specimens that were taken from these graves. The graves were all excavated before I came into the State and therefore only hearsay evidence concerning them is available. Fortunately, there were in Swanton several persons, who were intelligently interested in such things, and I have no reason to doubt the essential correctness of their statements.

As to the objects found in the graves, mention will be made of them later. In general, it may here be noticed that a few copper implements and ornaments, a number of shell beads, stone tubes, celts, amulets, bird-head stones, two-hole stones, boat-stones, discoidal stone, numerous arrow and spear points were taken from the graves. Also several nondescript articles. One of these is a gnarled mass of spruce about as large as one's two fists.

It has a spheroidal form and bears upon its surface several rounded, conical protuberances. Several objects which would not ordinarily attract attention were also found, such as a smooth white quartz pebble and two pieces of fossiliferous stone, had they not been found in graves.

Figures 25-7 pl. H, 101 I, 3,5,7 Pl. K. show some of the Swanton specimens in the State Collection. Others are shown on other plates.

As illustrating, tho less completely than might be desired, the archeology of Vermont, the specimens at Montpelier deserve a somewhat detailed notice. Accordingly, the different classes of objects will be taken up and briefly described with such illustrations as it has been found possible to give. Such an account as that which follows is the more important because, as is well known, these relics of aboriginal occupation are seldom found at present and most of those now in collections can never be duplicated.

Beginning with those objects that are everywhere most abundant we first consider the

Chipped and Flaked Implements.

There are certain common forms of chipped or flaked stone implements, which have been fashioned in much the same way all over the world. In making his first and necessarily rude

Plate V.

Vermont Stone Implements—Arrow and Spear Points, Knives.

One-half actual size.

implements, man, wherever he lived, appears to have worked in substantially the same manner and therefore to have produced very nearly the same results. It is a fact, very easily verified by anyone who will take the trouble to examine these ruder and simpler implements in any large museum, that such objects are very similar, whether from northern Asia, southern Africa, Europe or America. There is a certain amount of difference due to difference in the material used and usually, while there is general resemblance, there are a few pieces found in each locality, which are unlike those from any other place. Naturally, the most commonly used material is that most easily obtained in the locality occupied by the makers. The most accessible stone which can be used is always the source of most of the specimens in any given locality, but almost always some of the specimens are made from finer and more attractive stone than most localities afford.

The above remarks apply fully to our Vermont collections.

There is a bluish gray quartzite which is found in ledges in different parts of the State and from this by far the larger part of the chipped objects, arrow and spear points, knives, etc., were made. Very many other sorts of stone were also used, tho much less commonly. Agate, jasper, hornstone, milky or crystalline quartz and other materials occur in Vermont in the drift gravels or in seams in ledges of other rock and all these were used now and then, especially when some elegant point was to be fashioned.

Undoubtedly some material was imported, that is traded for, from the west where handsome material suited to this purpose is more common than in New England.

As the most common material used was the gray quartzite, so the most commonly found chipped implements are triangular and without haft or barbs. These triangular objects are of many sizes from those that are scarcely more than half an inch long, to the large spears or knives that may be five or even six inches long. The proportions of the triangle varies also indefinitely. Some are slender, others nearly or quite, as long as wide.

The specimens in the upper row in Plate V, are of this sort. The forms here shown are perhaps the most common in Vermont. While these triangular points may occur made of various sorts of silicious stone, the gray quartzite mentioned above is more frequently used than any other material.

This triangular form appears to have been the ordinary everyday point and few are as delicately finished or as perfectly regular in shape as some of the more elaborate stemmed and barbed points.

As compared with similar points found in the Ohio valley and elsewhere, our Vermont specimens are usually less finely made and of less attractive material, but those few that are our very best cannot be surpassed by specimens from any locality.

The specimens shown in the second row on Plate V are many of them from the Swanton graves mentioned above. Probably these were mostly used as knives and they differ somewhat from other specimens found in the State, as they are thinner and of different material.

They are made of a dark gray or bluish hornstone, which chips very smoothly, leaving a fine, even surface.

The specimens shown at the bottom of Plate V represent very well some of the less common tho not very infrequently found Vermont specimens.

The four specimens forming a diagonal series beginning with the lower right hand corner, are somewhat puzzling, for, while they and others similar are almost always exceedingly well shaped and finished, they are made of slate, red, purple or gray, a material not hard enough to withstand much usage nor are they strong enough to bear much strain.

Nevertheless, they occur, tho somewhat rarely, in sufficient numbers to convince one that they had a definite and important place in the economy of the aboriginese. They are nearly always stemmed and more or less completely barbed as the figures show. Naturally, made from such material, they were never chipped, but ground, and the surface is usually very nicely smoothed. They were probably knives, to be used perhaps in dressing skins or such other work as did not require hard usage.

In the University Museum at Burlington there is one of these slate knives which is eight and three quarters inches long and only an inch and a half wide at the largest part. Such an implement, if such it was, could not have endured any usage except the most careful.

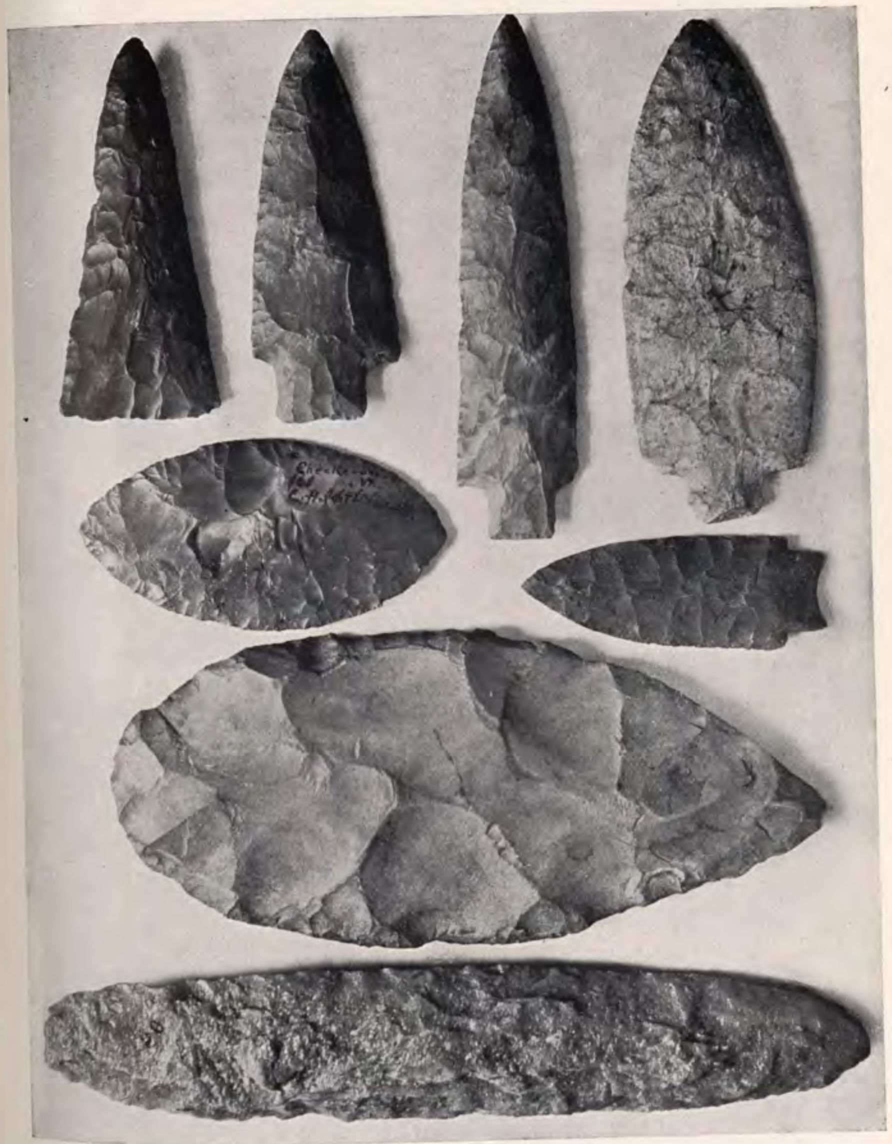
All the figures on Plate V are somewhat less than half natural size. The largest slate point for example is nearly six inches long.

All there are of the figures should be reckoned in the same way, that is, enlarged to a little more than twice the size on the plate.

Plate VI shows a few of the largest of our chipped specimens All the figures are shown on the plate somewhat less than half full size. Those in the top row may have been intended to be used as either spears or knives. The longest is seven and a half inches in length and, as the figure shows, it is quite slender and very well made. The large leaf-shaped object is well made, tho not finely finished. It is eight and a half inches long and may have been used in dressing skins or it may have been a hoe or spade as it closely resembles western specimens which are usually regarded as agricultural implements. The lowest figure on Plate VI is another of the largest chipped implements that have been found. It is of the common gray quartzite and is ten inches long and at the widest part two inches. It is light gray quartz and very well made.

Plate VII shows some of the more common scrapers and drills. The Scrapers are easily recognized by the abruptly bevelled edge. All of the figures in the upper row, down the left side and across

PLATE VI.



Vermont Stone Implements—Knives and Spear Points.

One-half actual size.

the bottom of the plate are of this sort. As is readily seen, the form may vary greatly, but in all the peculiar scraping edge is present.

The drills, too, are usually easily recognizable by the pointed and often polished end. Some of these drills are remarkable specimens of chipped work. The two longest in the center of the Plate VII show how it was possible for skilled workmen to chip from a flinty bit of stone a very slender point. The longest of the drills figured is over four inches from end to end.

The figures on this plate are somewhat more than one half full size.

Most of the chipped objects are of small size, but occasionally larger implements were made in this way. One or two axes and some other sorts of implement were chipped or flaked, usually from rather thin plates of quartzite. Sometimes, tho very rarely, thicker pieces of silicious stone were used as is seen in the celt at the bottom of Plate IX. This, however, is unique in that after the general form had been obtained by striking off flakes of the hornstone of which it is made, the entire surface was somewhat smoothed by rubbing or grinding and the edge, as the figure shows, was ground very smooth and sharp.

The axes, celts, gouges, etc., were nearly always broken into something like the desired form and then, by what must have been a slow and laborious porocess, rubbed into shape on another stone with the aid of sand and water. Of course, when a water worn pebble was found which had such form that it could be made to serve some useful purpose it was gladly picked up and became at once an implement. Certainly, we must believe that primitive man everywhere when he wished to attack animals or men or to defend himself when attacked, used the first pebble at hand and long after man had learned how to fashion all of the various tools and weapons that his needs called for, he still used the unworked worn pebble for a hammer, pot boiler or tool sharpener.

HAMMERS.

Smooth, regularly oval or round quartz pebbles furnished excellent hammers and many of these of a pound or more weight, are found about all village sites or even where there was once a long occupied camp. The pecked or battered ends of such pebbles tell the story.

Having no metal pots in which to boil their food, the Indians used those made of earthenware and these were too fragile to endure direct contact with the camp fire. Hence the boiling was effected by plunging hot stones into jars partly full of water until the water boiled. Great numbers of these boiling stones are sometimes found about an old camp. Of course these are merely pebbles and show no mark of use except that in some cases the heat to which they have been subjected has discolored them.

Figure 4 of Plate VIII shows one of the better sort of hammer stones and figure 7 may have been a tool sharpener.

In some localities, as near Lake Bomoseen, small and flat pebbles are found which are notched or even grooved rudely and these are supposed to have been net or line sinkers.

PESTLES.

Probably the first evolution from the hammer stone was the pounder and then the pestle, figures 1, 2, 3 on Plate VIII. Pounders like that seen in figure 3 are much more common in the Ohio Valley than here. Our more common form is the much more elaborately shaped pestle, figures 1 and 2.

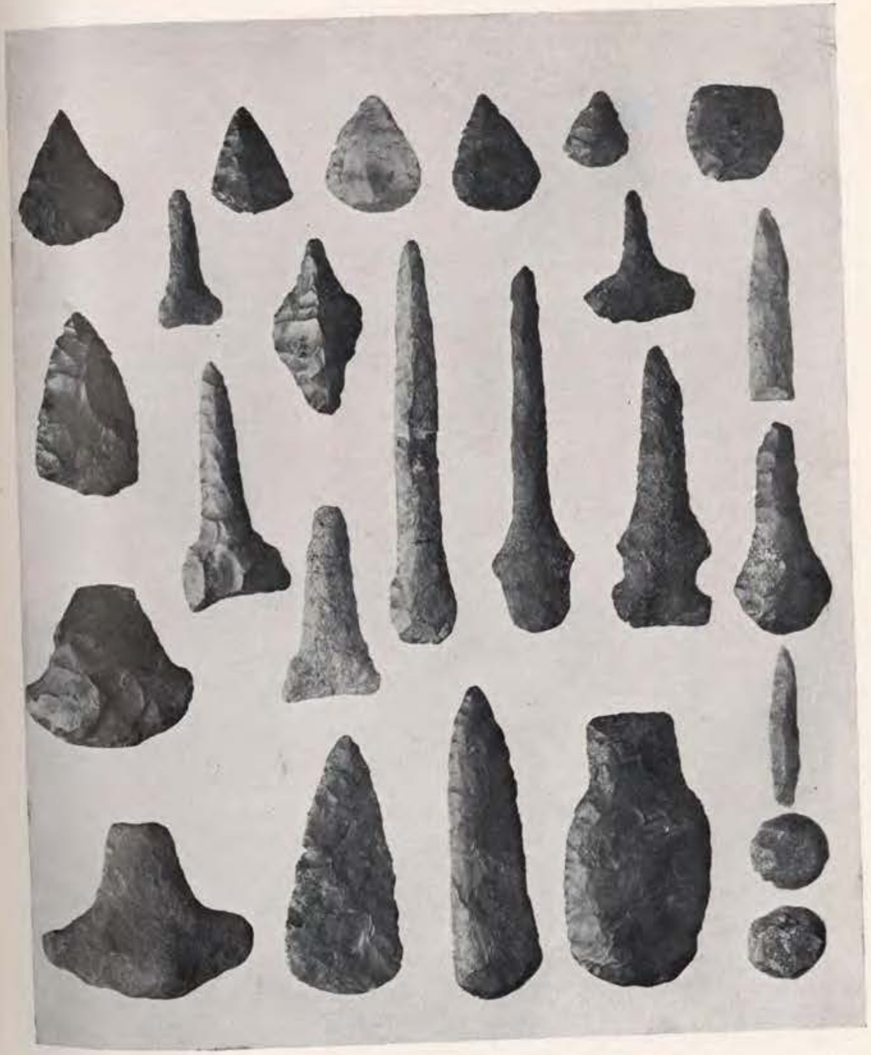
These were used in pounding the corn, acorns, nuts or whatever it might be and were often heavy and finely finished. The largest specimen in the collection at Montpelier is eighteen inches long and nearly three inches in greatest thickness and weighs 9 pounds. Most of the pestles, however, are somewhat smaller. Those shown on Plate 8 are less than half full size. In the Museum at Burlington there are several large pestles the upper ends of which are rudely, but distinctly carved to a semblance of animal heads.

Figures 5 and 6 of Plate VIII are similar to the best hammers but they are worked all over the surface and made very regularly circular in form and each of the flat surfaces is hollowed as may be seen in the figures. These were most probably used in playing certain games which are described by the earliest explorers.

CELTS.

These implements, which in great variety of form and size variously called chisels, hand axes or celts are more numerous than other ground objects. The rude pebble, at first only a hammer without any change in its shape, after awhile was ground at one end and sharpened and then became a celt. It probably, certainly, was used in many ways by its makers, who having few varieties of implements were forced to use the same for many purposes, chisel, ax, tomahawk, etc. The celts vary endlessly in form, finish and material, but all are longer than wide and usually narrowed at the end opposite the edge. Plate IX shows some of those in the State collection. Some are rude having little work put upon them except that necessary to form the edge, others are carefully worked in every part and some are finely smoothed or even polished. Some are flat, others almost cylindrical. In size they vary in length from less than three inches to ten or twelve. Usually, the larger celts are proportionally heavy. Rarely the celts are ground to an edge at each end and still more rarely to a curved edge at one end, making the implement half celt or chisel and half gouge, as in the middle left hand figure, Plate IX. The material is commonly hard stone, greenstone, trap, basalt,

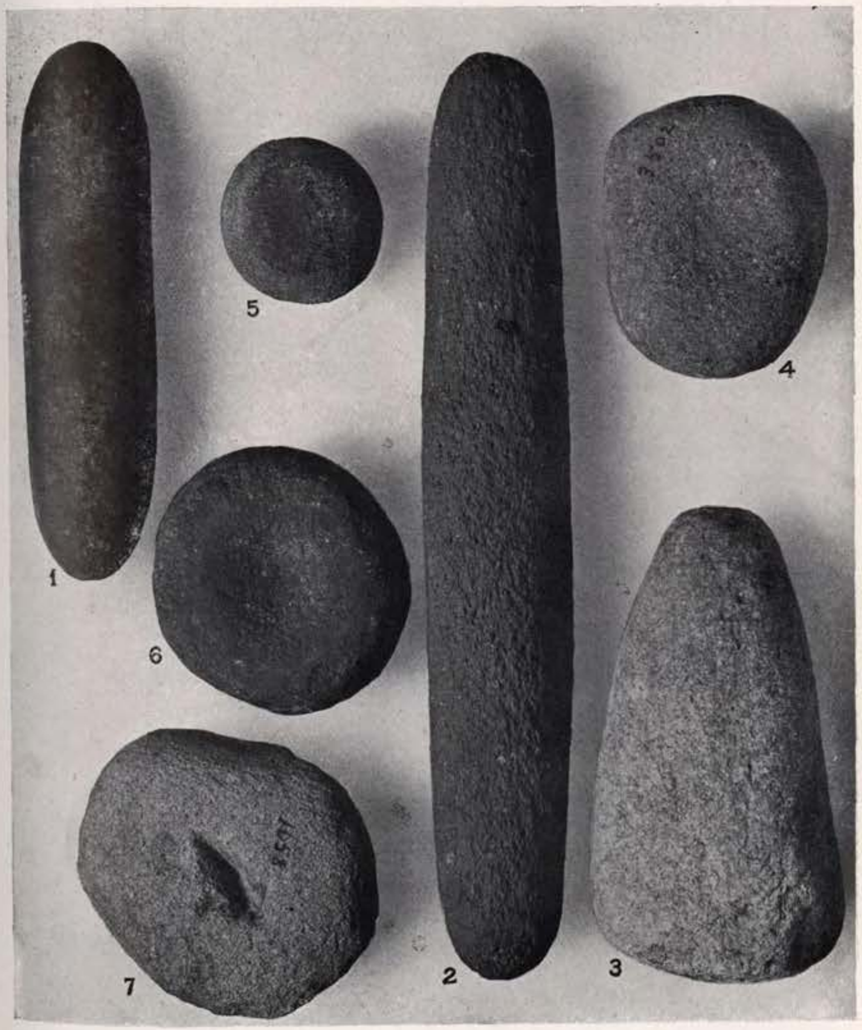
PLATE VII.



Vermont Stone Implements—Scrapers and Drills.

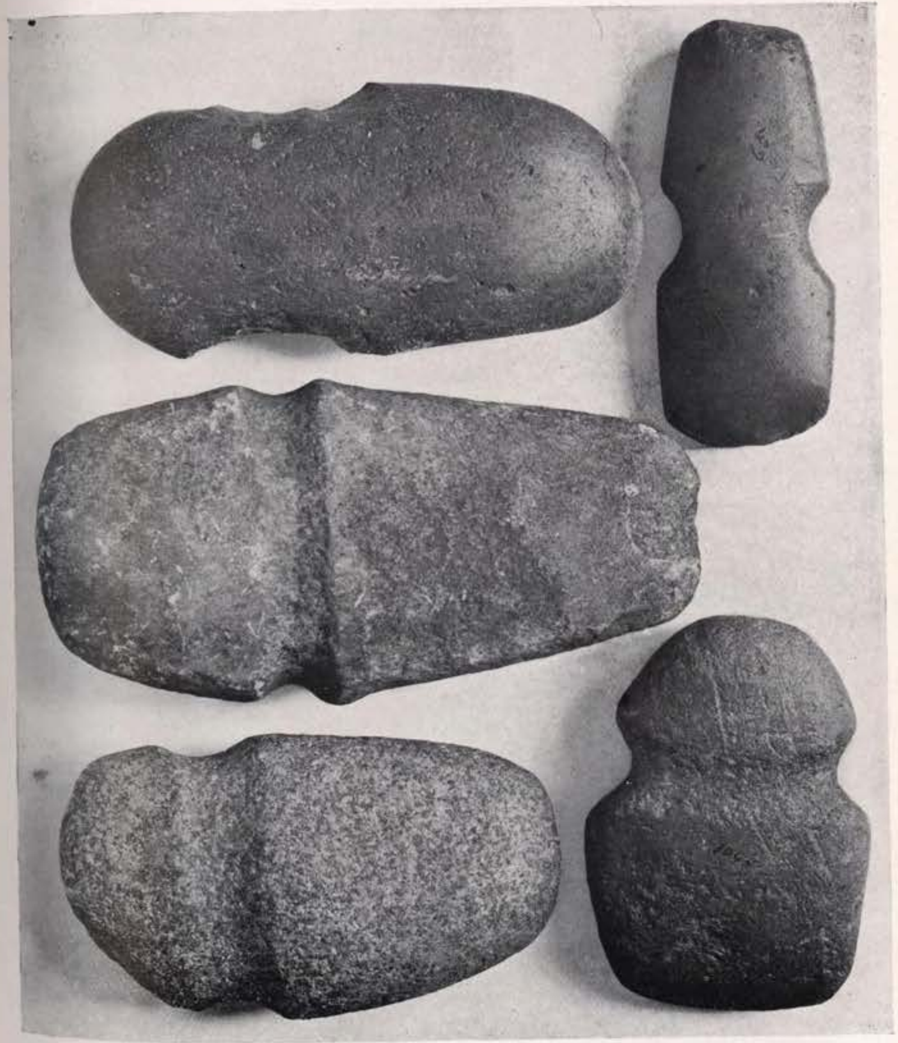
One-half actual size.

PLATE VIII.



Vermont Stone Implements—Pestles and Grinding Stones.
Reduced one-half.

PLATE X.



Vermont Stone Implements—Grooved Axes.
Reduced one-half.

of stone, but earthenware pipes were not uncommon and numerous fragments of them have been found, but, naturally, they were more perishable than those of stone and are more broken.

The specimens shown on Plate XIII have been selected from a larger number and very fairly represent the general character of our Vermont pipes. Plate XIV shows about two-thirds natural size one of several singular stone pipes which have been found.

Altho quite unlike the ordinary pipe in shape, this long, tubular form is not uncommon on the Pacific Coast, and pipes almost exactly like that figured are still used by some South American tribes. All the specimens of this kind of pipe have been taken from the Swanton graves, except one or two fragments. They are of stone and must have cost great labor. The bore is small at one end and large at the other. In some specimens a rudely made stone plug was fitted. These tubular pipes, a dozen of which have been found in the Swanton graves, vary in length from six to thirteen inches. The material is a rather hard slate.

The State collection is not rich in specimens of pipes and most of the specimens figured on Plate XIII are in the University Museum at Burlington, but are introduced here for the sake of completing our account. The specimens shown are figured about two-thirds of the full size.

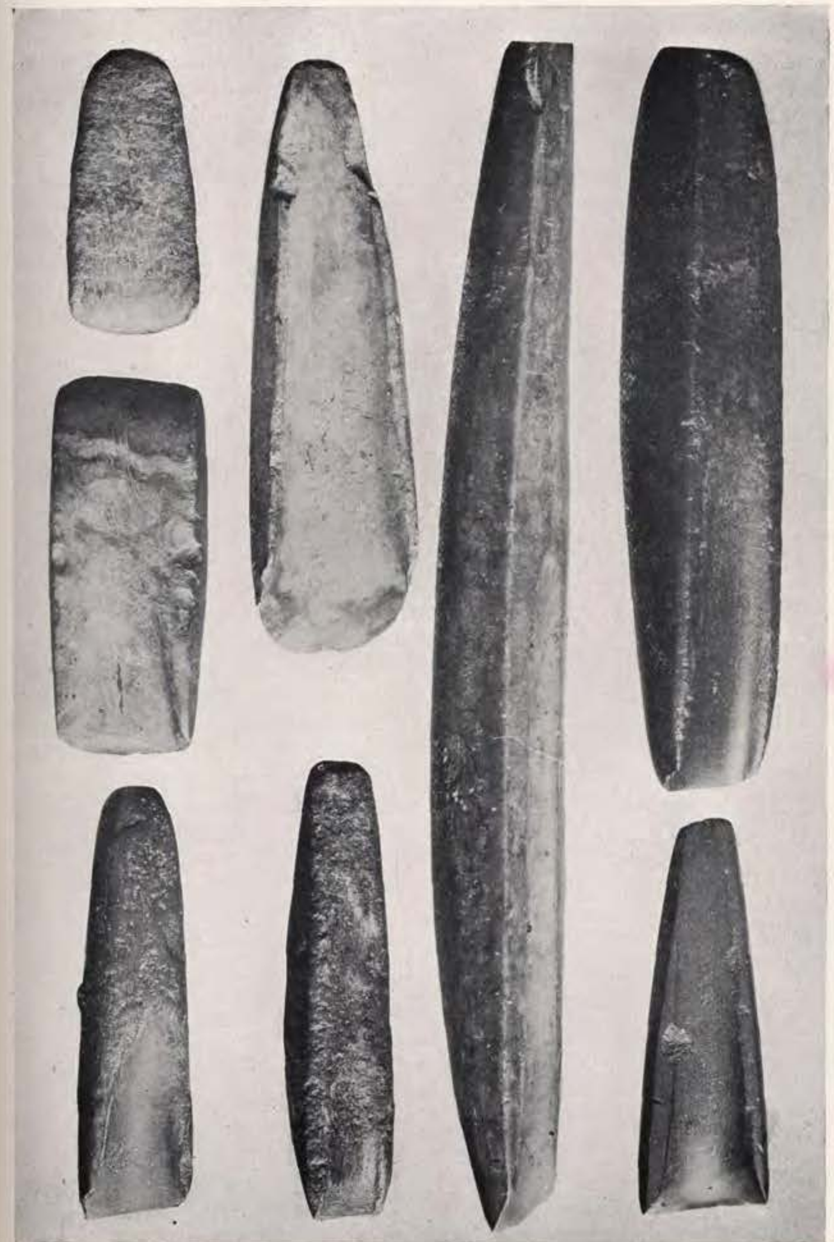
EARTHENWARE.

Soapstone does not appear to have been extensively used for making bowls or dishes, tho it occurs in several localities in the State. Earthenware, however, was evidently very common and while made in but few shapes, was decorated in almost endless variety of pattern.

Much of the earthenware is finely made and of fine material, but there was not a little that was more simple in design and coarser in everyway. The material was, in almost all specimens, a mixture of crushed granite or else the ingredients of granite, quartz, mica, feldspar and clay.

Entire jars have very seldom been found either in Vermont or anywhere in New England. So far as I know only three entire, or nearly so, jars found in this state are preserved. These are in the Museum of the University of Vermont. The material of which our pottery was made appears to have been easily broken, and while fragments are, in places, very numerous, they are only fragments. Most of our pottery is of a reddish brown color, the shade varying endlessly from light to dark and there are sometimes gray or drab pieces. Some is burned until it is black. Fortunately, the decoration was always placed about the upper part or rim, if anywhere, and it was usually confined to a limited space below the top, tho sometimes a large part of a jar was more or less ornamented. I say fortunately, because this part of all jars was made thicker, sometimes almost half an inch, than the

PLATE XI.



Vermont Stone Implements—Gouges.

Less than one-half actual size.

PLATE XII.

Vermont Stone Amulets and Ceremonial Stones.
One-half actual size.

rest and thus is better preserved, so that we may know more as to the patterns used than would have been possible had the more fragile parts of the jars alone been decorated.

Most of the jars made by the Indians of this region were of comparatively small size, holding from one to eight or ten quarts, but those holding twice as much have been found. In shape, nearly all are globular with a more or less constricted rim and, not infrequently, the upper third or more is made square or six-sided. In this case, the flat sides of the upper part are profusely marked with lines, dots, circles, etc.

Plate XIV shows twenty-four pieces of different patterns, shown a little less than half full size.

In thickness our pottery varies much. The smaller and finer pieces may not be more than a fifth of an inch in average thickness, except at the rim, while larger and coarser jars may be nearly half an inch thick. Pottery is far more commonly found in the Champlain Valley than in the eastern part of the state and the patterns are, some of them, Algonkin and some Iroquois. In fact, altho the Algonkins were, so far as we know, the bitter enemies of the Iroquois, who lived on the western side of the lake, they certainly either got a great deal of their pottery from them or learned many of the patterns used from them.

These patterns can not be very well described so that one who has not seen them can get a very good idea of their appearance, but some characteristic pieces are shown on Plate XV. In all the hundreds of fragments found no trace of any of the animal forms common in the mounds has been seen. Nor is there any evidence that paint or color was ever used here. All the designs, some of which are quite elaborate, were made by blunt points and variously shaped stamps on the moist surface of the clay with which all jars were coated before burning. Parallel lines in groups and slanting at various angles were most commonly used. I once counted over three hundred distinctly different patterns on a large series of fragments of rims found on the shore of Lake Champlain. Besides lines and groups of lines, there were stamped on the clay, either in rows or groups, circles, crescents, zig-zags, triangles, squares and other figures, varying not only in form, but also in size. Sometimes the effect is very pretty and in many cases the skill and regularity with which the decorating was done are remarkable.

Moreover, not only is the form of the upper part moulded in a rectangular or polygonal form, as has been noticed, and thus the appearance greatly changed, but the edge of the rim is very prettily scalloped in a few specimens. In a few examples there are lines or figures on the inside for a few inches below the top. Altho, as has been noticed, we have very few entire pieces of pottery, it is not very uncommon to find bits as large as one's hand, or to find several which can be fitted to each other and thus often a considerable portion of the whole jar maybe reconstructed, or could be if numerous small bits necessary to connect those present were not lacking.

Probably, many entire jars were originally buried in our soil, but because of the nature of the material from which the ars were made, as well as the freezing and thawing to which in our climate a buried jar is subjected, we now find only fragments, where under more favorable circumstances we should find whole specimens.

It is safe to say that less than a dozen entire jars found in New England are now preserved in all our collections.

Of these we have three in the University Museum at Burlington and they are larger and in some respects finer specimens than any others.

The paste from which our Vermont jars moulded was always much coarser and more liable to injury when buried than that used either in the Mississippi Valley or the west. Nor was it often as well burned.

Less clay and more stone broken into little pieces and mixed with the clay was used here. Quartz, mica, feldspar and occasionally other sorts of stone were used. Apparently, these were mixed with more or less clay of the proper consistency and the jar shaped from a mass of this, then the whole was coated outside and usually inside, with clear clay, thus giving the surfaces a smooth finish.

Plate XVI, *b*, *c*, *d* shows the three entire jars mentioned. While we have not the real jars in the State collection, we have exact copies of two of them made by an expert modeller and for all ordinary purposes these are as useful as the originals, which they exactly resemble.

The most ornate of the three, and probably none so fine has been found in this region, was dug from under the roots of a large tree in Colchester in 1825. Its form is peculiarly elegant and appears to have been not very uncommon, for we find a number of bits of rims, some of which are seen in figure *a*, which evidently had a similar square form and the decoration, lines and circles are the same on all. The arrangement of the lines, etc., can be well seen in the figure on Plate XVI. This jar is seven and a half inches high, inside diameter at top, five inches, circumference around the largest part, twenty-seven inches. When filled it holds nine pints. Figure gives this jar one-third actual size.

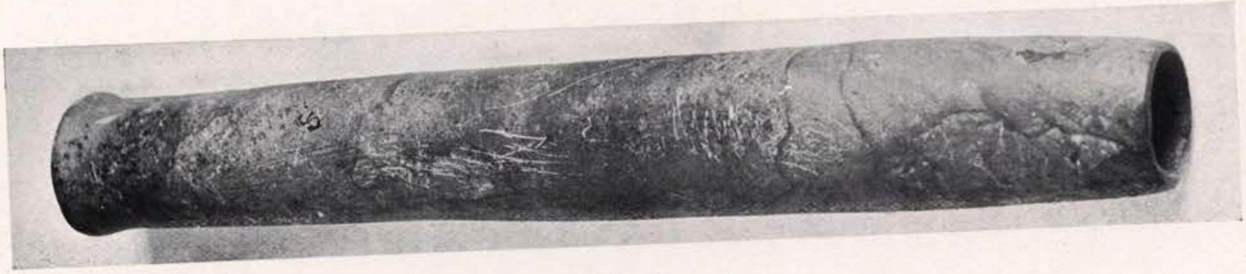
A second and larger jar is that shown in Plate XVI, figure *b*. This, as the figure shows, is much less decorated and was probably a more ordinary household article. Like all our Vermont jars, this was globular below the rim and is ornamented only by a band of deep oblique grooves around the thickened rim, below which is a series of deep notches. This jar was found in Bolton about fifty years ago and was owned by Mr. J. N. Pomeroy of Burlington, who, a few years ago, not long before his death, gave it to the Burlington Museum. It is nine and a half inches high, seven

PLATE XIII.

Vermont Stone Pipes.

Reduced one-half.

Plate XIV.



Tubular Pipe, Vermont.

Two-thirds actual size.

and a half inches in diameter at the top and twenty inches in circumference at the largest part. When filled it holds fourteen quarts.

The third entire Vermont jar has not yet been copied so that we have nothing to represent it in the State collection, but for the sake of completeness it is shown on Plate XVI, figure *c*. Figures *b* and *c* are reduced to pattern more than one-seventh of the real size of the jars.

As has been noticed above, the two other jars were discovered many years ago, but this lay unnoticed until found in the woods by a hunter in 1895. It lay in a sort of cave-like shelter made by large rocks that had fallen against each other in Bolton Falls. It was bought by Dr. C. G. Andrews, then of Waterbury, and given to the Museum at Burlington.

As the figure well shows, the general form is globular, while the rim is hexagonal. The shape is very regular and true. As will be seen, the ornamentation is very much like that of the first mentioned specimen.

Decoration is confined to the upper portion, except that a lightly marked band of simple oblique lines extends around the upper part of the globular body, below the neck.

This jar is ten inches high, nine inches across the opening, thirty-six inches in circumference at the largest part and holds, when full, twelve quarts.

It should be noted that in making the plate the photographs of the jars were not reproduced uniformly, *b* and *c* are really much larger than *d*, tho in the plate they are smaller. This plate was loaned by the American Anthropologist.

It is extremely fortunate that our jars were made thicker and consequently, more enduring about the upper part, for here is always found the decoration. As a result of this we have a large collection of larger or smaller bits of rims and upper portions of jars and from these we learn much as to the taste of the makers and styles of decoration that otherwise would be wholly unknown. Plate XVI, figure *a*, shows, about one-fifth natural size, an assortment chosen from many specimens and from these some idea as to the forms, decorations, etc., of our pottery may be gained.

When we consider that all jars were made entirely by hand without the use of any wheel or other appliance, the exactness of form and general regularity seen in all the specimens is remarkable.

Not only jars, but also pipes were made of earthenware. Some of these were of finer paste and more delicate finish than was usual in the jars. Most of these were bent, that is like modern pipes, the stem at right angle with the bowl, but some were only curved and others quite straight.

Dishes of Soapstone.

Fragments of what appear to have been more or less shallow and rather clumsy bowls or dishes, each cut from a single block of stone, have sometimes been found in this State. As only a few fragments of this not easily destroyed material have been preserved, it is safe to conclude that dishes of this sort were never common. The fragments are large enough to show that none were very large. There are a few of these in the State collection.

OBJECTS OF BONE.

Until quite recently only one or two specimens made of bone had been found in Vermont. The specimen figured on Plate XVII, at the lower part of the plate, was one of the first found. This appears to be somewhat imperfect along the upper edge.

The figure, which is nearly full size, gives a better idea of the decorating by incised lines than a verbal description. The character of this specimen must be problematical. It was, most likely, some sort of an ornament, as is indicated by the care with which it is decorated. It was found near Swanton. Bits of the prongs of deer's horn have now and then been found which bear some indications, notches, grooves or worked tips of having served some useful purpose in prehistoric times, but in most cases the the work shown is very little, tho sufficient, usually, to afford conclusive proof of use. They have also always been found associated with stone implements or pottery. A few years ago, however, our list of Vermont bone objects began to be materially increased. Mr. D. B. Griffin, in exploring what appeared to be an old camping place on the large Creek which flows thru the western part of Colchester and empties into Malletts Bay on the north-east side, found a number of bone implements associated with the usual forms of stone points, knives, pottery, etc. The locality is not far from the bay and just beyond is a large marsh filled with cat-tails in which, for no one knows how long, muskrats have lived in large numbers. The place was admirably adapted for a camp, as it could not be seen from the lake, nor even from the bay until approached quite closely. The soil in which the objects have been found is a compact clay, most of it being under water except when the lake is low.

All the specimens figured on Plate XVII, except those at the bottom, were found here. They are shown a little less than natural size. Not all those shown are in the State collection, some being in the Museum at Burlington. In the upper left corner are three teeth which have been much worked. The two canines at the top are from a bear. The first has been worked down obliquely to a sharp edge. The surface is polished. The second figure shows a tooth split in halves, or else it must have been worked down until one-half was worn away. The worked surface is very smooth and carefully finished. The object below this is not very well shown. It is the incisor or gnawing tooth of a woodchuck, a part of which has been obliquely worked off so that a very sharp point and edge is left. Another rodent tooth, perhaps from a beaver, is much more worked down. It is about two inches long and only a thin portion of the outer side is left.

PLATE XV.

Vermont Earthenware.
One-half actual size.


a
b
c
d

The three cylindrical points or perhaps awls, are very nicely worked and polished as are the two larger points shown on each side of that bearing four barbs. These are all excellent specimens of bone implements.

The curious specimen shown at the upper right hand corner appears to have been designed as a pottery marker. At least it is difficult to find another use for it. The upper end is only broken, but the lower is evenly worked and has three blunt points separated by curved edges, one of which is seen in the figure. The small spear point, having four more or less complete barbs on each side, is the only specimen of the sort that I have seen from Vermont, tho similiar forms have been found near Plattsburg, and on the west side of Lake Champlain. A larger and less carefully made specimen with one barb is shown at the right side of the plate.

Besides objects like those figured, numerous bones and deer prongs have been found in this locality which show some sort of notching or smoothing. Also many bones of deer, bear, wolf, beaver and other animals and some human bones, including nearly the whole of a skeleton. Most of these are in the University Museum at Burlington, but a representative series has been given to the collection at Montpelier.

Objects of Shell.

There are in the Montpelier collection a number of cylindrical beads made from shell. Two of the larger of these are shown at the lower right hand corner of Plate XVII. Smaller beads have also been found and little shells, Marginealas, were bored from end to end and used as beads. All of these were found in the Swanton graves. It is an interesting fact that these shell beads are made from southern species, such as are not found north of the Carolinas.

Objects of Copper.

The native copper from the Lake Superior region was evidently obtained and used by the Indians of the Champlain Valley, or they may, by trade or capture, have obtained the implements after they were made.

Figures 1–7 of Plate XVIII show, reduced to rather less than one-half full size, several of our copper objects. They are nowhere common but appear to have been used in different parts of the State, tho it is true of all classes of Indian relics that more and finer specimens have been obtained in the western part of the State. Figures 1 and 2 are examples of points of which quite a number have been found in different parts of Vermont. Some have no notched stem and may have been simply knives.

Points having a semi-tubular half, as in figure 2, are occasionally found, some of them large. Celts like those seen in figures 3 and 6 are usually not large. The specimens figured were all beaten from the native copper and are more or less corroded.

A very large celt, which is not figured, is in the Museum at Burlington. This is much larger than any other copper specimen that has been found in Vermont. It is eight inches long, two wide and weighs thirty-eight ounces. It was found near the mouth of Otter Creek at Fort Cassin. The size, however, is not the most remarkable feature of this specimen. While all other copper objects that we have appear to have been without doubt beaten into shape, this appears to have been cast. Not only does it present a surface which shows no hammer marks, but it bears thru the length of the upper or flat surface an irregular ridge as if from a rude mould. Along the sides are other less continuous ridges. The appearance is that of small, raised, irregular, ridge-like marks as if from a rudely made mould. Altogether this is a very interesting specimen.

A fine copper gouge was found in Milton, shown in figure 4.

Figure 5 is one of several copper bars found in the Swanton graves, as was also the bead, figure 7, of which a number were found.

Objects of Iron.

When the first white men came to America the natives had no knowledge of working iron. Now and then they picked up a bit of meteoric iron and fashioned it into some charm or ornament, but they could do nothing with the very abundant ores of iron. Copper and bronze were used, but no iron.

Hence all the implements found which are of iron must have been introduced by the white traders. That is, all iron objects, except as indicated, date from the sixteenth century or later. Probably those found in this region are not earlier in origin than the latter part of the seventeenth century.

Some, of course, may be much later, still the form and appearance of those in our museums indicate considerable age. Figures 8–10 on Plate XVII show the more characteristic forms of the iron implements that have been dug up. All are much rusted and probably many have wholly perished for, while comparatively few have been found, it seems quite certain that many must have been used in barter with the Indians.

The Indians when trade began were eager, as all old writers tell us, to get iron in any form, while they had no use for money. Hence iron was the common currency for a long time.

The most common form of trade ax used in the Champlain Valley was that shown by figure 8, Plate XVIII. These axes were of various sizes, from those that can hardly be called more than hatchets to full sized axes. That is, they were from less than five to more than seven inches long and proportionally wide and thick. These axes were apparently in common use both among

PLATE XV.

Vermont Earthenware.
One-half actual size.

PLATE XVIII.

Vermont Implements—Copper and Iron.
About one-half actual size.

those tribes which had trade with Europeans and also the white settlers themselves. Another less common form is that shown in figures 9 and 10 and a still different and probably more modern form was a combination pipe and tomahawk, the part above the handle being fashioned into a pipe bowl and the handle perforated for the stem, while below was a blade that could be used as hatchet or tomahawk. This form has persisted until now, for some of the pipes made within the last fifty years by Indians of the plains are quite similar to those that have been dug up in Vermont. Some of the modern pipes, made from the red pipe stone, are also of similar shape.

It has been noticed that, while most of the objects figured on the accompanying plates are those taken from specimens in the State collection, a few have been made from objects in the Museum of the University at Burlington. Only when objects could not be well figured from the Montpelier specimens have others been taken. All are more or less reduced as has been stated.

For the benefit of special students of Vermont Archæology it may be proper to state here that by far the most extensive and complete collection of Vermont Indian Relics that has been or that ever can be gathered together is that at the University of Vermont. This contains over fifteen thousand specimens. Nevertheless, tho small, the Montpelier collection possesses some exceedingly good representative specimens of most of the different kinds of objects of this sort that are found in this State and it is hoped that ere long all the groups will be represented in the State collection. The figures are all from photographs taken directly from the specimens.

As to the origin of the Indian relics of this State, we know pretty certainly that all, unless now and then a stray piece, came in by trade or fortune of war from outside, were made and used by Algonkin and Iroquois tribes. But when we attempt to separate our specimens into two groups, one of which represents one people and the other the other, we find ourselves quite puzzled. Of course, if we could definitely determine which of these people occupied the Champlain Valley at a given time we could be much more sure as to our conclusions, but this is not easy to do. For a very long time before the coming of the first white men the western side of the lake was inhabited solely by Iroquois tribes, but the eastern side of the lake, between it and the Green Mountains, is less certain as to its occupation. It is well known that when the first white settlers came into what is now Vermont they found the region held and more or less fully occupied by Algonkins, as was the case throughout New England, but this does not appear to have been so always, for Champlain, in his account of the discovery of the lake, says that, when in course of his journey from the large islands in the northern part, he looked at the lands and mountains to the east and asked his savage companions who lived there, they told him that they were inhabited by their enemies, the Iroquois, who had there fertile fields where they raised crops. And there is abundant evidence that Colden, the first English historian of the Six Nations, and other early writers spoke of the lake as possessed by the Iroquois. Champlain himself on his first map, published in 1612, puts down the lake as "Lac des Iroquois" and for a long time in the 17th century the Sorel was called "Riviere des Iroquois." Still, too much may not be concluded from this for in the Jesuit Relation of 1664–65 we find the statement that this name was given to the river "Because it forms the highway leading from them to us and by that route the Barbarians have most often come to attack us." It is also well known that, beginning with 1798 and repeating the claim from time to time until 1874, the Iroquois presented demands for payment for a large tract of land in western Vermont to successive Legislatures. They based their claim on the fact of original occupancy of the region.

The claim was made first in 1798 by Indians of the Cognawaga tribe. They claimed as their long possessed hunting lands all the territory on the east side of Lake Champlain "Beginning on the east side of Ticonderoga from thence to the great falls on Otter Creek and continues the same course to the height of land that divides the streams between Lake Champlain and the river Connecticut; from thence along the height of land opposite Mississquoi and then down to the Bay." This claim was signed by twenty chiefs of several tribes.

As those familiar with Vermont geography will at once see, this claim includes the whole of the Champlain Valley. While carefully investigated by several committees appointed by the Legislature, they were not allowed. But that some foundation for them did exist is evident and the main reason for refusing to grant any of them was based upon other grounds than that the plea of former occupation was false.

The Algonkins claimed that, altho the Iroquois did possess, in Champlain's time, most of western Vermont, the land originally belonged to them and had been taken from them by their enemies who had no right to it.

In the Appendix to his History of Montpelier, pp. 303–309, Mr. D. P. Thompson discusses the "Aboriginal Inhabitants of Winooski Valley" in a very satisfactory manner and concludes by saying, "In view then of all the evidence on both sides of this question, we think we are warranted in deducing the following conclusions:—1st. That the Abenaki or Eastern Indians, were the original owners and the first and last possessors of the Winooski Valley and all the rest of Vermont was claimed by the Iroquois. 2nd. That the Iroquois did come in possession of this territory by conquest some short time previous to 1540 and held it and lived in it till near 1640, when they voluntarily relinquished it to the original owners, the Abenakis, who coming in, perhaps stealing in, took full possession and retained it for the next hundred years, or till the settlement of the State by our ancestors between 1740 and 1760."

From this it may be easily seen that any separation of Algonkian and Iroquoian objects found in Vermont must be practically impossible except in some cases. Probably most of the specimens found in eastern Vermont are to be considered Algonkin or what is the same thing, Abenakis, for these are a division of the Algonkins. The specimens from western Vermont are to be regarded as in part Algonkian and in part Iroquoian. In the forms and character of many of the stone implements there does not seem to be much difference. In the designs on the pottery, while there is similarity, there are differences. Some or our pottery is of the Iroquoian stamp and some with simpler decoration, Algonkian. Probably most of that shown in Plate XVI is Iroquoian, as also the three entire jars.

Attention may be called in closing this account of the collections to a very instructive series of large photographs which are placed on the walls of the main cabinet room. A number of marble and granite quarries are shown and from them some idea of the nature of our quarries and the methods employed in working them may be gained.

Visitors are also urged to examine with care the frames which contain in all a hundred and fifty of Mr. W. A. Bently's photographs of snow flakes. These show, as never has been done before, not only the outside form, but the internal structure of these exquisite objects.

The Granites of Vermont.

INTRODUCTION

BY

THE STATE GEOLOGIST.

In the Sixth Report of the Vermont State Geologist there was published an article with the above title. As was stated in an introductory note, this was merely an abstract of a more complete discussion of the subject to be issued later as one of the Bulletins of the U. S. Geological Survey. The granite industry of Vermont has in recent years assumed such great importance, having become one of the largest interests we have, or can have, and promising further increase in the immediate future, that it did not seem wise to wait for the publication of the Bulletin before placing the main results of Dr. Dale's investigations before those most likely to be interested in them. During the two years that have passed since the Sixth Report was printed the entire Bulletin has appeared and as it contains much that could not be included in the abstract, and numerous illustrations, none of which were available for the abstract it has been regarded as eminently desirable that it be republished in the present volume. This is desirable, both because of the intrinsic value of the Bulletin, especially to Vermont granite workers and dealers, and also because its matter is such as to entitle it a place in the scientific literature of Vermont. It is also well that this Bulletin should be placed within easy reach of all citizens of the State who are in any way interested in granite. The Geologist considers it extremely fortunate that the granites of the State could have been investigated by one who is probably better fitted to do the work satisfactorily than any other geologist in the country. Dr. Dale has for years given especial attention and study to the granites of the country and, as is stated in his introduction, before coming into Vermont he had already studied most of the other granite areas in New England.

Thru the courtesy of Dr. G. O. Smith, director of the U. S. Geological Survey and of Dr. Dale, it has been made possible not only to give the Bulletin entire, but also most of the illustrations which accompanied the text. In addition, thru the kindness of several of the granite companies, illustrations of some of the quarries are given, tho it should be noticed that as quarries are worked their appearance and condition is constantly changing.

The Granites of Vermont.

By T. NELSON DALE.

INTRODUCTION.

It is not proposed to present in this Bulletin an exhaustive geologic and petrographic account of Vermont granites. For such a work years of geologic exploration and much petrographic skill and study would be required; but it is proposed for immediate economic purposes to locate definitely, describe briefly, and classify all known granites of present or prospective economic value within the State. The method of treating the subject will, like that adopted in the bulletins on the granites of Maine* and on those of Massachusetts, New Hampshire, and Rhode Island,† be both scientific and economic. Features of general geologic interest presented by the stone and the quarries or their immediate vicinity, as cursorily examined, and features of economic interest, particularly those resulting from the location, character, or structure of the stone, will both receive due attention.

The elementary facts as to the origin, composition, physical properties, texture, structure, variations, discoloration, and decomposition of granite, together with a summary of the methods of classifying, testing, and quarrying it, will be found, in a form intended for general readers, in Bulletin No. 354,† pages 9 to 72.

The field work upon which this report is based was done in 1907, when 79 quarries and prospects were visited. One small quarry was visited in 1909. Prof. G. H. Perkins, state geologist, collected data from two prospects. Dr. Albert Johannsen, of the United States Geological Survey, critically revised the writer's petrographic determinations. Mr. W. T. Schaller, chemist, of the Survey, determined the percentages of lime soluble in acetic acid in 10 specimens of granite. Miss Altha T. Coons, of the Survey, has contributed some statistics of Vermont granite production. Dr. G. P. Merrill, of the United States National Museum, has rendered some bibliographic aid. The results obtained by Finlay and Daly from their special studies of certain Vermont granites have been utilized and will be referred to in their place.

As in Bulletins 313 and 354, the number of each specimen described, to which that of one or more thin sections corresponds, is given, so that the description can be verified by consulting the collections at the National Museum. These specimens, except those from idle quarries, have been prepared from blocks selected by the foreman or superintendent. The words "coarse" "medium," and "fine," as applied to granite, are to be understood as in the two previous granite bulletins: *Coarse*, with feldspars over 0.4 inch; *medium*, with those under 0.4 and over 0.2 inch; *fine*, with those under 0.2 inch. The Rosiwal method of estimating mineral percentages has been applied as far as practicable to the principal types of granite described. These types are defined and classified for economic purposes in the table on page 186, a bibliography of the economic geology of granite is given on page 192, and a glossary of scientific and quarry terms will be found on page 195.

The names applied to the various granites in this report are, with a few exceptions, merely local or trade designations. Their employment in this economic bulletin does not affect the standing of any particular name as a geologic formation name.

*Dale, T. N., The granites of Maine; with an introduction by George Otis Smith: Bull. U. S. Geol. Survey No. 313, 1907.

†Dale, T. N., The chief commercial granites of Massachusetts, New Hampshire and Rhode Island: Bull. U. S. Geol. Survey No. 354, 1908.

PART I.—SCIENTIFIC DISCUSSION.

GEOGRAPHIC DISTRIBUTION OF VERMONT GRANITES.

Not until a contour map of the mountainous portions and of the eastern half of the State is completed and a careful geologic survey based upon such a map is made will the geographic distribution and extent of the granite areas of Vermont be accurately known. According to the geologic map of the State traced and compiled by the authors of the State report of 1861* and also according to the geologic map of Orange and parts of Washington and Windsor counties by C. H. Richardson,† a series of granite areas, varying greatly in size but mostly small, extend in a north-northeasterly direction between the central Green Mountain axis on the west and Connecticut River on the east for almost the entire length of the State.

The distribution by counties of all the granite quarrying centers and of the prospects included in this bulletin is shown in figure 1. At the extreme north end of the State, in Orleans County, granite is quarried in Derby, east of Lake Memphremagog. Near the northeast corner of Caledonia County, the next county south, there is a granite prospect in Newark; and there are several quarries in Kirby about 14 miles south of Newark. There are also several quarries near the western corner of this county, 20 to 23 miles west of Kirby in Hardwick; and the quarries of Ryegate and Groton lie near its southern edge. In Washington County, the southern half of which adjoins Caledonia on the west, there are three groups of quarries: The Woodbury quarries at the north, and east of them a prospect in Cabot; south of Woodbury the quarries in Calais; and 20 miles southwest of Woodbury and 8 miles southeast of Montpelier, the quarries of Barre, which is the chief granite-producing center of the State. A few of the Barre district quarries lie south of the Orange County line. About 20 miles southwest of Barre is the granite prospect of Randolph in Orange County. In the northern part of Windsor County is the small but important white granite area of Bethel; 10 miles southwest of it is a quarry in Rochester, and 33 miles south-southeast of Bethel and near the Connecticut is the green syenite of Mount Ascutney in Windsor and West Windsor. Finally, in Windham County, toward southern border of the State, 37 miles south-southwest of Ascutney, near Brattleboro and the Connecticut, are the light-granite quarries of Dummerston.

The Map of Vermont showing the distribution of granite, marble, etc., Plate LXVII page 330, may be consulted with interest in this connection.

*Hitchcock, C. H. and E. Jr., and Hagar, A. D., Report on the geology of Vermont, vol. 2, 1861, Pl. I. This map, valuable as it is, can to-day hardly be regarded as more than a reconnaissance map. Some of its granite areas are wrongly located and granite has been found where the map does not show any.

†Richardson, C. H., The terranes of Orange County, Vt.: Rept. State Geologist of Vermont, 1902, Pls. IX and IX, A.

GENERAL PETROGRAPHY OF VERMONT GRANITES.

The granites of this bulletin fall into three petrographic groups: Biotite granites, quartz monzonites, and hornblende-augite granites. In biotite granites the mica is almost entirely the black magnesia mica known as biotite. In quartz monzonite the soda-lime feldspar occurs in unusual amount, nearly equaling or even exceeding that of the potash feldspars. In hornblende-augite granite the dark silicates, hornblende and augite, take the place of the micas. The gray granites of Barre, Calais, and Woodbury and the pinkish of Newark are biotite granites. This granite also occurs at one of the Ryegate and one of the Kirby openings. The white granites of Bethel, Randolph, Rochester, the very light gray of Dummerston, the gray of Cabot, Derby, Groton, Hardwick (Buffalo Hill), Kirby, South Ryegate, and Topsham are quartz monzonites. The green syenite of Mount Ascutney is a hornblende-augite granite.

As a paragraph on the petrographic characteristics of the stone of each of these places precedes its detailed description in connection with that of the quarries it will suffice here to note the peculiarities of some in each group.

Biotite granite.—In "Barre granite" the plagioclase ranges from oligoclase-albite to oligoclase and oligoclase-andesine. The amount of $CaCO_3$ indicated by two acetic acid tests is nearly 1 per cent., and the orthoclase particles show much carbonate. A marked feature of this granite is the freshness of its microcline and the general kaolinization and micacization of its orthoclase. Some particles of orthoclase inclose microcline. In two dark-gray granites of Barre the contrast between the hammered and cut face is as marked as it usually is in diorites and quartz monzonites, indicating the presence of more plagioclase than in ordinary biotite granites, a feature which the microscope corroborates. In the stone of Calais, which resembles that of Barre, the feldspar, second in abundance, is oligoclase-albite. In the "Woodbury granite" it is oligoclase-albite to oligoclase, exceptionally oligoclase to oligoclase-andesine, and the $CaCO_3$ is 0.28 per cent. The biotite granite of South Ryegate has oligoclase and only 0.05 per cent. of $CaCO_3$. The granites of Kirby and Newark have albite to oligoclase-albite and the latter has 0.41 per cent. of $CaCO_3$.

Quartz monzonite.—The coarse white granite of Bethel contains oligoclase and its mica is mostly muscovite. None of the sections or polished specimens obtained show magnetite or pyrite. The only available analysis shows only 2.56 per cent. of CaO_3 and the $CaCO_3$ indicated by acetic acid test is only 0.12 per cent. The flow structure is marked by courses of discoid nodules of mica described more fully on page 25. In the coarse white granite of Rochester the feldspar is largely albite to oligoclase-albite. Muscovite is in conspicuous aggregates, roughly parallel, producing a gneissoid structure. It is also in minute scales through the feldspars. The amount of $CaCO_3$ indicated is unusually high, 2.46 per cent. The very fine white granite of Randolph has albite to oligoclase-albite, and the muscovite is in scarcely perceptible scales and in finer microscopic ones in the feldspars. The $CaCO_3$ indicated is 0.66 per cent. The very light-gray medium-grained granite of Dummerston has oligoclase to oligoclase-albite and both micas. These are intergrown and bent or twisted with sericite stringers extending from them into the other particles. Crush borders appear about quartz and feldspar. The $CaCO_3$ indicated is 0.125 per cent. The dark-gray stone of Cabot has oligoclase and the mica is almost entirely biotite. The light gray granite of Derby has oligoclase and both micas. No pyrite or magnetite was detected. The $CaCO_3$ indicated is only 0.09 per cent. The bluish-gray granite of Groton and Topsham has oligoclase and the mica is nearly all biotite. The very dark-gray granite of Buffalo Hill in Hardwick has oligoclase to oligoclase-andesine. The percentage of quatz is low, 21.75, and that of biotite high, 16.19. The gray granite of South Ryegate has oligoclase and its mica is almost entirely biotite.

It will be observed that the microscopic descriptions os these various granites note the arrangement of the cavitie- within the quartz particles in intersecting sheets and their re, lation to the rift and grain cracks.*

Hornblende-augite granite.—This is the olive-green syenitef "nordmarkite phase" of Daly, exhaustively described in his monograph on Mount Ascutney.† Its feldspar appears to be albite and oligoclase more or less obscurely intergrown with orthoclase and also rarely occurring separately. Biotite is present in places. Daly has shown experimentally that the green color which appears soon after exposure is due to the oxidization of extremely minute blackish granules of ferrous oxide in the feldspars and to the combination of the yellowish-brown color from the limonite thus produced with the bluish-gray of the unaltered feldspar. To judge from what has been found in other green granites and from the presence of allanite in this rock, a part of this limonite stain is probably due to the oxidation of allanite particles.‡ Daly estimates that this granite contains about 6 per cent. more soda-lime than potash feldspar. The strong contrast of shade between its cut and polished surface, as shown in Plate XXVIII, also points to a large percentage of soda-lime feldspar.

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*This subject is discussed and illustrated in Bull. U. S. Geol. Survey No. 354, pp. 42-48 and fig. 1.

†Daly, R. A., The geology of Ascutney Mountain, Vermont: Bull. U. S. Geol. Survey No. 209, 1903.

‡See Bull. U. S. Geol. Survey No. 354, p. 52 and fig. 3.

GEOLOGIC RELATIONS OF VERMONT GRANITES.

These studies have not thrown new light on the problem of the geologic relations and age of the granites, although they have brought out some previously known facts in greater definiteness and detail.

The biotite granite of Barre contains inclusions up to 57 by 10 by 6 feet of quartz-biotite-muscovite schist and quartz-biotite schist interbedded with quartzite, the details of which are described more fully on page 88 and shown in Plate **XXII**. At two or more of the Barre quarries (pp. 91, 92), the granite is in contact with a similar schist, and minute dikes of pegmatite, starting from the granite surface, penetrate the schist, which near the contact is spotted with granitic lenses as described on page 91. The schists and mica slates of Barre are in many places spangled with biotite and ilmenite (?). As they contain beds of quartzose crystalline limestone they are clearly of sedimentary origin. (See p. 117.)

On Robeson Mountain in Woodbury the contact of granite and schist is also observable. (See p. 92.) Minute pegmatite dikes from the granite surface penetrate the schist, and the granite carries inclusions of the schist measuring up to 25 by 10 feet. The schist of the original capping here is a biotite-muscovite-quartz schist containing beds of dark calcareous muscovitic, or in places epidotic, quartzite. At one quarry a small inclusion of fine-grained quartzose marble was found. These beds are also all of sedimentary origin.

The southern face of Blue Mountain in Ryegate consists of schists and very quartzose mica slate; its upper portion is granite, mostly quartz monzonite. This also contains inclusions of schist (quartz-microcline-biotite) as described on page 89 and shown in Plate **XXII** *b*.

The coarse white quartz monzonite of Bethel is bordered by a zone of fine-grained, more biotitic, and thus grayish quartz monzonite produced by more rapid cooling along the contact with a schist mass. The details of these relations are given on page 90. In places the schist is a fine-grained garnetiferous mica slate with small calcareous beds spangled with biotite. The "Bethel granite" contains inclusions up to 21 by 12 by 5 inches, of very fine black biotite-orthoclase-oligoclase schist apparently not related to the schists and slates surrounding the granite area.

At one quarry in Derby the foreman stated that a dark slaty rock occurred in contact with the granite (quartz monzonite with both muscovite and biotite) on the west, the plane of contact being very steep; but this was covered in 1907 by the falling in of drift.

Schist occurs in the village of Adamant in Calais, within a small fraction of a mile of a ridge of biotite granite.

On Buffalo Hill in Hardwick a very biotitic quartz monzonite is in contact with a medium-grained biotite-quartz schist containing zoisite.

The inference from the contacts and inclusions referred to is that the gray biotite granite of Barre, Calais, and Woodbury, the white quartz monzonite of Bethel, and the gray of Ryegate and of Buffalo Hill in Hardwick, and probably that of Derby, were intruded into certain mica schists and mica slates which metamorphosed clayey and sandy sediments. Whether the intrusion of granites of such diverse characters as those of Barre, Bethel, and Hardwick was simultaneous can not yet be determined.

The green syenite (hornblende-augite granite) of Mount Ascutney in Windsor is in contact with a mass of schist which crops out along the base of the mountain a little below the Norcross quarry and has been carefully traced by Daly on three sides of the syenite mass and mountain.* He has also described the changes brought about in the schist by the intrusion of the syenite† and shows a biotite granite intrusive in syenite on the eastern flank of the mountain.

In view of the pressure needful for the formation of granite the original thickness of the schist masses into which these various granites were intruded must have been very considerable. The present granite surfaces have only become exposed by the erosion of those schist masses. Views have changed as to the age of these schists. On Hitchcock and Hager's map the granite areas are represented as surrounded by "calciferous mica schist" which was regarded as not later than Devonian.‡ Richardson in his papers and map †† subdivided the "calciferous mica schist" belt of Hitchcock and Hager into a calcareous formation (in places a marble but containing schist phases) which he finally designated Waits River limestone, and an overlying noncalcareous schist member, the Vershire schist. He associates this latter formation with a certain belt of slate which flanks the central Green Mountain axis on the east and extends from Lake Memphremagog south to Barnard and includes the roofing slate of Northfield and Montpelier. This slate he finally designated the Memphremagog slate. About 3 miles west of the head of Lake Memphremagog, at Willards Mills, Castlebrook, Magog, Province of Quebec, this slate bears abundant graptolites of lower Trenton age, and he also cites finds of crinoid stems and crushed graptolites at several

*Daly, op. cit., map, Pl. VII.
†Idem, pp. 33, 34.
‡Op. cit., vol. 1, p. 470.
††Richardson, C. H., The Washington limestone in Vermont: Proc. Am. Assoc. Adv. Sci., Boston meeting, vol. 47, 1898, pp. 295–296; also, The terranes of Orange County, Vt.: Rept. State Geologist of Vermont, n. s. 3, 1902, pp. 84, 97, 98, Pl. IX; and The areal and economic geology of northeastern Vermont: Rept. State Geologist of Vermont, n. s. 5, 1906 pp. 86, 90; also, The geology of Newport, Troy and Coventry: Rept. State Geologist of Vermont, n. s. 6, 1908, pp. 274–279.

points in the Waits River limestone.* In his last paper (p. 279) he subdivides the Memphremagog slate at the north into three members, separated by two limestone members, and places them all in the Ordovician.

Daly, basing his opinions on Richardson's results and inferences, regards the schist of Mount Ascutney as of Trenton or pre-Trenton age and the intrusion of the syenite as "of later date than the last great period of rock folding which has affected the Ascutney region," and says that "the balance of probability makes them of post-Carboniferous and pre-Cretaceous age."†

Great difficulties have been experienced on the west side of the Green Mountain range in distinguishing slates and schists of Cambrian, Trenton, and upper Silurian age, because of their petrographical identity in places and also because of the unexpected unconformity between the Cambrian and Ordovician, and the frequence of faults, as well as the general obscuration of original structure by cleavage. In view of that it will be well to proceed cautiously in discussing the age of slate and schist belts on the east side of that range. This is the more important because of the uncertainty of the geologic mapping, owing to the want of contour maps. In such a territory paleontologic evidence should be confirmed by carefully established areal and structural relationships in order to obtain final age determinations.

With the understanding that the age determinations obtained thus far are, for the reasons given, somewhat provisional, the schists and slates of central and eastern Vermont into which the various granites were intruded may be regarded as of Ordovician age and the intrusions as having taken place not during the post-Ordovician mountain-making movement, but during that which occurred at the close of Devonian or of Carboniferous time.

Evidences are not wanting in the composition and microscopic structure of the granites and in their larger structures as exposed at the quarries that since their intrusion they have been subjected to one and possibly several crustal movements. (See pp. 87, 124, 125.)

The basic dikes which traverse the granite or their inclosing schists at Barre, Groton, and Mount Ascutney are of later, possibly Triassic date.

OUTLINE OF THE EARLIER GEOLOGIC HISTORY OF VERMONT GRANITES.

The general earlier history of the granites and associated rocks of eastern Vermont may be tentatively put in the following simple form:

*See Richardson, op. cit., Rept. State Geologist of Vermont, 1902, pp. 94–98, and 1906, pp. 112–114; also 1908, pp. 290, 291.
†Op. cit., pp. 20, 21.

(1.) In Algonkian time a period of sedimentation followed by the intrusion of granitic rocks into the sedimentary beds. These granites are the present gneisses of the Green Mountain range.

(2.) At the close of Algonkian time a crustal movement metamorphosing the Algonkian sediments into schists and the granites into gneisses. This movement was accompanied by folding and elevation. The earlier mountain system of the State was thus formed.

(3.) In early Paleozoic time the submergence of a large area of Algonkian rocks and the deposition thereon of sediments resulting from the erosion of Algonkian land masses, together with calcareous sediments largely of organic origin.

(4.) At the close of Orovician time a crustal movement took place, metamorphosing the Cambrian and Ordovician sediment into schist, slate, and marble, and powerfully folding and also elevating them. Some of these schists and slates are those which now surround the granite areas in the eastern half of the State.

(5.) After a long time interval, probably at the close of Devonian or Carboniferous time, another crustal movement occurred, accompanied by the intrusion of the schist mass by granitic material in a state of fusion with superheated water. The intrusion produced in places further changes in the schist and also injected it with dikes of pegmatite. Fragments of the schist became included in the granite.

(6.) Not long after the crystallization of the granite it was traversed by granitic dikes (pegmatite and aplite).

(7.) The schist and granite masses were traversed, possibly in Triassic time, by basic dikes (diabase, etc.).

(8.) Atmospheric erosion of the Paleozoic schists and slates, begun at the close of Ordovician time, has finally removed those parts of the schist mass which covered the granite domes. This process of erosion has been accelerated by successive uplifts.

IMPORTANT GEOLOGIC FEATURES AT THE QUARRIES.

The following prargraphs are devoted to those geologic features of Vermont granite quarries which are of general interest because of their bearing upon the origin and constitution of granite.

DOUBLE-SHEET STRUCTURE.

Robeson Mountain, in Woodbury, is a narrow granite ridge, attaining an elevation of about 1,100 feet above Hardwick station and some 930 feet above Woodbury (Sabin) pond. It is from 300 to 400 feet above the hollows on either side of it.

Its axis trends from N. 80° E. to S. 70° W., describing a slight curve. Near its west-southwest end the Fletcher quarry cuts the ridge from southeast to northwest, and in 1907 had reached a depth of 40 feet. The sheets exposed here are from 1 to 5 feet thick, horizontal at the top of the ridge, but curving over on the southeast with a dip of 15° to 30°, and determining the slope of the ridge on that side. These sheets are, however, intersected by another set from 5 to 9 feet thick, dipping 5° to 10° S. 70° W. in the direction of the axis of the ridge. In the Woodbury Granite Company's quarries, roughly about 1,750 feet N. 80° E. of the Fletcher quarry, the sheets at the top of the ridge turn, dipping to the northern horizon. Lower down on the southeast side of the ridge they are from 2 to 18 feet thick and dip 20° SSE., with an intersecting set which is horizontal and evidently corresponds to the second set of the Fletcher quarry.

The only explanation offered for this double-sheet structure is the existence at some time of a secondary compressive strain operating differently from that which produced the primary sheet structure to which the ridge owes its form, and giving rise to a nearly horizontal set of joints or sheet partings. There is now a marked compressive strain in the Fletcher quarry, operating from northeast to southwest, parting the sheets and giving rise even in the upper part of the quarry to horizontal strain fractures. Its existence lends support to such an explanation. In 300 granite quarries visited thus far by the writer this is the first case of double-sheet structure or horizontal jointing observed.

COMPRESSIVE STRAIN.

The existence of compressive strain in the granite quarries of New England has long been known. It has also been observed in other places and is believed to bear on the origin of sheet structure.* The effects of this strain have been noted at the following quarries in Vermont: The Woodbury Granite Company's quarry at Bethel, direction of strain, east-west; certain quarries in Barre—Boutwell, strain north-south; Bruce, north-south, strong; Wells Lamson, north-south; Canton, west-east; in Woodbury, Fletcher quarry (see above), about north-east-southwest; in Groton, Benzie quarry, in all directions; in Ryegate, on Blue Mountain, Tupper quarry, east-west; in Dummerston, Black Mountain, Lyons quarry, N. 10° E. to S. 10° W., marked.†

The usual effect of such a strain is the closing of channels or the crushing of cores between drill holes. A fracture or fault plane has arisen extending tangentially from the side of one

*See Bull. U. S. Geol. Survey No. 313, 1907, pp. 32–37, Pl. VII, A; and Bull. No. 354, 1908, pp. 25, 28.

†See Bull. U. S. Geol. Survey No. 354, Pl. VIII, B.

drill hole to that of the next and a slippage of part of the core has occurred along it, giving the drill holes an elliptical outline and bringing them nearer together.

SCHIST INCLUSIONS.

Among the notable features of Vermont granite quarries are the schist inclusions. Those at Barre have been briefly referred to by Finlay.* Eighteen schist inclusions were noticed by the writer in the Barre quarries: Three at quarry 32 (Pl. XXI), one of these, 25 by 10 by 10 feet, has a foliation striking N. 30° W. and dipping 60° E.; another is 20 by 8 by 5 feet. The granite is slightly darker for a space of 7 feet from these inclusions. At quarry 25 several measure up to 8 by 2 feet. At quarry 8 two are 10 by 6 by 2 to 3 feet. One at quarry 6 is 20 by 5 feet. One at quarry 10 is 30 by 3 feet, tapering. The largest was at the Boutwell quarry, No. 1, measuring 57 by 10 by over 6 feet, with a foliation striking N. 10° E. and dipping 55° W. Another, 10 by 8 feet, has a foliation striking north and dipping west. Some of these do not seem to have suffered much horizontal displacement, for their foliation nearly agrees with that of the schist capping. In others it differs greatly.

The larger Boutwell quarry inclusion was examined in detail. Parts of it are lustrous dark-gray muscovite-biotite quartz schist spangled with biotite flakes (0.15 inch long) and with garnets (about 0.05 inch). Parts of it consist of small beds of medium greenish gray fine-grained quartzite (grains to 0.2 inch) alternating with dark beds of quartz-biotite schist. The quartzite bands contain plates of green hornblende (to 0.75 by 0.37 millimeter) and larger garnets which inclose the puartz grains of the rock. The schist bands contain similar plates of biotite lying transverse to the bedding and the foliation. Both kinds of bands contain lenses of carbonate (up to 0.37 millimeter) and irregular particles and crystals of zoisite and epidote. As the schists of Barre away from the granite are spangled with various minerals (see p. 117) it is hardly possible to determine which if any of the isolated minerals in this mass was formed at the time of the granitic intrusion. The hornblende and garnet may have been. A few inches of the underside of this inclusion consist of interbanded granite and schist, the schist having evidently at the time of the intrusion been broken into slivers along its schistosity, and the semi-liquid granite having been forced in between them. The specimen in Plate XXII*a*, is from this point. It shows two minute dikes of granite (0.5 to 1.2 inches wide) penetrating the schist and ramifying. The main ones follow the foliation but the minor branches form very acute angles with it and taper out. A thin section made across one of these little dikes and

*Finlay, George I., The granite area of Barre, Vt.: Rept. Vermont State Geologist, No. 3, 1902, p. 51.

PLATE XIX.

Granite Quarry, Kirby Mountain.

the inclosing schist shows the former to be the typical biotite granite of Barre and the latter a quartz-muscovite-biotite schist spangled with biotite plates (to 0.1 inch). The quartz of the granite shows marked strain effects. The demarcation between granite and schist is sharp and no effect of granite upon schist appears.

At the Morrison quarry on Blue Mountain in Ryegate two schist inclusions were noticed measuring 8 by 4 and 3 by 1 foot. The edge of the larger one is injected with granite which fills lenticular spaces, as shown in Plate XXII*b*. In another specimen the schist has sharp plications, 5 inches high, with lenses of smoky quartz parallel to them, but the nearest edge of the inclusion is nearly a plane surface. A thin section, 1.6 by 0.7 inches, across the edge of this inclusion shows a little granite dike, the quartz monzonite of the quarry, 0.3 to 0.6 inch thick, with schist on both sides. The latter is a quartz-microcline-biotite schist with a little muscovite and rare grains of oligoclase. It has lenses of biotite and muscovite in which large scales of each mica lie at right angles to one another. The sheets of cavities in the quartz of the granite are about parallel to the course of the dikelet and the foliation of the schist. Two other sections of the schist show much apatite in minute crystals and rare particles of allanite. The sheets of cavities in the quartz particles of the schist are at right angles to its foliation and do not penetrate the quartz of the granite.*

The general inference from these observations is that where a rock already schistose becomes included in granite the two may become somewhat minutely interbanded because of the ready fracture along the schist foliation, and that where such interbanding occurs the mineral changes in the schistose rock may be relatively slight.†

CONTACT PHENOMENA.

Those places where quarried granite is in contact with schist or slate have already been mentioned. At some of the Bethel, Barre, and Woodbury quarries the contact phenomena are of sufficient general interest to warrant more detailed descriptions.

BETHEL.

As already stated, the white granite at Bethel appears to be encircled by a zone of finer-grained light buff-gray granite, which is about 40 feet thick. Both rocks are quartz monzonites, but the finer contains more biotite scales than the

*See Bull. U. S. Geol. Survey No. 354, p. 46.

†In connection with this and the next subject the general reader will find some instructive matter in Kemp, J. F., a handbook of rocks for use without the miscroscope, 4th ed., New York, 1908: Generalities regarding contact metamorphism.

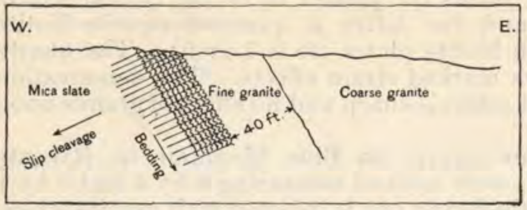


FIGURE 1.—Contact of quartz monzonite on the west side of Ellis quarry, Christian Hill, Bethel, Vt., showing relations of zone of fine granite to coarse granite and to bedding and cleavage of schist.

coarser, and they are mostly very minute and evenly distributed. On the west side of the Ellis quarry the plane of contact between the coarse and fine granite strikes N. 15° W. and dips 60° E. The fine-grained granite is in contact on the west with a finely plicated, very fine grained quartz-muscovite-biotite schist, and this granite is finer grained at its contact with the schist than it

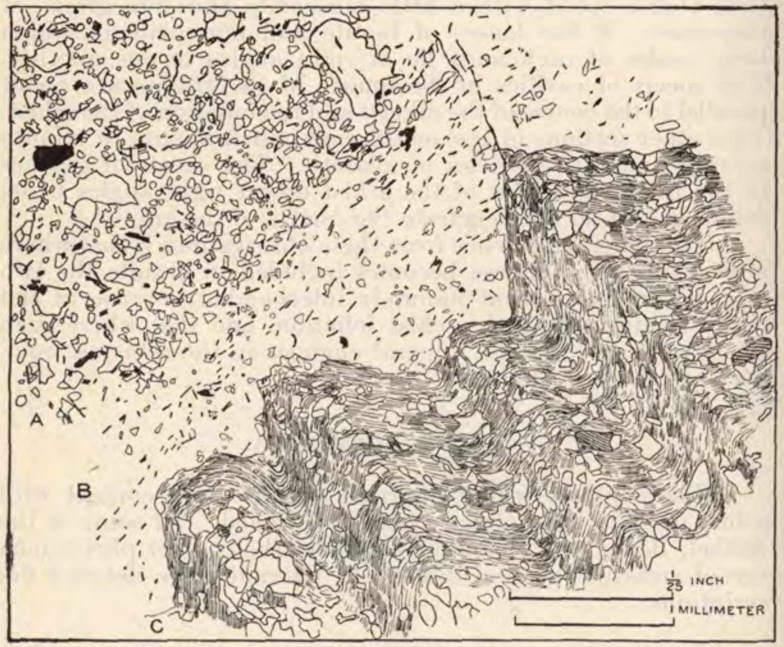


FIGURE 2.—Camera lucida drawing of enlarged thin section across contact of schist and granite at Bethel, Vt., shown in diagram in figure 1. A, Fine granite with some larger porphyritic feldspars and biotite scales. The finer undistinguishable particles of matrix are not shown. B, Zone, 1 to 2 millimeters wide, of glassy material with but few quartz and feldspar particles and biotite scales (in black); most of the latter with their long axis parallel to the general contact surface; a few at right angles to it. A fracture with limonite stain crosses this zone. C, Sharply plicated schist of fibrous muscovite with a little biotite and much quartz (unshaded particles). The two shaded particles are nonmetallic opaque mineral.

is 20 feet away. The plane of contact strikes and dips about as that between the two granites, and the plications of the schist run parallel to this plane but are crossed by a slip cleavage

Black Mountain Quarry, Dummerston, Vt.

PLATE XX.

Blue Mountain Granite Quarry, Ryegate, Vt.

striking N. 70° W. and dipping 25° WNW. The relations are shown in figure 1. Figure 2 shows how the granite has been molded by the minute wrinkles in the schist. The schist contains a few small garnets and plates of magnetite. In the glassy zone the particles range from 0.009 to 0.03 millimeter. In the next the porphyritic feldspars measure as high as 0.92 by 0.5 millimeter. There are thus four grades of texture in the granite: The glassy, 1 to 2 millimeters thick; the very fine (porphyritic, at least toward the glassy), about 20 feet wide; the fine with feldspar and mica not over 1 millimeter, about 20 feet wide; and the coarse with feldspars up to 0.4 and 0.5 inch and mica to 0.3 inch, over 200 feet wide.

BARRE.

The schist which overlies the granite is well exposed at several quarries. Finlay * finds a darkened, more biotitic rim about a centimeter wide in the schist along the granite contact. At two quarries contact phenomena were well exposed at the time of the writer's visit. At the Anderson quarry (No. 8, Pl. XXI) the under surface of the schist is coarsely serrate, forming as it were a series of folds, which, however, are not structural. The granite is darker for a space of 25 feet from the schist, and a foot-thick pegmatite dike borders one of the schist tongues. (See fig. 3).

In the southern corner of this quarry pieces of the mica slate have scaled off from the mass and been carried a few inches into the granite. (See fig. 4). At this point the schist

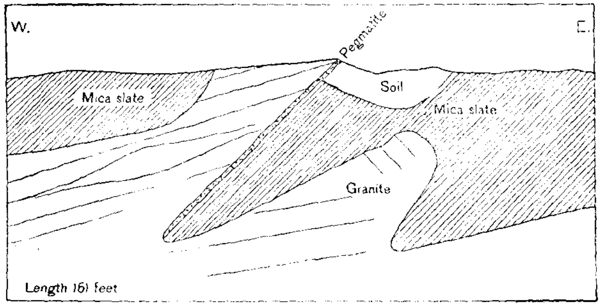


FIGURE 3.—Diagrammatic sketch showing relations of granite and mica schist and slate at Anderson quarry, Barre, Vt. Length, 175 feet.

is a purplish-gray, very quartzose mica slate of quartz-feldspar-biotite, in places with muscovite also, in others without feldspar. Generally the rock resembles the mica slates used for whetstones. The slate has little dikes of pegmatite which start from the granite surface with a thickness of 0.5 inch and taper out at a distance of 4 feet. The course of these dikes has no reference to the cleavage of the slate and their thickness is apt

*Op. cit., p. 51, and Pl. VIII.

to be very irregular. The pegmatite consists, in descending order of abundance, of quartz, orthoclase, microcline, oligoclase-albite, and biotite. The quartz has cavities in sheets, some parallel to the dike, others across it. Minute particles of slate are here and there included in the pegmatite. The slate within a few inches of the granite is marked by very fine-grained, oval greenish-white spots, 0.1 to 0.5 inch and rarely 4 by 2 inches. These lenses lie with one of their major axes in the plane of the slaty cleavage. In some the biotite is zonally arranged, or the lens has a flange of biotite extending considerably beyond it and parellel to the slaty cleavage. Small ones (0.15 to 2.2 by 0.1 to 1 millimeter) were found in thin section to consist of granitic quartz with biotite and muscovite scales transverse or diagonal to the longer axis of the lens, and to be surrounded by a zone, 0.11 millimeter wide, of apatite particles. One has a little pyrite; another has apatite disseminated throughout it; another a little carbonate. The schist for a little space about the lens is finer grained than it is farther away. The little dikes do not show apatite except in rare, very minute prisms.

These lenses have usually been regarded as the result of vaporous impregnation from the granite along the cleavage foliation.* The slate about the lenses shows dark intersecting streaks which are due to more or less complete fractures lined with chlorite with a wide border of exceedingly minute undeterminable black particles.

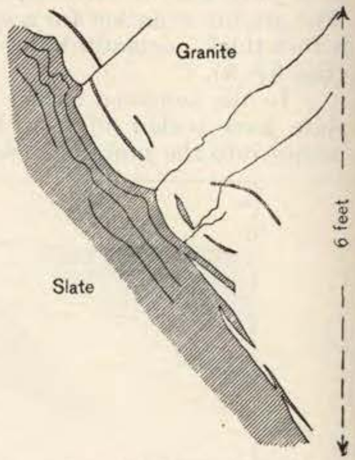


FIGURE 4.—Details at contact of mica slate and granite at south corner of Anderson quarry, Barre, Vt., as viewed along the strike of cleavage. Height, 6 feet.

At the Bailey quarry (No. 6, Pl. XXI) the contact is somewhat obscured by an inclusion which lies very near the schist capping. As the bedding of the inclusion strikes nearly east and west and that of the capping N. 20° to 60° E., the inclusion has been revolved. Both capping and inclusion have been shattered and injected with aplite and pegmatite. The schist, which is like that of the large inclusion at the Boutwell quarry, described on page 88, consists of little beds of whitish quartzite dotted with greenish hornblende and a few garnets, alternating with little beds of quartz-biotite schist spangl-

*Vogt regards apatite in veins as having been found by pneumatolytic agencies. Vogt, J. H. L., Ueber die durch pneumatolitsche Processe an Granitgebundenen Mineral-neubildungen: Zeitschr. prakt. Geologie, 1894, p. 458; and Die Apatit-Ganggruppe: Idem, 1895, pp. 367, 444, 465. Barrell describes the occurrence of apatite in a banded hornstone at contact with granite. He attributes this apatitization to pneumatolytic impregnation. See Barrell, Joseph, Geology of Marysville mining district, Montana: Prof. Paper U. S. Geol. Survey No. 57, 1907, pp. 128, 130. For the formation of apatite at contact of diabase and granite, see Bull. U. S. Geol. Survey No. 354, p. 50.

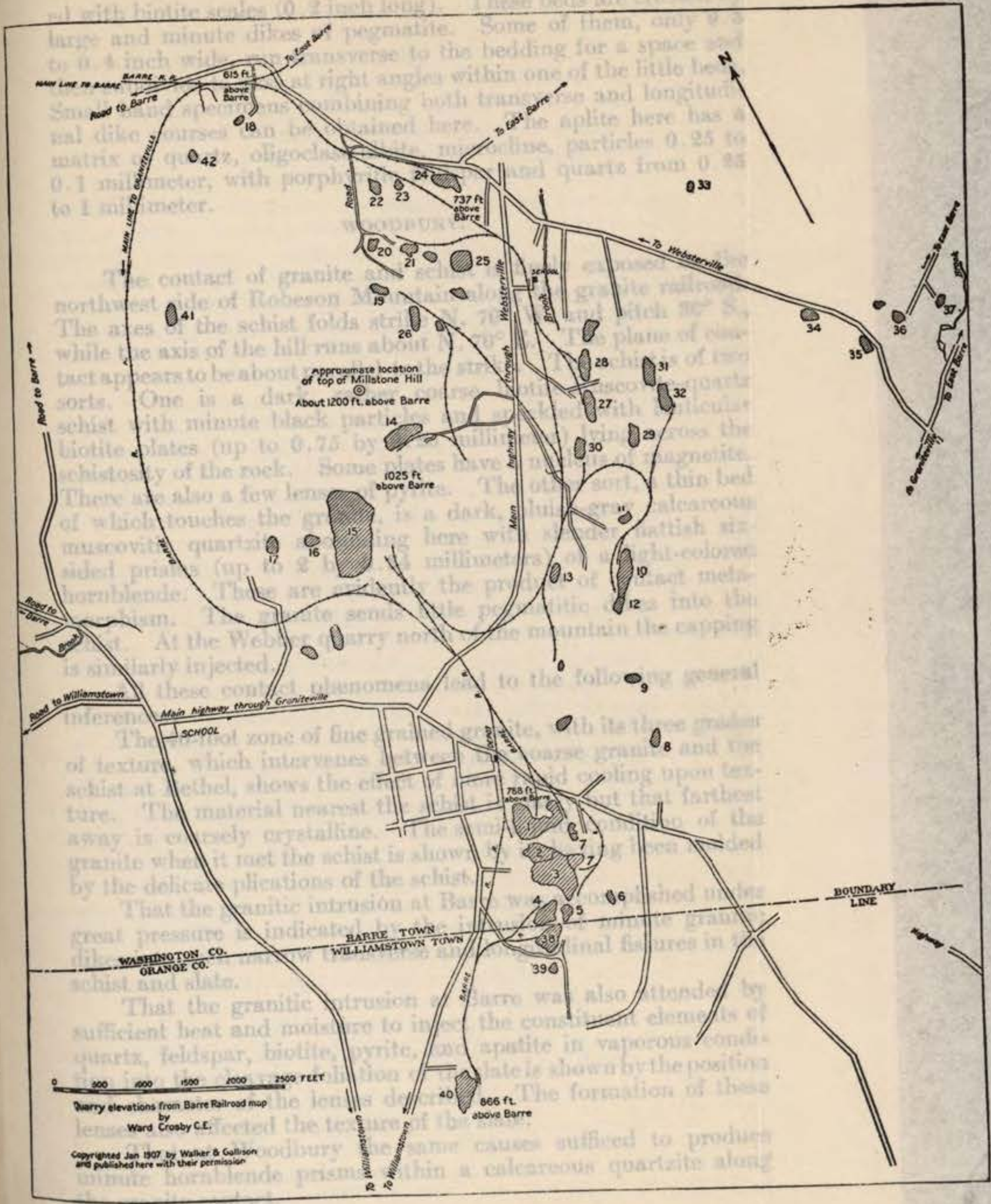
Plate XXI.

PLATE XXI.

Index to Quarries.

1. Boutwell.
2. Bruce.
3. Milne & Wylie.
4. Empire.
5. Marr & Gordon.
6. Bailey.
7. Barre Granite Co.
8. Anderson.
9. Stephen & Gerrard.
10. Jones, light, old.
11. Jones, light, new.
12. Barclay.
13. Acme.
14. Wetmore & Morse.
15. Smith, upper.
16. Duffee.
17. Smith, lower.
18. Sanguinetti.
19. Bond & Whitcomb.
20. Barney.
21. Canton.
22. O'Herin.
23. Walker.
24. Wells and Lamson.
25. Pruneau.
26. Consolidated Marr & Gordon.
27. McDonald & Cutter.
28. Innes & Cruikshank.
29. Capital.
30. Couyellard.
31. McIver & Matheson.
32. Manufacturers.
33. Barre.
34. Milne.
35. Barre Medium.
36. Empire Granite Co.
37. Stratton.
38. Jones, dark.
39. Jones, small, dark.
40. Pirie.
41. U. S. Quarries and Granite Construction Co. (Not operated.)
42. U. S. Quarries and Granite Construction Co. (Not operated.)

Plate XXI.



ed with biotite scales (0.2 inch long). These beds are crossed by large and minute dikes of pegmatite. Some of them, only 0.3 to 0.4 inch wide, run transverse to the bedding for a space and then subdivide to pass at right angles within one of the little beds. Small hand specimens combining both transverse and longitudinal dike courses can be obtained here. The aplite here has a matrix of quartz, oligoclase-albite, microcline, particles 0.25 to 0.1 millimeter, with porphyritic feldspar and quartz from 0.25 to 1 millimeter.

WOODBURY.

The contact of granite and schist is finely exposed on the northwest side of Robeson Mountain along the granite railroad. The axes of the schist folds strike N. 70° W. and pitch 30° S., while the axis of the hill runs about N. 70° E. The plane of contact appears to be about parallel to the strike. The schist is of two sorts. One is a dark, rather coarse biotite-Ruscovite-quartz schist with minute black particles and speckled with lenticular biotite plates (up to 0.75 by 0.25 millimeter) lying across the schistosity of the rock. Some plates have a nucleus of magnetite. There are also a few lenses of pyrite. The other sort, a thin bed of which touches the granite, is a dark, bluish-gray calcareous muscovitic quartzite abounding here with slender flattish six-sided prisms (up to 2 by 0.34 millimeters) of a light-colored hornblende. These are evidently the product of contact metamorphism. The granite sends little pegmatitic dikes into the schist. At the Webber quarry north of the mountain the capping is similarly injected.

All these contact phenomena lead to the following general inferences:

The 40-foot zone of fine grained granite, with its three grades of texture, which intervenes between the coarse granite and the schist at Bethel, shows the effect of more rapid cooling upon texture. The material nearest the schist is glassy but that farthest away is coarsely crystalline. The semi-liquid condition of the granite when it met the schist is shown by its having been molded by the delicate plications of the schist.

That the granitic intrusion at Barre was accomplished under great pressure is indicated by the intrusion of minute granitic dikes into such narrow transverse and longitudinal fissures in the schist and slate.

That the granitic intrusion at Barre was also attended by sufficient heat and moisture to inject the constituent elements of quartz, feldspar, biotite, pyrite, and apatite in vaporous condition into the cleavage foliation of the slate is shown by the position and character of the lenses described. The formation of these lenses also affected the texture of the slate.

That at Woodbury the same causes sufficed to produce minute hornblende prisms within a calcareous quartzite along the granite contact.

ORBICULAR GRANITE.

The white quartz (muscovite-biotite) monzonite of Bethel is crossed on the east side of the Ellis quarry (see p. 000 and fig. 18) by a belt a few feet thick which has a marked flow structure consisting of vertical micaceous bands half an inch or less wide, a foot or more apart, and with a northerly strike. The micas in these bands tend to arrange themselves about the quartz and feldspar particles and are roughly parellel. Near the granite surface there is here a branching mass of wrinkled bronze-colored micaceous material a foot thick lying in the plane of flowage. Biotite appears to be chief constituent in this mass. In thin section it consists of coarse stringers of an olive-greenish biotite, more or less completely surrounding particles of quartz and soda-lime feldspar. There are also small scales of muscovite penetrating the quartz and feldspar particles. In this same flowage belt there are crowds of elliptical discoid nodules of bronze-colored mica from 0.7 to 0.5 to 2 by 1.5 inches, and about 0.2 inch thick. The surfaces of these disks are either longitudinally or concentrically corrugated. While most of these nodules are discoid, some of the smaller ones are nut shaped, resembling those in the well-known butternut granite of Craftsbury and Northfield, Vt.*

Aside from their discoid form, the noticeable features of the Bethel nodules are that they lie in sheets parallel to the flow structure and that the major axes of the disks are parallel to the micaceous flowage bands. Plate XXII*a*, is from a photograph of a hand specimen containing one of the larger disks.

The attention of geologists was first called to the nodular granite of Craftsbury ("Craftsbury pudding granite") by Hitchcock and Hager in 1861. It was next described by Hawes in 1878† and in 1885 in greater detail by Chrusthov,‡ and again by the same geologist in an elaborate monograph in 1894.†† He found that the nodules contained over twice as much calcite as the granite. As both the granite and nodules of Craftsbury differ from those of Bethel, his inferences do not exactly apply to the Bethel nodules. But a conclusion of Frosterus from the study of a nodular granite in Finland applies well to that of Bethel, and shows the real significance of its nodules. It is that the nodules are basic segregations lying in a more basic part of the granite, indicating that the orbicular structure is simply a basic flowage band ("Schliere") and that the nodules themselves lie in this as still more basic segregations.**

*See Hitchcock and Hager, Report on the geology of Vermont, 1861, vol. 2, pp. 563, 564, 721; also Dale, T. N., Bull. U. S. Geol. Survey No. 275, 1906, p. 90; Perkins, G. H. Report state geologist of Vermont, 1906, p. 108, Pl. XXXII, fig. 2.

†Hawes G., Geology of New Hampshire by C. H. Hitchcock, vol. 3, pt. 4, 1878, p. 203, pl. XI, fig. 4.

‡Chrusthov, Konstantin Dmitrijevie, Note sur le granite variolitique de Craftsbury en Amerique: Bull. Soc. min. de France, 1885, vol. 8, pp. 132–141.

††Ueber holokrystalline makrovariolitische Gesteine: Mem. Acad. imp. des sciences de St. Petersbourg, ser. 7, vol. 42, No. 3, 1894, Pudding granit von Craftsbury, Vt., pp. 132–146, pl. 2, fig. 9 and pl. 3, fig. 22.

**Frosterus, Benj., Ueber ein neues Vorkomnis von Kugelgranit unfern Wirvik bei Borga in Finland, nebst Bemerkungen uber ahnliche Bildungen: Tschermaks Min. pet. Mitt., Vienna, vol. 13, pt. 3, 1893, p. 187.

The nodules in orbicular granite vary greatly in composition, size, and structure. Orbicular granites have been described from Bohemia, California, Corsica, Finland, France, Germany, Greece, Ireland, North Carolina, Norway, Ontario, Portugal, Rhode Island, Sardina, Scotland, and Sweden. The literature of the subject is already large, embracing forty-six papers and probably more.*

DELIMONITIZATION ON THE UNDER SIDE OF SHEETS.

At the Frazer quarry on Blue Mountain, in Ryegate, there is a band of rusty stain or "sap" along the base of a sheet 12 feet thick which dips 25° SW. away from the mountain. Usually this limonitic stain affects the upper and lower parts of granite sheets for several inches from the sheet surface, but in this case the rusty band, which is only an inch thick, is separated from the lower sheet surface by an interval of 1 or 2 inches of clear granite. These rusty bands are due either to the oxidation of ferruginous minerals by clear water or to the deposition of limonite by ferruginous water—in both cases circulating between the sheet surfaces. (See further, Bull. 354, pp. 35, 56.)

A careful examination of the specimen shows that all the minerals in the rusty band are stained a medium brown, and that the space below it, although of the same color as that above it, yet has dots 0.1 inch wide of very dark brown. A thin section of this part shows limonite proceeding from biotite and allanite crystals. A thin section of the clear granite above the band shows no limonite whatever about a crystal of allanite. There seems, therefore, to have been a partial delimonitization of the lower part of the zone of "sap," which may be attributed to organic acids in the water circulating between the sheets after that which produced the stain.

*See Zirkel, F., Lehrbuch der Petrogrophie, 2d ed., vol. 2, 1894, Kugelbildung, pp. 50 51; also Rosenbusch, H., Mikroskopische Physiographie der Mineralien und Gesteine, 4th ed., vol. 2, 1907, Kugelstruktur, pp. 85–94.

PART II.—ECONOMIC DISCUSSION.

THE GRANITE RAILROADS.

The granite industry of Vermont owes no small part of its present prosperity to "granite railroads," which connect not only groups of quarries, but every quarry in each group with the main line, although these quarries are situated at considerable elevations and are inconveniently related to one another. Plate XXI shows the intricate character of the granite railroad about Millstone Hill near Barre; figure 5 gives a general idea of that connecting Robeson Mountain in Woodbury with Hardwick, and figure 17 that leading from Christian Hill to Bethel.

DESCRIPTION OF THE GRANITES AND QUARRIES.

CALEDONIA COUNTY.

The quarries of this county are in the towns of Hardwick, Kirby, Newark, Ryegate, and Groton.

HARDWICK.

Professor Perkins, in 1906, called attention to a fine light granite quarried in this town by the Northern Granite Company, from which stone more than 50 statuettes had been cut. He also mentioned granite quarries at Mackville, a mile east of Hardwick village, as then operated by the same company.* As none of these quarries were in operation in 1907 they were not visited by the writer.

The Buffalo Hill quarry is on Buffalo Hill about 2½ miles S. 60° W. from Hardwick village and about 500 feet above it. (See map, fig. 5). Operator, Hardwick Granite Company, Hardwick, Vt.

The granite (specimen D, XXIX, 58, a and d), "dark-blue Hardwick," is a quartz monzonite of dark-gray shade, a little darker than "dark Barre" and a trifle lighter than "dark Quincy." Its texture is medium, with feldspar up to 0.3 inch and mica to 0.2 inch, generally even grained but with sparse, clear, porphyritic feldspars up to 0.4 inch, inclosing the feldspars, quartz, and mica. Its constituents, in descending order of abundance, are smoky quartz with hairlike crystals of rutile, with cavities in sheets parallel to rift cracks and with another shorter and rarer set at right angles to the first; milk-white soda-lime feldspar (oligoclase to oligoclase-andesine), much kaolinized, somewhat micacized and epidotized, and containing calcite; in about equal amount with this feldspar a clear to bluish-white potash feldspar

*See Perkins, George H., Report state geologist of Vermont, n. s. 5, 1906, p. 105.

(microcline with a little orthoclase), some of it kaolinized, some inclosing particles of all the other constituents; olive-colored biotite (black mica) with a little muscovite or bleached biotite.

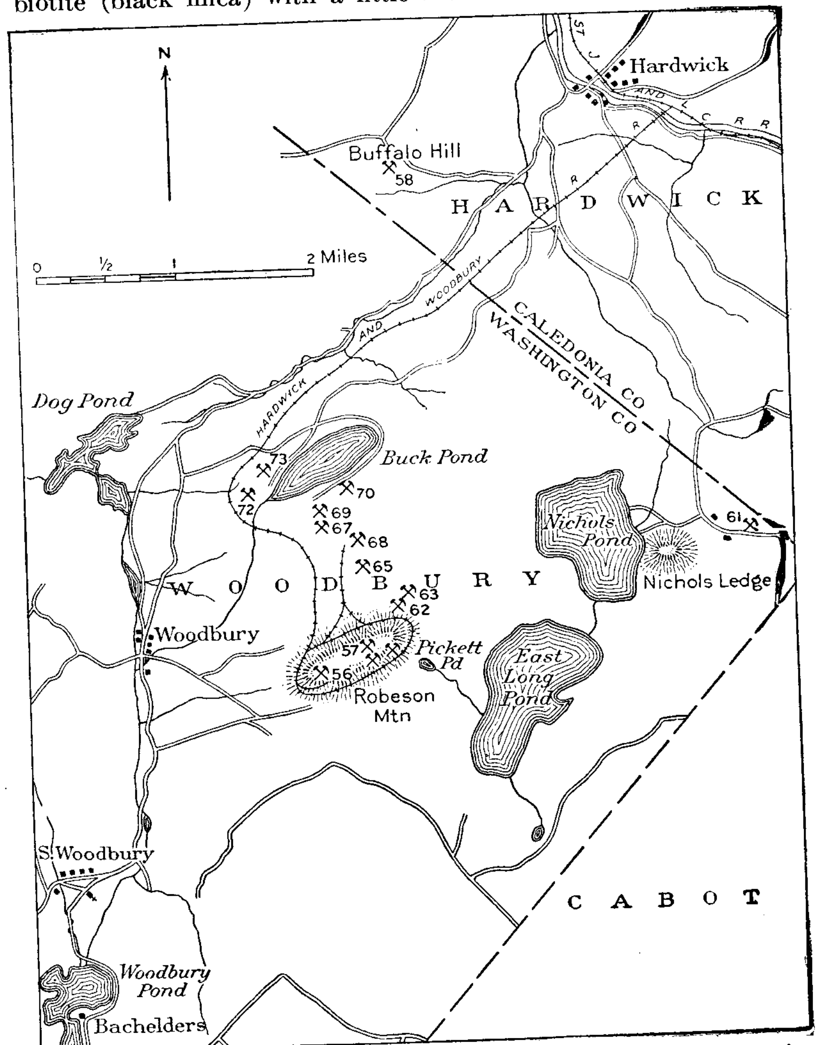


FIGURE 5.—Map compiled from various sources showing approximate locations of granite quarries in Woodbury, Washington County, Vt. Quarries; 56: Fletcher; 57, Woodbury Granite Company; 61, Carter; 62, Carson; 63, Ainsworth; 65, Drenan; 67, Webber, new; Webber, main; 69, 70, old quarries; 72, Leach; 73, Chase.

The accessory minerals are pyrite, magnetite, apatite, zircon (crystals), and allanite; the secondary, kaolin, a white mica, epidote, and calcite. The soda-lime feldspar is radially intergrown with quartz.

The stone effervesces slightly with dilute muriatic acid.

An estimate of the mineral percentages by the Rosiwal method gives these results with a mesh of 0.4 inch and a total linear length of 38.8 inches.

Estimated mineral percentages in "dark-blue Hardwick" granite.

Feldspar	62.05
Quartz	21.75
Mica (biotite)	16.20
	100.00

The average diameter of all the particles by the same calculation in 0.093 inch; that of feldspar, 0.106 inch; of quartz, 0.122 inch; and of mica, 0.052 inch.

This is a bright stone with strong contrast between the white feldspar and black mica. It takes a fair polish, and hammers light with marked contrast to the polished face, which shows some pyrite and less magnetite.

The quarry, opened about 1887, is a small irregular opening 20 to 30 feet deep. It is a bowlder quarry without sheets. There are the following joint systems: (a), strike, N. 30° W., dip 35° W., spaced about 10 feet; (b), strike, N. 45° E., dip 40° NW., spaced about 10 feet; (c), strike, N. 25° W., dip 50° to 75° NE., spacing irregular. The rift is reported as vertical with N. 50° E. course, and the grain as about like joints (a), but neither is marked. There are some white, probably feldspathic, and black biotitic "streaks," really veins, with curving course. Rusty stain up to 6 inches thick appears on joint faces.

The plant consists of one horse derrick.

Transportation is by cart 2½ miles to Hardwick.

The product is used for monuments, particularly for polished and rock-faced work.

KIRBY.

The quarries are all on Kirby Mountain in the east part of the township and about 9 miles northeast of St. Johnsbury. (See map, fig. 6).

GROUT QUARRY.

The Grout quarry is on the south side of Kirby Mountain in Kirby, 2½ to 3 miles N. 20° W. of North Concord and about 450 feet above the station there. (See fig. 6). Operators, Carlton & Lake, East St. Johnsbury, Vt.

Grout quarry gray granite (specimen D, XXIX, 76, a) is a biotite granite of light to medium, slightly bluish-gray color and of medium inclining to fine, even-grained texture with feldspars

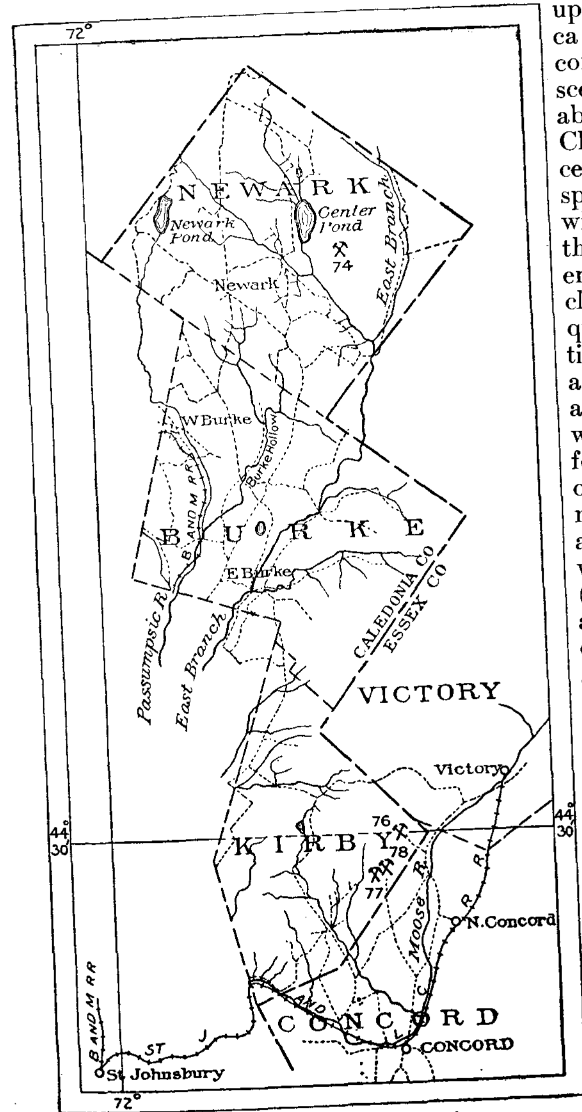


FIGURE 6.—Map of Kirby and Newark, from Beer's Atlas. 74, Bugbee; 76, Grout; 77, Kearney Hill; 78, Burke Granite Co.

up to 0.25 and mica to 0.1 inch. Its constituents, in descending order of abundance, are: Clear to translucent potash feldspar (microcine, with inclusions of the other constituents, and also orthoclase); light smoky quartz with cavities in sheets with a set of cracks parallel to them; milk-white soda-lime feldspar (albite to oligoclase-albite) much kaolinized and with some white mica; biotite (black mica) and a little muscovite or bleached biotite. Zircon is an accessory mineral. Neither magnetite nor pyrite was detected. Secondary minerals are kaolin and a white mica. The granite does not effervesce in cold dilute muriatic acid.

This is a bright stone, but the fineness of its mica and the light shade of its quartz preclude strong contrasts.

The quarry, opened about 1899, consists of two openings, the northern and upper one 40 by 25 feet and 10 feet deep; the lower one 70 feet square and 3 to 5 feet deep.

The sheets, from 6 inches to 4 feet thick, but obscure in the upper opening, strike N. 55° E. and dip 25° SE. The joints are: (a), vertical, strike N. 25° W., spaced 1 foot to 2 feet 6 inches to 50 feet; (b) strike N. 85° E., dip 55° N., forming the south wall, spaced 6 to 8 feet; (c) strike N. 80° W., dip 40° N. 20° E., spaced 9 feet. The rift is reported as vertical, with N. 70° E. course, and grain as horizontal. The flow structure, consisting of streaks of biotite, is parallel to rift. There are some biotitic knots. A vertical quartz vein, half an inch thick, strikes N. 65° E. Rusty stain is confined to the surface and the thinnest sheets next to it.

Three aplite dikes strike N. 80° E. and are 6 feet 6 inches, 6 feet, and 1 foot thick. This aplite (specimen D, XXIX, 76, b) is dark gray and of very fine porphyritic texture. But few particles can be distinguished; feldspar 0.1 inch, mica 0.05 inch. It effervesces slightly with cold dilute muriatic acid. In thin section the particles of groundmass range from 0.037 to 0.148 millimeters, and consist, in descending order of abundance, of quartz, microcline (possibly also orthoclase), rare soda-lime feldspar, minute biotite scales, muscovite or bleached biotite, and secondary zoisite. The porphyritic particles and crystals are quartz, soda-lime feldspar, orthoclase, and biotite. One of the former feldspar has curved twinning planes, another is faulted across them, and has much secondary quartz about it, all indicating motion after crystallization. Calcite was not detected microscopically, but is present.

The plant consists of one horse derrick and one hand derrick.

Transportation is by cart 5 to 6 miles to rail at Concord.

The product is used for monuments.

KEARNEY HILL QUARRY.

The Kearney Hill quarry is on the west foot of Kirby Mountain, in Kirby, about 2¼ miles, roughly, N. 55° W. of North Concord. (See fig. 6). It is operated by the Kearney Hill Quarry Company, Concord, Vt.

Gray granite of Kearney Hill (specimen D, XXIX, 77, a, b) is a quartz monzonite of light-gray shade with conspicuous fine black specks and medium inclining to coarse, generally even-grained texture, with feldspars up to 0.3 inch and mica to 0.2 inch, but with sparse porphyritic clear feldspars, embracing the other constituents, up to 0.5 inch. Its constituents, in descending order of abundance, are: Clear, colorless quartz with hairlike crystals of rutile and fluidal cavities in sheets; bluish to milk-white soda-lime feldspar (oligoclase), somewhat kaolinized and micacized, and inclosing much carbonate; some of it is intergrown with quartz in vermicular structure; clear potash feldspar (orthoclase and microcline, some of the orthoclase micacized); a large porphyritic orthoclase embracing all the other constituents; biotite (black mica), some of it chloritized; and a little muscovite. The accessory minerals are pyrite, allanite, apatite, zircon, and rutile. The secondary are kaolin, a white mica, chlorite, and calcite. There is some effervescence with cold dilute muriatic acid.

Owing to the larger size of the biotite scales and the clearness of the quartz the contrasts are more marked than in the stone of the Grout quarry, and the sheen of the porphyritic feldspars on the rough face is marked.

The quarry, opened in 1906, measures about 100 by 35 feet and 5 feet in depth.

The sheets, from 1 to 3 feet thick, are horizontal or inclined 15° S. There is but one set of joints, which strikes N. 65° E. and is vertical, and is spaced 5 to 20 feet. The rift is reported as horizontal and the grain as vertical, with N. 20° W. course. Biotitic knots are up to 1.5 inches across. A "shake" structure extends down to 16 inches from the surface.

The plant consists of one hand derrick.

Transportation is by cart 5½ miles to a cutting firm and rail at Concord.

The product is used for monuments.

BURKE QUARRY.

The Burke quarry is on the west foot of Kirby Mountain, in Kirby, about 1,000 feet N. 60° E. from the Kearney Hill quarry, and about 2⅛ miles, roughly, N. 50° W. from North Concord. (See map, fig. 6). Operator, Burke Granite Company (Incorporated), East Burke, Vt.

The granite (specimen D, XXIX, 78, a) is a quartz monzonite of light to medium gray shade, and of medium inclining to fine, even-grained texture, with feldspars up to 0.25 inch and mica to 0.1 inch. Its constituents, in descending order of abundance, are: Light smoky quartz with hairlike crystals of rutile, and sheets of cavities with cracks parallel to them; milk-white soda-lime feldspar (oligoclase) much kaolinized and micacized, with some carbonate and epidote, and in places intergrown with quartz in vermicular structure; clear to scarcely bluish potash feldspar (microcline with inclusions of oligoclase, quartz, and mica, also orthoclase micacized); biotite (black mica) some of it chloritized; and muscovite (white mica). Accessory minerals are very little magnetite, apatite, zircon, and rutile. Secondary minerals are kaolin, a white mica, epidote, zoisite, carbonate, and chlorite. There is no effervescence with cold dilute muriatic acid.

This stone closely resembles that of the Grout quarry in its shade and weakness of contrasts.

The quarry measures about 175 by 100 feet and from 10 to 20 feet in depth.

Between this and the Kearney Hill quarry there is an outcrop of schist, either an inclusion or the original schist capping, which strikes N. 15° E. The sheets, from 1 to 5 feet thick, dip 10° S. There are three sets of joints: Set (a), striking N. 25° to 30° W., dipping 30° W., forms the east wall, recurs 100 feet west, and has some parallel sub-joints; (b), discontinuous, strikes N. 5° W., dips 65° E. to 90°, and is spaced 100 feet; (c), discontinuous strikes N. 75° E., is vertical, and is spaced 2 to 50 feet. The rift is reported as horizontal and marked, and the grain as vertical with N. 70° E. course. Biotitic knots are up to 2 inches across. There is little or no rusty stain below the top sheet.

The plant consists of a derrick and hoisting engine, an air compressor (capacity 100 to 200 cubic feet of air per minute), two large rock drills, and three air plug drills.

Transportation is by cart 5½ miles to rail at Concord.

The product is used for rough and cut monuments, and finds a market mostly in the West.

NEWARK.

The Bugbee, Alexander & Packer prospect is in the eastern part of Newark, on the west side of a ridge between Center Pond on the west and the East Branch of the Passumpsic on the east. This ridge lies north of Burke Mountain and southeast of Ball Hill. There is a marked east-west sag in the ridge. The prospect is a little north of the sag on a gently-sloping bench below the steeper part of the ridge and 363 feet above Center Pond, about east-southeast from its south end. (See map, fig. 6). The intending operators are E. H. Bugbee and W. S. Alexander, of Barre, and H. D. Packer, of Newark, Vt.

The granite (specimen D, XXIX, 74, b), "Newark pink," is a biotite granite of light pinkish gray color and of coarse, even-grained texture, with feldspars up to 0.8 inch and mica to 0.15 inch. Its constituents, in descending order of abundance, are: Light pinkish gray potash feldspar (orthoclase and microcline), some of it intergrown with soda-lime feldspar or with inclusions of it, slightly kaolinized; medium smoky quartz with cavities in sheets; cream-colored, in places slightly greenish gray, striated soda-lime feldspar (albite to oligoclase-albite), much kaolinized, and with some white mica and carbonate; biotite (black mica), some if it chloritized. Accessory minerals are magnetite, pyrite, titanite, and allanite. Secondary minerals are kaolin, a white mica, epidote and calcite.

An estimate of the mineral percentages by the Rosiwal method, with a mesh of 0.6 inch and total linear length of 46 inches, yields these results:

Estimated mineral percentages in granite at Newark.

Feldspar	64.80
Quartz	30.30
Mica	4.64
Magnetite	.26
	100.00

The average diameters of the particles obtained from the same calculation are: Feldspars (adding 20 per cent. to the number as an estimate of the uncounted soda-lime particles), 0.162 inch; quartz, 0.106 inch; mica, 0.0406 inch. Average diameter of all particles, 0.123 inch.

The rock effervesces slightly with cold dilute muriatic acid. W. T. Schaller, chemist, of the United States Geological Survey, finds that it contains 0.23 per cent. of CaO (lime) soluble in warm dilute acetic acid (10 per cent.), which indicates a content of 0.4 per cent. of $CaCO_3$ (lime carbonate, calcite), the presence of which mineral is also shown by the microscope.

The contrasts in this granite are chiefly between the smoky quartz and the combined feldspars. It has very sparse porphyritic feldspars up to 1.5 by 0.5 inches, but these are hardly numerous enough to impart to it a technically porphyritic texture. The polished face shows magnetite in minute particles, and very few of pyrite. The polish is fairly good, the mica particles, although somewhat large, not being very abundant.

The sheets on the steeper, higher part of the ridge 110 feet above the bench carrying the outcrop sampled, are from 3 to 6 feet thick and not far from horizontal. Joints (a) strike N. 30° E., dip 70° W.; (b) strike N. 5°W. and are vertical. The rift is possibly N. 85° E. and vertical. The granite for a thickness of 110 feet and presumably to the top of the ridge is the same as that described.

The nearest railroad is 8 miles away.

RYEGATE.

Topography.

The Ryegate quarries are on the southwest and northeast sides of Blue Mountain, a ridge with a northwest-southeast trend situated about 5 miles west of Connecticut River in the east-central part of the town. (See maps, fig. 7.)

General Geology.

A mica schist crops out in the village of South Ryegate with a very steep dip, and appears to continue 3 miles north onto a bench on the southwest side of Blue Mountain and 770 to 800 feet above the village. The granite extends from the back or northeast part of the bench to the top of the ridge. At a point about 770 feet above the village the foliation and bedding of the schist strike N. 50° W. and dip 55° NE. In places the schist is coarse and speckled, but with it is interbedded a very quartzose mica slate (quartz-biotite-muscovite-epidote).

Description of Ryegate Granite.

The granites of Blue Mountain are quartz monzonites and biotite granites of light and medium more or less bluish gray color and of medium, very rarely fine to medium, even-grained texture, and are used chiefly for rough or hammered monuments. All the quartz monzonites of Ryegate ought to cut light.

FIGURE 7.—Map of Ryegate, Groton and part of Topsham from Beers's Atlas. Quarries: 80, Benzie; 87, Ricker.

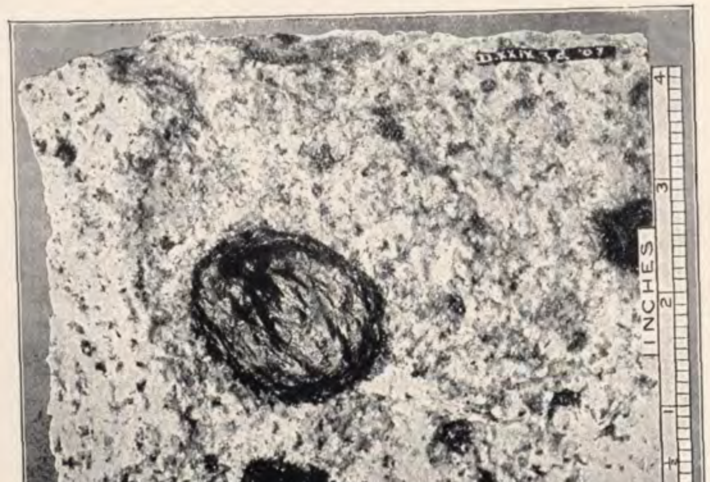
Geology of Ryegate Quarries.

The inclusions of schist in "Ryegate granite" have already been described on page 88 and shown in Plate XXII *b*, at the right. The sheets, ranging from 6 inches to 12 feet thick, are in places horizontal and in others dip from 5° to 25° S. 25°, 45°, 60° W., also gently S. and S. 45° E., on the southwest side of the mountain. Their relation to that slope of the mountain is apparent at the Frazer quarry and on the ridge northeast of the Italian quarry for some 300 feet above it; but at the Rosa quarry, on the other side of the axis of the ridge, the sheets range from horizontal to 10° E., thus indicating a broad anticlinal sheet structure. There are four sets of joints or two sets, each with its complementary one. The strikes are N. 70° to 90° W., N. 5° E., N. 50° W., and N. 30° E. The flow structure, shown by biotitic streaks and planes, strikes N. 70° W., and dips 20° to 25° N. 20° E. The rift is reported as vertical with north-south or N. 55° E. course, and the grain as horizontal. A 22-inch basic dike crosses the granite on the northeast side with a N. 65° W. course. The granite for a foot on either side of it has subjoints one-half to 3 inches apart parallel to the dike. Small pegmatite dikes have N. 50° W. and N. 15° E. courses. The delimonitization of the rusty stain on underside of sheets has been noticed.

GIBSON QUARRY.

The Gibson quarry is on the southwest side of Blue Mountain, 940 feet above the village of South Ryegate. Operator, Ryegate Granite Works, South Ryegate, Vt.

PLATE XXII.



a. Nodular Granite, Ellis Quarry, Bethel

The nodules are mainly muscovite, generally corrugated, and lie with their major axes in the plane of flow structure.

b. Mica Schist With Granite Injections

Specimen at left (6 by 5 inches) from under side of large inclusion at Boutwell quarry Barre, shows light granite bands alternating with dark bands of schist parallel to its foundation. Specimen at right (8 1-4 by 3 inches) from edge of inclusion at Morrison quarry, South Ryegate. The light granite forms lenses in the schist foliation.

The granite (specimen D, XXIX, 81, a, from upper sheets) is a quartz monzonite of light to medium gray shade and medium, even-grained texture with feldspar up to 0.4 inch and mica to 0.1 inch. Its constituents, in descending order of abundance, are: Very light smoky quartz with fluidal and other cavities in sheets and a set of cracks parallel thereto, also with traces of another set of sheets at right angles to these; milk-white soda-lime feldspar (oligoclase) slightly kaolinized with a little white mica and epidote, some of it intergrown with quartz in vermicular structure; bluish potash feldspar (microcline, also orthoclase) similarly intergrown; biotite (black mica) and a little muscovite or bleached biotite. Accessory, titanite, zircon crystals, apatite and pyrite. Secondary, epidote, kaolin, and white mica.

The rock does not effervesce with cold dilute muriatic acid. Its contrasts are weak.

The quarry, opened in 1906, is about 200 feet square and from 2 to 4 feet deep.

The sheets, from 6 inches to 4 feet thick, dip 15° S. 25° W. and are normal. There is but one set of joints, which strike east-west, and are vertical, at irregular intervals, and discontinuous. The rift is reported as vertical north-south and the grain as horizontal. The flow structure (biotitic streaks) strikes N. 70° W. and dips 20° N. 20° E. A schist inclusion measures 12 by 8 inches. Small vertical pegmatite dikes strike N. 15° E.

The plant consists of a derrick, hoisting engine, two air compressors, a steam drill, and two air-plug drills.

Transportation is by cartage 3 miles to cutting sheds at South Ryegate, 940 feet lower.

The product is used for monuments and bases, and to some extent for building.

MORRISON QUARRY.

The Morrison quarry is on the southwest side of Blue Mountain, in Ryegate, about 940 feet above the village of South Ryegate and about 700 feet southeast of the Gibson quarry. Operators, D. A. Morrison & Co., South Ryegate, Vt.

The granite (specimen D, XXIX, 82, b) is a quartz monzonite of medium gray shade and medium, even-grained texture, with feldspars up to 0.4 inch and mica to 0.2 inch. Its constituents, in descending order of abundance, are: Very light smoky quartz with hair-like crystals of rutile and cavities in sheets in two rectangular directions and cracks parallel thereto; milk-white soda-lime feldspar (oligoclase), somewhat kaolinized, with some white mica and rarely epidote, also intergrown with quartz in vermicular structure; bluish potash feldspar (microcline and orthoclase), intergrown with quartz in the same way; biotite (black mica); and a little muscovite or bleached biotite. Accessory: Zircon, apatite, rutile. Secondary: Kaolin, epidote, a white mica, and calcite, as shown also by muriatic acid test.

This stone is identical with that of the Gibson quarry, but its contrasts are a little sharper, as the quarry had got down to thicker sheets. Although the contrasts are feeble the smoky quartz is somewhat conspicuous.

The quarry, opened in 1900, measures about 400 by 200 feet, with an average depth of 20 feet.

The sheets, from 1 to 5 feet thick, dip very gently south and southeast. There are two sets of joints: (a), striking N. 85° E., dipping 70° S., forms a heading on the north side; (b), striking N. 30° E., dipping 75° N. 30° W., is discontinuous and spaced very irregularly. The rift is reported as vertical north-south, and the grain as horizontal. Schist inclusions measuring 3 feet by 1 foot and 8 by 4 feet are described on pages 88, 89. (See also Pl. XXII, B, at the right.) Small pegmatite veins, "tight sets," are bordered with large biotitic spots and muscovite flakes.

The plant consists of two horse derricks.

Transportation is by cartage 3 miles to South Ryegate, 940 feet lower.

The product is used for bases and hammered monuments.

ITALIAN QUARRY.

The Italian quarry is on the southwest side of Blue Mountain, 940 feet above the village of South Ryegate and about 400 feet N. 60° W. from the Gibson quarry. Operator, Caledonia Quarry Company, South Ryegate, Vt.

The granite is a quartz monzonite of light to medium gray shade and medium, even-grained texture, identical with that of the Morrison and Gibson quarries.

The quarry, opened in May, 1907, measures about 250 by 100 feet and from 1 to 5 feet in depth.

The sheets, from 10 inches to 5 feet thick, dip 20° W. Only one set of joints, which strikes N. 50° W. and dips 30° E., and is spaced 50 feet. The rift is reported as vertical with N. 55° E. course and the grain as horizontal, and both as equal. Two pegmatite dikes (0.25 and 2.5 inches thick) strike N. 50° W. and dip 45° N. 50° E. There is a biotitic segregation 3 inches by 1 inch. There is little or no rusty stain on sheet surfaces.

The plant consists of one horse derrick.

The product is carted 3 miles to South Ryegate, and is used for bases and hammered monuments.

TUPPER QUARRY.

The Tupper quarry is on the southwest side of Blue Mountain about 600 feet S. 20° E. of the Italian quarry and from 940 to 960 feet above South Ryegate. Operators, W. S. Tupper & Co., South Ryegate.

The granite is a quartz monzonite of light to medium gray shade and medium texture, identical with that of the Morrison, Gibson, and Italian quarries.

The quarry, opened in May, 1907, measures about 100 by 50 feet and 3 feet in depth.

The sheets, from 1 to 3 feet thick, dip 5° S. 60° W. There is only one joint, which strikes N. 40° W. and dips 35° S. 40° E. Little pegmatite dikes up to 0.75 inch wide occur at irregular intervals, striking N. 50° W. and dipping 30° N. 50° E.

There is a compressive east-west strain.

The plant comprises one horse derrick.

Transportation is by cartage 3 miles to South Ryegate, 950 feet lower.

The product is used for bases and hammered monuments.

ROSA QUARRY.

The Rosa quarry is on the northeast side of a southeast spur of Blue Mountain, which is about 300 feet below its top and in line with its main axis. This quarry is about one-third mile by road from the Frazer quarry and about 1,100 feet above South Ryegate. Operator, Vermont Gray Granite Company, South Ryegate, Vt.

The granite is of two kinds. The first is fine gray (specimen D, XXIX, 79, a), a biotite granite of medium gray shade and of fine inclining to medium even-grained texture with feldspar up to 0.2 inch and mica to 0.1 inch. Its general shade is a trifle darker than that of the quartz monzonite of the Morrison quarry. Its constituents, in descending order of abundance, are translucent to very light bluish gray potash feldspar (orthoclase and microcline); light smoky quartz with hair-like crystals of rutile, and fluidal and other cavities in sheets with cracks parallel thereto; whitish soda-lime feldspar (oligoclase) slightly kaolinized, micacized, and epidotized, in places intergrown with quartz in vermicular structure; biotite (black mica), a little muscovite or bleached biotite. Accessory: Apatite, zircon crystals, titanite. Secondary: Kaolin, a white mica, epidote, limonite.

W. T. Schaller, chemist, of the United States Geological Survey, finds that this stone contains 0.03 per cent of CaO (lime) soluble in warm dilute (10 per cent.) acetic acid, which indicates the presence of 0.05 per cent. of $CaCO_3$ (lime carbonate). No carbonate was detected in thin section nor any effervescence with cold dilute muriatic acid.

The fineness of the texture of this stone precludes mineral contrasts.

The other granite (specimen D, XXIX, 79, b), "coarse gray," is a biotite granite of medium bluish-gray shade, and medium, even-grained texture, with feldspars up to 0.3 inch and mica to 0.15 inch. This is also a trifle darker than that of the Morrison quarry. Its constituents, in descending order of abundance, are: Translucent bluish-gray potash feldspar (microcline and orthoclase); light smoky quartz with fluidal and other cavities in sheets, with cracks parallel to or coinciding with them; milk-white soda-lime feldspar (oligoclase) somewhat kaolinized, a little micacized, with some carbonate and less epidote; biotite (black mica), some of it bleached. Accessory: Apatite in slender prisms, allanite. Secondary: Kaolin, calcite, white mica, epidote. The stone effervesces with cold dilute muriatic acid.

Its contrasts are stronger than those of the quartz monzonites of the Morrison and Gibson quarries. It contains more biotite.

The quarry, opened in 1906, measures about 150 by 75 feet and from 10 to 25 feet in depth.

The sheets, from 1 to 10 feet thick, are horizontal or dip to 10° E. There are three sets of joints: (a), striking east-west, dipping 65° S., forms a 3-foot-wide heading on the north; (b), striking N. 70° to 80° W., dipping 40° N. 10° to 20° E., is spaced 1 to 25 feet, coated with epidote and slickensided; (c), striking N. 5° E., vertical, one only. The rift is reported as vertical with N. 60° E. course, and the grain as horizontal. The fine granite (specimen 79, a) occurs only north of heading (a). On the south edge of the quarry a vertical basic dike, 22 inches thick, strikes N. 65° E. Rusty stain does not exceed 2 inches. In a surface sheet it measures an inch.

The plant includes, at the quarry, a 45-ton derrick hoisting engine, a small air compressor for two air plug drills, a large steam rock drill, and a steam pump, besides at the cutting shed a hand derrick and a 10-ton overhead crane.

The product is carted nearly 4 miles to the cutting shed at South Ryegate, and is used for hammered and rock-faced monuments and bases.

FRAZER QUARRY.

The Frazer quarry (formerly known as Hall's) is on the southwest side of the southeast spur of Blue Mountain, about 950 feet above South Ryegate. It was not in operation in 1907. The owner is Mrs. Margaret Hinchey, Hydeville, Vt.

The granite (specimen D, XXIX, 85, b), gray granite, is a quartz monzonite of light to medium gray shade and of medium inclining to coarse, even-grained texture, with feldspars up to 0.4 inch and mica to 0.2 inch. Its constituents, in descending order of abundance, are: Light smoky quartz with hair-like crystals of rutile and cavities in sheets, with a set of cracks parallel to them; milk-white soda-lime feldspar (oligoclase) somewhat kaolinized, with some small plates of white mica and a few grains of epidote. In places it is intergrown with quartz in vermicular structure; translucent bluish potash feldspar (microcline), some of it slightly kaolinized; biotite (black mica) and a little muscovite. Accessory: Titanite, allanite, apatite, zircon. Secondary: Kaolin, a white mica, epidote, and carbonate shown by slight effervescence with cold dilute muriatic acid.

While the general shade of this stone differs but little from that of the Morrison and Gibson quarries, the contrats between its minerals are much more marked.

The quarry measures about 300 feet square and from 5 to 20 feet in depth.

The sheets are normal and from 1 to 12 feet thick, dipping 25° SW. There is but one joint (southwest side), striking N. 70° W., dipping 35° N. 20° E. A flow structure of biotitic streaks and sheets strikes N. 70° W., and dips 45° N. 20° E. In the west half of quarry this is so prominent as probably to detract from the value of the stone. Rusty stain along sheet surfaces is up to 3 inches thick. (See, further, p. 26.)

The plant comprises two horse derricks.

The product must be carted 3½ miles to South Ryegate.

GROTON.

The Benzie quarry is in Groton about a mile S. 25° W. from the Wells River Bridge at Groton and 300 feet above it, and about 4½ miles S. 85° W. from Blue Mountain in Ryegate. (See fig. 7.) Operators, McCrae, Benzie & Co., Groton, Vt.

The granite (specimen D, XXIX, 80, a), "Vermont blue," is a quartz monzonite of medium, very bluish gray color and even-grained medium inclining to fine texture. Its constituents, in descending order of abundance, are: Clear, colorless to very light smoky or very light bluish quartz, with few cavities and brightly polarizing rift and grain cracks; light-bluish translucent soda-lime feldspar (oligoclase), somewhat kaolinized and with white fibrous mica, also a white mica in small scales, and some calcite; a little clear potash feldspar (microcline, also orthoclase), with inclusions of oligoclase, quartz, and biotite; biotite (black mica) and a little muscovite or bleached biotite. Some of the feldspars are minutely intergrown with quartz in vermicular structure. Accessory: Titanite, pyrite, zircon crystals, apatite, allanite. Secondary: Kaolin, a white mica, calcite, leucoxene. The granite effervesces with cold dilute muriatic acid.

This stone is brilliant and markedly bluish, but its mineral contrasts are feeble owing to fineness of texture and similarity in shade of feldspar and quartz.

The quarry, opened in 1896, measures about 200 by 175 feet and from 40 to 60 feet in depth.

The sheets are normal, from 1 to 10 feet thick, and range from the horizontal to a very low dip north and also east. There are three sets of joints: (A), striking N. 55° E. and vertical, spaced 15 to 50 feet, forms a rusty heading on the west wall, with short vertical subjoints at right angles to it; (B), striking N. 50° E. (diagonal to quarry), dipping 60° S. 50° E., discontinuous and at irregular intervals; (C), striking N. 20° W. and vertical, discontinuous and rare. The rift is reported as horizontal and the grain as vertical, with N. 55° E. course. There is a coarse "shake" structure in bands up to a foot thick parallel to the sheets, at points 25, 40, and 60 feet below the surface.* There are biotitic

*See glossary (p. 132); also Bull. U. S. Geol. Survey No. 354, p. 31.

masses on the west side parallel to joints (A), the course of which is also that of the grain, and thus also that of the flow. On the west wall is a dike of quartz monzonite (specimen D, XXIX, 80, b) 5 feet thick, of medium bluish-gray color and very fine, even-grained texture, with feldspars up to 0.1 and mica mostly under 0.05, exceptionally 0.1 inch. Its constituents are the same as those of the main granite. There are two dikes of similar quartz monzonite but of dark, slightly bluish-gray color and extremely fine texture, with feldspars up to 0.06 (exceptionally 0.1) and mica to 0.04 inch. These dikes are 6 and 2 inches thick, strike N. 5° and 20° E., and dip 70° E. and 90°. Several pegmatite dikes from 1 to 6 inches thick cross the entire quarry, cutting the first granite dike, some striking N. 17° W., others in various directions. There is also a 3-inch diabase dike on the west wall. It contains porphyritic augite crystals, some of which have been replaced by quartz or calcite or chlorite. A compressive strain is reported here as from all directions. Rusty stain is only an inch thick on sheets 10 feet below the surface.

The plant at the quarry consists of a 50-ton derrick, hoisting engine, steam pump, and large rock drill, to which were added in 1908 a 90-foot derrick and an air compressor with a capacity of 130 cubic feet of air per minute, sufficient for two large rock drills and four air-plug drills. At the cutting shed there are two hand derricks, two steam derricks, an air compressor, two surfacers, 20 air hand tools, two steam engines, and three polishers.

The product is carted $1\frac{1}{2}$ miles to the cutting shed at Groton. It is used for monuments and buildings. The fine stone of the granite dike is used for special orders and carved work. Examples are the Davison monument at Woodsville, N. H., and the Dr. S. N. Eastman monument at Groton, Vt.

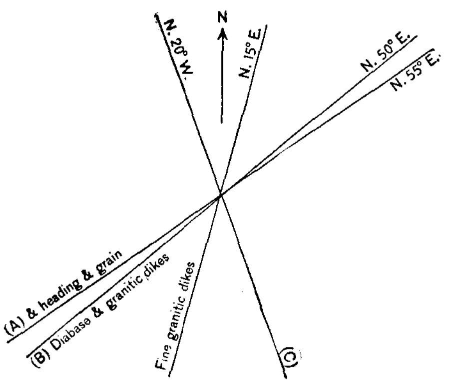


FIGURE 8—Structure at Benzie quarry, Groton.

ORANGE COUNTY.

The quarries of Orange County are in Williamstown, but as these closely adjoin those of Barre, as shown on the map (Pl. XXI), they will be considered in connection with the Barre quarries. (See pp .151, 153.) A quarry in Topsham and a prospect in Randolph properly belong here.

TOPSHAM.

Granite was formerly quarried at two points in Topsham. One was very near the village of South Ryegate, the other on

Pine Mountain about south-southeast of Groton.* Hitchcock and Hager's geologic map represents a granite area extending from Groton into Topsham, but it seems too far west. (See map, fig. 7.)

The Ricker quarry is in Topsham at the west foot of Pine Mountain, roughly about $5\frac{1}{2}$ miles west-southwest of Blue Mountain, $2\frac{1}{4}$ miles southeast of the Benzie quarry, and $2\frac{3}{4}$ miles south-southeast of Groton and 490 feet above it. (See fig. 7.) Owner is Isaac A. Ricker, Groton, Vt.

The granite (specimen D, XXIX, 87, a), "Pine Mountain," is a quartz monzonite of medium bluish-gray color and medium, somewhat even-grained texture with feldspar up to 0.4 inch and mica to 0.1 inch, but with sparse, clear, porphyritic feldspars, including all the other chief constituents. The stone is not quite so bluish as that of the Benzie quarry in Groton, nor do its feldspars seem to be as evenly distributed. Its constituents, in descending order of abundance, are clear colorless to very pale smoky quartz with cavities in intersecting sheets; bluish translucent to milk-white soda-lime feldspar (oligoclase) somewhat kaolinized and micacized, and with calcite; clear potash feldspar (microcline and orthoclase) inclosing oligoclase, quartz and biotite; biotite (black mica); and a little muscovite or bleached biotite. Accessory: Titanite, allanite, apatite, zircon. Secondary: Kaolin, a white mica, calcite, zoisite. There is some intergrowth of feldspar and quartz. The stone effervesces with cold dilute muriatic acid.

The porphyritic clear feldspar enhance the brilliancy of the rough surface. Its contrasts are greater than those of the Benzie quarry stone, but there are minute rust spots on the long-exposed blocks about the quarry, the cause of which was not manifest.

The quarry is about 40 by 32 feet and the working face on the east is 20 feet high from the road and quarry level. It has been idle a number of years.

The sheets, from 5 to 12 feet thick at their widest parts, are normal and horizontal or inclined as high as 10° N. 45° W. There are two sets of joints: (a), striking N. 70° E., vertical forms the north wall, and a 25-foot heading north of it with joints 2 to 4 feet apart, and another on the south wall; (b), striking N. 40° E. and dipping 55° N. 45° W., forms the east wall and recurs 10 feet east. The flow structure has a N. 35° E. course. Vertical pegmatite dikes up to 1.5 inches thick strike N. 25° W. Aplite dikes up to 1 inch thick strike N. 45° and 55° E.

The product was carted about 3 miles to rail at Groton, 490 feet lower.

RANDOLPH.

Beedle's prospect is in the west corner of the town of Randolph between the Bethel line and the west branch of White River,

*This last, here described, is probably the one referred to by the state geologist in 1900 as operated then by the Pine Mountain Granite Company. (See Perkins, G. H., Mineral resources of Vermont, 1899–1900, p. 75.)

in school district 11, three-fourths of a mile west and southwest of the Vermont Central Railroad, which here describes a curve. It is on the farm of A. H. Beedle of Randolph, Vt. (See fig. 20.) The particulars were obtained by Professor Perkins.

According to the state geologic map of 1861 this granite should be on the west side of the western belt of "clay slate," but no granite is shown on the map in this town.

The granite (specimen D, XXIX, 100, a, and b), fine white granite, is a quartz monzonite of extremely light gray shade without any mica spots. It is lighter than "Dummerston white" but not as white as that of Bethel when the rough faces are compared, and its slight grayness has a tinge of green in it. Its texture is even-grained and fine with feldspars nearly all under 0.1 inch and none over 0.15 inch. Its constituents, in descending order of abundance, are: Milk-white striated soda-lime feldspar (albite to oligoclase-albite), some of it intergrown with potash feldspar (microcline), the latter forming, however, but a small portion of the particle (the soda-lime feldspar is more or less kaolinized and micacized); colorless, clear quartz with fluidal and other cavities, rarely with hairlike crystals of rutile; very little separate potash feldspar (microcline) in minor particles; muscovite (white mica) in scales up to 0.37 millimeter. The accessory minerals are zircon, apatite, and rutile. No magnetite or pyrite was detected. The secondary minerals are kaolin, a white mica, rather abundant epidote, and zoisite in irregular particles up to 0.5 millimeter, exceptionally 0.75 millimeter, accounting for the greenish tinge (this is really the fifth mineral in order of abundance); a little calcite and rare chlorite scales up to 0.22, exceptionally 0.75 millimeter, reenforcing the greenish tinge.

An estimate of the mineral percentages made by applying the Rosiwal method to a camera lucida drawing of a thin section enlarged 40 diameters yields these results with a mesh of 1 inch and a total linear length of 34 inches.

Estimated mineral Percentages in fine white granite of Randolph.

Feldspar	76.5
Quartz	21.2
Mica	2.3
	100.0

The average diameter of the particles obtained from the same calculation is 0.0049 inch; that of the feldspar, 0.0083 inch; of the quartz, 0.0032 inch; and of the mica, 0.0024 inch.

The stone effervesces slightly with cold dilute muriatic acid. W. T. Schaller, chemist, of the United States Geological Survey, finds that it contains 0.37 per cent. of CaO (lime) soluble in warm dilute (10 per cent) acetic acid, which indicates a content of 0.66 per cent of $CaCO_3$ (lime carbonate, calcite) which mineral also appears in thin section.

The stone takes a high polish, as the absence of all but very minute mica plates implies. Being a quartz monzonite, and being also free from mica spots, it will probably hammer quite as white as the quartz monzonite from Bethel. The hand specimens show traces of rift or flow structure.

There are no data as to size of outcrop or as to structure. The principal opening is 60 by 30 feet.

ORLEANS COUNTY.

Newport Granite Company's Quarry.

The Newport Granite Company's quarry is near the center of the town of Derby and about 4 miles roughly east of the city of Newport, on Lake Memphremagog. Operator, George R. Farquharson, Newport, Vt.

The granite (specimen D, XXIX, 75, a), gray granite, is a quartz monzonite, with both biotite and muscovite, of light bluish-gray color and even-grained, medium inclined to fine texture with feldspars up to 0.25 and 0.3 inch, and mica to 0.15 inch. Its constituents, in descending order of abundance, are: Light smoky quartz with hairlike crystals of rutile, fluidal and other cavities in sheets with cracks parallel to and in places coinciding with them; clear to bluish milk-white striated soda-lime feldspar (oligoclase), mostly much kaolinized and somewhat micacized, also intergrown in places with quartz in vermicular structure; clear to translucent bluish potash feldspar (microcline and orthoclase) slightly kaolinized; biotite (black mica); muscovite (white mica). Accessory: Apatite, titanite, allanite, rutile. No magnetite or pyrite was detected. Secondary: kaolin, a white mica, and calcite from chemical test.

There is no effervescence with cold dilute muriatic acid, but W. T. Schaller, chemist, of the United States Geological Survey, finds that it contains 0.05 per cent. of CaO (lime) soluble in warm, dilute (10 per cent.) acetic acid, which indicates the presence of nearly 0.09 per cent of $CaCO_3$ (lime carbonate, calcite), which is very slight indeed.

The shade of this stone is between that of "light Barre" and that of the granite of Hallowell, Me. It has more black mica than "light Barre" and stronger contrasts. These are bright between the black mica, the feldspar, and an intermediate shade formed by the muscovite and quartz together. The stone should hammer lighter than a biotite-muscovite granite.*

The quarry, opened about 1880, measures about 300 feet N. 45° W. by 250 feet N. 55° E., and averages 20 feet in depth.

The sheets, from 3 to 18 feet thick, dip 20° S. 55° W. They "grow together," that is, sheet structure is undeveloped in the western part of the quarry, making masses 22 to 25 feet thick.

*See a recent reference to this stone and quarry in Richardson, C. H., The geology of Newport, Troy, and Coventry: Rept. State Geologist of Vermont, 1908, p. 280 and Pl. LVIII

One set of vertical joints, discontinuous, strikes N. 55° W., is spaced 10, 30 and 100 feet and forms a heading on the north wall. At the northeast corner there is a trace of a transverse set. The rift is reported as horizontal and the grain as vertical with N. 55° E. course. Both are marked. Flow structure, consisting of muscovite and biotitic bands, is vertical with N. 50° E. course. The muscovite scales in these bands measure up to 0.25 inch. There are very irregular biotitic surfaces in the eastern part of quarry, resembling tree roots in form. Associated with them are non-micaceous lighter tortuous band. These are presumably irregularities in the flow structure. A "shake structure" up to 5 inches thick occurs on some sheet surfaces, and the rock there is passing into sand. The contact here has already been alluded to on page 83. A north-south compressive strain is reported by the foreman. There is no "sap" on the sheet surfaces.

The plant consists of one 40-ton and two 20-ton derricks, three hoisting engines, an air compressor (capacity 292 cubic feet of air per minute), four large rock drills, fifteen air plug drills. and three steam pumps.

The product is carted 4 miles to the railroad at Newport. It is used for monuments and buildings, and finds its chief market in the West. Specimen: The prison ship martyrs' monument in Fort Greene Park, Brooklyn, N. Y. Height, 150 feet, shaft 18 feet in diameter at base and 14 feet at top.

PARMENTER QUARRY.

The Parmenter quarry, visited in 1909, is in Derby Township, near Beebe Plain, close to the Canada line and about a mile east of Lake Memphremagog. Operator, W. H. Parmenter, North Derby, Vt.

The granite (specimen D. XXX, 72, a), light granite, not examined microscopically, is either a biotite granite or a biotite-quartz monzonite of very light gray shade and even-grained medium texture, with feldspars up to 0.3 and micas to 0.2 inch. Its constituents are slightly bluish milk-white feldspars, light-smoky quartz, and biotite (black mica). It effervesces slightly with acid test.

The general shade of this granite is lighter than that of North Jay and darker than that of Bethel, or nearly the same as that of 'West Dummerston white" but with more conspicuous black micas.

The quarry, recently opened, is 40 by 25 feet in area and 10 feet deep.

The sheets, 2 to 5 feet thick, are insufficiently exposed but appear to undulate horizontally. Joints (a) strike N. 50° W., dip 60° SW., are spaced 10 to over 20 feet. Joints (b) strike N. 30° E., dip 80° S. 60° E., one only. The rift is reported as horizontal and grain vertical with N. 50° E. course. In a larger quarry on the Canadian side, a few hundred feet from the other, worked by the same operator, granite of the same mass and character has sheets 10 feet thick and a flow structure with N. 60° W. course.

The plant consists of one hand derrick.

The product is carted half a mile to a siding on the Canadian Pacific Railway at North Derby and is used for hammered monuments or bases.

WASHINGTON COUNTY.

The quarries are in Barre, Cabot, Calais, and Woodbury. Those of Williamstown, in Orange County, will be described in connection with those of Barre, as they belong to the same group and their granite is continuous and identical.

BARRE AND WILLIAMSTOWN.

Topography.

The city of Barre lies about 5 miles southeast of Montpelier and the Barre quarries are 3 miles farther southeast, near the southeast corner of the township of Barre, and a few of them are in Williamstown, in Orange County, which adjoins Barre on the south. The city of Barre lies on Stephens Brook, a tributary of the Winooski, which empties into Lake Champlain. About half a mile south-southeast of Barre City this brook receives a tributary from the southeast, known as Jail River. Some $2\frac{1}{2}$ miles southeast of the city this river flows through a canyon-like gorge between flat-topped masses of sand, clay, and bowlders over 200 feet thick. A little north of Jail River at this point a roundish granite mass, known as Cobble Hill, rises to a height of 1,100 feet, by aneroid, above the city; and 2 miles about southwest of this hill and a little south of the river another granite mass, known as Millstone Hill, rises to a height of 1,200 feet, by aneroid, above the city. Fifty-six quarries are grouped about these two granite masses, and of these 52 are about Millstone Hill. The section (fig. 9) will serve to convey a general idea of the surface features described. The locations and designations of the Millstone Hill quarries are given in Plate XXI.

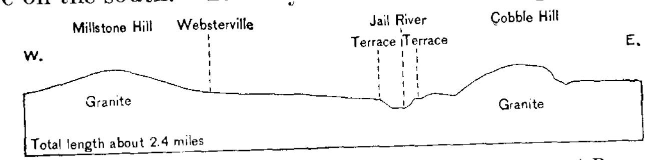


FIGURE 9—General topographic section through granite mass at Barre. Scale, 194 feet to 0.1 inch.

General Geology.

The geology of the granite area of Barre was last treated by George I. Finlay.*

*The granite area of Barre, Vt.: Rept. Vermont State Geologist (3), 1902, pp. 46–59 and Pl. IV.

His map shows that he regards the two granite hills as parts of one granite area with a north-northeast trend over 4 miles long by $1\frac{1}{2}$ wide, surrounded by slate and schist. Its representation on the state geologic map of 1861 is not far different. The writer's time was too short to enable him to trace the boundaries of the granite and schist, nor was a map suitable for such purpose available. Finlay represents a shist tongue crossing Millstone Hill diagonally from northwest to southeast, and Cobble Hill as all granite, but the writer found schist on the north side of the top of the Cobble, without, however, determining its northern limit. The schist capping also crops out at Jones Brothers' and Barclay's quarries, and near the Marr & Gordon quarry of the Consolidated Company (Nos. 10, 12, 26 in Pl. XXI), and in Websterville. Some of these schist masses are probably lesser bands still lying on the Granite, which Finlay states were too small to enter on his small-scale map. The strike of the foliation of the schist about the quarries varies from N. to N. 60° E., and the dip is steep west or 90°. In a group of quarries south-southeast of Millstone Hill it strikes uniformly from N. 30° to 35° E.

These are the chief geologic features of the Barre district. Four formations are represented: (1) The schist, a metamorphosed marine argillaceous and calcareous sediment of unknown thickness, underlying the city and surrounding the granite area; (2) the granite, of igneous origin, intruded in the schist and forming two domes, 2 miles apart, with an intervening depression, which in consequence of the erosion of the schist now project through it; (3) certain dark basic dikes of later date cutting the granite and the schist also; (4) finally, masses of sand, clay, and bowlders, over 200 feet thick in the hollow between the domes, of glacial origin, overlying the schist and part of the granite.

The geologic age of schist and granite have been discussed on page 83, and their probable history was sketched on page 86.

As many as seven different sets of surface forms have existed here: (1) The original surface of the sediments of clay and sand before their emergence from the sea; (2) the surface of those sediments after their metamorphism into schist and before the granitic intrusion; (3) the surface of the schist mass as modified by the granitic intrusion; (4) the surface of the schist and granite masses which resulted from the long period of preglacial erosion; (5) the original surface of the superimposed glacial deposits; (6) the surface of the glacial deposits as modified by glacial lake levels; (7) the surfaces produced in both unmodified and modified glacial deposits by post-glacial streams. It is assumed in this outline that any modifications of the eroded rock surface by the glacier were unimportant, and the surface of the ice sheet itself has not been considered.

The present surface is evidently of complex origin. Parts of it were formed under (4), (5), (6), and (7). Wherever no glacial deposits were formed or wherever they were afterward removed we have the surface (4). In the gorge between Millstone and Cobble Hills, as shown in figure 12, the coarse and fine glacial deposits have a nearly level surface, which is probably due to terracing by a glacial lake (6). These opposite terraces may have been continuous but the gorge itself is partly or entirely the result of the cutting of the terraced glacial deposits (7). In places the processes of (7) have exposed the schist surface formed by (5) and made small inroads upon it.

The schist of Barre varies much in character. A few observations were made and specimens collected. In many places it contains lenses and beds of calcareous quartzose rock. On Brook avenue, in the northwest part of the city, a mass of this dips 30° to 40° about southwest, but with traces of plicated bedding in the opposite direction. It is a very dark gray fine-grained *quartzose crystalline limestone*. The sections show quartz particles to 0.24 millimeter in a cement of calcite plates with rare muscovite scales and many minute black (carbonaceous?) particles. At the other end of the city near the covered bridge over Jail River it is a very fine black roofing slate with minute secondary plications, and spangled with black tabular crystals up to 0.1 inch across, probably of ilmenite. The microscope shows it to be a *muscovite-quartz slate* with a little biotite and chlorite. Part of the outcrop is a muscovite schist with quartz and calcite and spangled with biotite scales lying across the schistosity, also with rhombic plates of chlorite and ilmenite up to 0.2 inch. Near quarry No. 26 (Pl.XXI) a 3-foot thick granitic dike crosses the schist. This proves to be a light-gray fine-textured porphyritic biotite granite differing from "Barre granite" mainly in texture. There are here and there within the granite area strips of schist which are parts of the original capping left by erosion. There are also blocks of schist within the granite (inclusions) which probably dropped into the rising semiliquid granite from the under side of the fractured capping. These are described more fully on pages 88-89.

The pegmatite and aplite dikes which traverse the granite belong to a later stage of the period of intrusion, but after the consolidation of the granite. The basic dikes described later (p. 123) and referred to by Finlay* belong to a still later date. He describes as camptonite a 5-foot thick dike which crosses the schist just south of Barre on the road to South Barre, and he illustrates its spheroidal weathering.

"BARRE GRANITE."

"Barre granite" is known commercially as "dark Barre," "medium Barre," and "light Barre," with some exceptional "very dark Barre" and "white Barre." It appears to be everywhere a biotite granite in which the orthoclase is considerably kaolinized and micacized, but the microcline is fresh. The dark stone of the Milne & Wylie quarry and of the Jones dark quarry shows such

*Op. cit., pp. 49, 50, Pl. VI.

a contrast between its hammered and polished faces as to indicate that the amount of soda-lime feldspar in it is larger than it is in the other granites of Barre or in biotite granites generally, and the thin sections show considerable plagioclase altered like the orthoclase. But Whitman Cross, of the United States Geological Survey, found a specimen of "dark Barre" quarried by Wells, Lamson & Co. to be a typical biotite-muscovite granite in which the amount of plagioclase (soda-lime feldspar) was so small as to place it among the accessory constituents.

The various shade designations of this granite are due in part to the different degree of kaolinization and micacization of its orthoclase feldspar, causing it to range from a translucent bluish gray to milk-white, and in part also to the varying content of black mica. Technically its shades are here defined as: (1) *Very light gray* (Wheaton quarry), equivalent to that of North Jay, Me.; (2) *light inclining to medium, slightly bluish gray* (Jones light quarry), between that of North Jay and of Hallowell, Me.; (3) *light medium bluish gray* (Smith upper quarry), between that of Hallowell, Me., and Concord, N. H.; (4) *medium bluish gray* (Duffee quarry), a trifle darker than "Concord granite;" less (5) *dark inclining to medium bluish gray* (Bruce quarry); (6) *dark bluish gray* (Marr & Gordon quarry); (7) *very dark bluish gray* (Marr & Gordon quarry knots), equivalent to "dark Quincy." The chief product consists of (3), (4), and (5). The dark shades occur near the Williamstown line, the light near the top of Millstone Hill on its south and southwest sides, and also about three-fifths of a mile south-southwest of the top. The cause of this distribution is not evident.

Its texture ranges from fine to medium; that is, with feldspars up to 0.2 and 0.4 inch, generally, however, not exceeding 0.2 inch, few reaching 0.3 inch, so that it may be generally designated fine inclining to medium or medium inclining to fine. But the light granites of the Bond & Whitcomb quarry on Millstone Hill and of the Wheaton quarry on Cobble Hill are of medium texture with feldspars to 0.4 inch. Its mica particles range up to 0.1 and 0.2 inch, but in the "very dark" to 0.3 inch.

Its constituents, in descending order of abundance, are: (a) Clear colorless or bluish to translucent, and milk-white potash feldspar (orthoclase, kaolinized, and micacized, and less of clear microcline, rarely intergrown with a little soda-lime feldspar); (b) light smoky quartz, showing optical effects of strain, rarely with rutile needles, generally with fluidal and other cavities in sheets, and with rift cracks parallel to or coinciding with them, and in some sections with another set, of fewer and shorter sheets of such cavities, at right angles to the other and with grain cracks parallel to them (in one place the rift cracks extend into the feldspar and are there filled with fibrous muscovite);† (c) translucent

*See Nineteenth Ann. Rept. U. S. Geol. Survey, pt. 6, continued, 1898, p. 224.

†Finlay (op. cit., p. 54) describes these rift cracks as crossing from one quartz crystal particle to another without interruption, and as containing arborescent crystalline growths, possibly of manganese dioxide.

to milk-white soda-lime feldspar (oligoclase-albite to oligoclase and olgoclase-andesine), some of it with flexed twining lamellæ, more or less kaolinized and micacized, and in places with calcite; (d) biotite (black mica), some of it chloritized; (e) a little muscovite or bleached biotite. The accessory minerals are pyrite, magnetite, titanite, allanite, apatite, zircon, rutile. The secondary are calcite, abundant within the orthoclase, one or two white micas, epidote, and chlorite. Minute veinlets of quartz, of calcite and of epidote occur exceptionally.

An estimate of the mineral percentages made by the Rosiwal method on a piece of "dark" yielded these results:

Estimated mineral percentages in "dark Barre" granite.

Feldspar	65.522
Quartz	26.578
Mica	7.900
	100.000

All the "Barre granites" effervesce with cold dilute muriatic acid. W. T. Schaller, chemist, of the United States Geological Survey, finds that the "light Barre" contains 0.49 per cent. of CaO (lime), soluble in warm dilute (10 per cent.) acetic acid, and the dark 0.63 per cent., indicating a content of 0.87 and 1.12 per cent of $CaCO_3$ (lime carbonate, calcite), respectively, the presence of which mineral is also shown by the microscope.

Finlay's analysis of the darker granite from the area south of Millstone Hill is given here for reference.*

Analysis of "dark Barre" granite.

SiO_2 (silica)	69.89
Al_2O (lumina)	15.08
Fe_2O_3 (iron sesquioxide)	1.04
FeO (iron oxide)	1.46
MgO (magnesia)	.66
CaO (lime)	2.07
Na_2O (soda)	4.73
K_2O (potash)	4.29
H_2O at 110° (water uncombined)	.31
H_2O ignition (water combined)	.23
P_2O_5 (phosphorus pentoxide)	Trace.
	99.76

W. C. Day found the specific gravity of "dark Barre" and "medium Barre" to be 2.662 to 2.672, and its crushing strength to range from 14,968 to 19,957 pounds per square inch. (See p. 144.) L. P. Kinnicutt in 1908 found that 100 pounds of "Barre granite" absorb 0.294 pound of water. (See p. 179.)

"Barre granite" is mostly monumental, but some is building granite. The light, medium, and dark monumental stone, al-

*Op. cit., pp. 55, 56.

though brilliant in the rough, has weak mineral contrasts, but these are stronger on the polished face of the dark. The white of the more kaolinized and micacized orthoclase feldspars and the black of the mica, and the combined bluish gray of some of the feldspar and smoke color of the quartz form three distinct shades, but owing to the fineness of the texture these merge a few feet away, and the white alone shows against a dark-gray ground. "Light Barre" granite is never polished, but is hammered, because of the feeble contrast between the polished and cut surface, but the dark is often used for polished work. Its polish is fair, and the contrast between the polished and cut face is more marked along the hard way than in the rift or grain directions. In the Milne & Wylie and Jones dark quarry stone this contrast is so marked as to imply the presence of considerable soda-lime feldspar, for the contrast is almost as great as in a quartz monzonite. The polished face shows pyrite and a little magnetite.

Geology of Barre Quarries.

The granite was observed in contact with the schist at seven quarries (Pl. XXII, Nos. 6, 8, 9, 10, 12, 20). The results of a study of the contact phenomena at two of these are given on pages 89–92.

The schist inclusions have already been dwelt upon (pp. 88–89). At two quarries (Pl. XXI, Nos. 6, 32) these inclusions have been penetrated by minute dikes of granite and pegmatite preeeding from the granite, as has been the schist capping. At one of these quarries the granite is darkened for a space of 7 feet from the inclusion.

The sheet structure of Millstone Hill appears to form a more or less unsymmetrical flattish dome. The central part of this is exposed at the Wetmore and Morse quarry (Pl. XXI, No. 14), where the sheets dip from the horizontal both eastward and westward 10°. West-southwest of that point and lower down, at the Smith upper quarry (Pl. XXI, No. 15), they dip 10° to 15° SW., and so also in the Duffee quarry; still farther down, at the Smith lower quarry (Pl. XXI, No. 17), they dip 20° to 30° SW. On the northeast side, at the Bond & Whitcomb quarry (Pl. XXI, No. 19), the sheets dip low to the northeast, and at the next quarry (Pl. XXI, No. 26) 15° E.; at the Canton quarry (No. 21) 10° N., but at the Barney quarry (No. 20) 10° NE. and NW. At the Walker quarry (No. 23) low east and northeast. An east-northeast to west-northwest section of the hill passing through the quarries named would thus give a general low anticlinal structure.

The sheets of Cobble Hill also form a dome, for at the Wheaton quarry, north-northwest of the top, they dip 10° NW. and NNE., but on the southwest side of the hill, at the Wildbur quarry, they dip 60° S. 75° W., and at the Bianchi quarry, farther south, 35° S. 50° W. But the sheet structure half a mile southeast of Millstone Hill (Jones and Consolidated quarries) and toward the Williamstown line is too complex to unravel. The sheets are lenticular and

PL. XXIII.

Gneiss in Granite Millstone Hill.

normal at only 21 out of the 41 quarries visited. These 21 quarries include, besides those named above, the small group of quarries in the northwest corner of the map (Pl. XXI), also the Milne & Wylie, the Anderson, Acme, O'Herin, Wells-Lamson, and Pruneau quarries, also the Pirie in Williamstown. In the remaining 20 quarries the sheets are more or less irregular or absent. In places the lenses are very short and thick, in others, as in the large Jones Bros. quarry, there are only traces of sheets. In several quarries, as the Manufacturers and Anderson quarries, the sheets "grow on"—that is, the sheet partings stop laterally, leaving the center or half of the quarry without sheets. In several quarries sheet structure stops vertically at depths of 20, 25, or 35 feet from the rock surface; for example, at the Barclay, Capital, and Milne quarries. At the Smith lower quarry there is a mass 58 feet thick without sheets; at the Bruce, one such of 48 feet; at another of 40 feet, and at the Marr & Gordon of 80 feet. At some quarries there is no trace of sheet structure. This incomplete development of sheet structure is the chief difficulty in quarrying at Barre. Wherever low dipping joints occur these are utilized as sheets, but where such are wanting horizontal channeling has to be resorted to, which is expensive. The sheets range from 6 inches to 30 feet in thickness. At the Wells-Lamson quarry the "toe-nail" structure intersects the sheets. At one quarry a sheet surface is slickensided.

There are ten sets of joints: (a), striking N. 5° W. to 10° E.; (b) N. 15° to 20° E.; (c) N. 30° to 40° E.; (d) N. 45° to 55° E.; (e) N. 60° to 70° E.; (f) N. 75° to 90° E.; (g) N. 60° to 80° W.; (h) N. 45° to 50° W.; (i) N. 30° to 40° W.; (j) N. 10° to 25° W. Of these (c) occurs at 21 and (f) at 18 quarries. The next most frequent are (e) and (i), each at 10 quarries, and (j) at 8. These joints divide themselves into five complementary sets; that is, sets at right angles to one another and presumably due to the same strain. These sets consist of (a) and (f), (b) and (g), (c) and (h), (d) and (i), and (e) and (j). The spacing of the joints ranges from 1 to 200 feet. In 26 quarries the spacing ranges from a minimum of 1 to 8 feet to a maximum of 20 to 50 feet; in 18 quarries from a minimum of 10 to a maximum of 100 to 200 feet. Many of the joints are intermittent or discontinuous. In some quarries joints of the same strike incline in opposite directions, as shown in figure 11.

Some joints are coated with limonite and calcite; others with a greenish, usually slickensided film of muscovte, secondary quartz, and chlorite. Back of it the feldspars are microscopically brecciated and cemented with fibrous muscovite, also minutely veined with calcite and quartz. These veins run at right angles to the face. Some joint faces are very uneven and their minor protuberances slickensided. Other joint faces are coated with somewhat large muscovite scales. The slickensides of joints usually have their furrows pointing in the direction of the dip of the joint, indicating motion up or down along the dip.

Headings are numerous and usually rusty. On the northwest wall of the Marr & Gordon quarry the central part (25 feet) of a heading striking N. 35° E. branches off to the northwest; and at another quarry (p. 147) a heading undulates back and forth laterally.

Flow structure is rarely observable. At the Wells-Lamson quarry (Pl. XXI, No. 24) a 12-inch band of darker granite shows the flow to have been N. 70° E., with an inclination of 60° N. 20° W. On Cobble Hill (Bianchi quarry) it is about north and vertical. At the Barney quarry for a space of 15 feet from the contact with schist the granite is coarse and fine in alternating bands.

Segregations are uncommon. At the Sanguinetti quarry (Pl. XXI, No. 18) the granite is concentrically banded in a pear-shaped mass, 1 and 2 feet in its diameters. Biotitic knots are rare and small. One 1.5 by 0.5 inch was noted. Possibly the darker, more biotitic, irregular roundish portions of the granite near the schist contacts at the Marr & Gordon and Jones dark quarries (pp. 129, 152) are of the nature of segregations.

The rift as reported by foremen is everywhere vertical and the grain in all but two quarries is horizontal. The course of the rift about Millstone Hill and in Williamstown appears to range from N. 30°, 35°, 40°, 42°, 50°, 55° to 60° E. and on Cobble Hill from N. 50° to 75° E. In the group of quarries about the Boutwell and Bruce quarries and the adjoining ones in Williamstown the rift ranges from N. 50° to 60° E., but near the top of Millstone Hill (Duffee, Bond & Whitcomb) from N. 30° to 40° E. At the Capital and Barre quarries (Pl. XXI, Nos. 29, 33) it is reported as varying in different blocks. At the Anderson quarry (Pl. XXI, No. 8) as N. 60° E., and the grain, here better than rift, as dipping 20° N.; but at the Jones light quarry, only 1,500 feet away, the rift is reported as N. 35° E. and the grain as horizontal. At the Pirie quarry the grain is reported as dipping 35° N. 30° W. The courses of rift and grain are thus far from uniform, and the cause of their variation is not apparent. It is to be noted, however, that the general course of the rift has a range like that of the strike of the schist foliation, which suggests the possibility of both being due to the same cause.

Pegmatite dikes are not abundant. The Pirie quarry is crossed by one 3 feet 6 inches wide, with a N. 65° E. course, consisting almost entirely of light bluish-gray feldspars, and with a 6-inch biotitic border on either side with biotite crystals pointing toward the center. This dike has small lateral branches up to a foot long. A 1-foot pegmatite dike intervenes between schist and granite at the Anderson quarry (see fig. 3), and the schist capping is injected with minute dikes of pegmatite up to 4 feet long. (See p. 91.) At the Barney quarry a pegmatite lens occurs between granite and schist. A muscovite and feldspar (1.75 inches thick) coating on a joint plane at the Pruneau quarry (p. 79) is probably of pegmatitic origin, and likewise one of quartz and muscovite at the Manufacturers' quarry (p. 149).

Aplite occurs in irregular veinlike masses in contact with schist inclusions at two quarries. Specimen D, XXIX, 14, a, from the Jones dark quarry, is of light medium bluish greenish gray and of very fine texture with mica up to 0.05 inch, its other minerals not distinguishable. In thin section this consists of microcline, kaolinized albite to oligoclase-albite, and quartz with a little biotite, some of it chloritized, and still less muscovite or bleached biatite. It contains allanite and carbonate. Specimen 44, c, from the Bailey quarry, is of light medium purplish gray and of porphyritic texture. It consists of light purplish gray to milk-white feldspar, clear quartz, and black mica. The particles of matrix are from 0.025 to 0.1 millimeter in diameter. The porphyritic crystals (mostly oligoclase-albite, some with zonally arranged quartz, rarely microcline) measure from 0.25 to 1 by 0.5 millimeter. Pyrite is accessory.

Quartz veins, from 0.05 to 2 inches wide, are more abundant. At the Milne quarry (Pl. XXI, No. 34) veins of smoky quartz with diagonal fractures recur at intervals of 3 feet with a N. 60° E. course.* The granite for 0.2 inch next to a vein is largely feldspar. Along the edge of the vein there are bands of fibrous muscovite, and in places, streaks of granulated quartz. Sheets of fluidal cavities run discontinuously parallel to the vein and at right angles to it, and cracks here and there with granular quartz zigzag along these directions. Similar veins with pegmatite strike N. 40° E. Both are evidently of pegmatitic origin. At the Boutwell quarry (see p. 125 and fig. 10) the granite parts along minute veins of quartz and muscovite with N. 10° E. course. Another little vein or dike with N. 80° E. course and 0.05 inch wide consists of alternating sets of contiguous quartz and feldspar particles. The quartz particles have sheets of cavities and cracks, both parallel to the course of the vein. It has also a border, 0.25 inch wide, on either side of bleached biotite or muscovite, with chlorite, fibrous muscovite, and feldspar veined with calcite, together with magnetite particles of some size staining the rock with limonite. Quartz veins also occur at the Canton and Pruneau quarries.

Basic dikes were noted at seven quarries. At three (Jones light, Capital and McIver & Matheson) the exposures may all belong to one dike, which would thus be one-half mile long; and as two others (Barney and Walker quarries) are clearly the same dike, thus 800 feet long, only four dikes were actually observed. The long one is from 2 feet 6 inches to 9 feet thick with a N. 40° to 45° E. course and vertical. The other, from 1 to 2 feet thick, has a N. 35° to 40° E. course. One at the Bond & Whitcomb quarry, up to 2 feet thick, has a N. 25° W. course and weathers spheroidally. One at the Bianchi quarry on Cobble Hill is 6 inches thick with a N. 55° E. course. Two of these dikes were examined in thin section: The Jones light quarry dike rock is a dark greenish diabase of very fine texture (labradorite, augite, magnetite, apatite, needles, secondary calcite). Its augite is

*Referred to in Bull. U. S. Geol. Survey No. 354, p. 44.

altered to a chlorite-like mineral giving the greenish color. The Bond & Whitcomb dike rock appears to be an altered camptionite of very dark gray shade and porphyritic texture with very fine matrix (plagioclase, micacized, kaolinized, and with calcite, magnetite in crystals, and skeleton crystals). The porphritic crystals or masses appear to be hornblende more or less altered to chlorite and calcite; one is replaced by quartz.

At three quarries the granite within 1 to 2 feet of these dikes is crossed by the vertical subjoints 1 to 6 inches apart parallel to the dike wall; and the granite scales off along them. These subjoints are to be regarded as the effect either of the heat of the dike or of the strain which accompanied its intrusion.

A north-south compressive strain is reported at the Bruce and Wells-Lamson quarries, and an east-west one at the Canton quarry.

The formation of granite sand by decomposition between sheet surfaces was noted at the Innes & Cruikshank quarry.

Rusty stain ("sap") along sheet surfaces varies greatly in amount. In many quarries it does not exceed 6 inches in thickness; in others it reaches 12, 16, and 18, and in one place 24 inches, but that was confined to the upper sheets. Generally it is confined to the lower surfaces of sheets. On joint faces it is from 6 to 24 inches, and abounds on headings.

In concluding this part of the subject attention is recalled to the evidence of minor mineral and structural changes brought out n this and the previous section. The rift and grain cracks in the quartz the straining of the quartz as shown by its optical behavior, the bending of the twinning lamellæ of the soda-lime feldspars, the formation of minute veins of secondary quartz, calcite, and epidote, the brecciation of feldspars and the formation of fibrous muscovite and of chlorite and of little veins of quartz and calcite in consequence of motion along joint planes, the formation of subjoints near basic dikes—all these facts point to crustal movements of different dates, some probably preceding the sheet and joint structure, others subsequent to it.

BOUTWELL QUARRY.

The Boutwell quarry is about south of the top of Millstone Hill, in Barre. (See Pl. XXI, No. 1.) Operator, Boutwell, Milne & Varnum Company, Barre, Vt. The granite, chiefly "dark Barre" (but also some "dark medium" and "medium"), is a biotite granite of dark, inclining to medium, bluish-gray shade and of fine, even-grained texture, with feldspars up to 0.2 inch and mica to 0.1 inch. Its shade, texture, constituents, and qualities correspond to those of the "dark" of the Bruce quarry described on page 126.

The quarry, opened about 1886, is somewhat T-shaped, measuring about 600 feet in a N. 80° E. direction by 60 feet north-south at the east end and 120 feet at the west end, with a 150-foot

square extension on the north side but only 150 feet from the west end. Its depth is from 50 to 100 feet.

The sheets are irregular, 4 to 30 feet thick, striking N. 30° E. and also east-west, and dipping 10°, 20°, and 35° N. 30° W. and north. Joint, rift, and dike courses are given in figure 10.

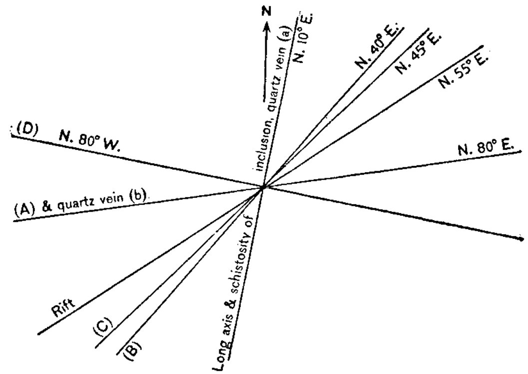


FIGURE 10—Structure at Boutwell quarry, Barre.

Joints (A) dip 55° to 70° S. 10° W., are spaced 5 to 50 feet, and form the north and south walls of the main part. They are mostly limonitic or slickensided with a lustrous greenish coating, described on page 121. (B) is vertical, discontinuous, only a few feet long, forms small headings, and is coated with calcite and limonite to 0.25 inch. One at the southeast corner dips 60° N. 40° W. (C) dips 10° S., exceptional, only a few feet long, with lustrous coating, as under (A). The rift is reported as vertical and grain as horizontal. Three large schist inclusions measure respectively 55 by 10 by over 6 feet; 20 by 4 by 3 feet; and 10 by 8 feet. The first has been described on page 88. A minute vein (a) of muscovite and quartz dips 50° E. The granite parts along it. Vein (b) is scarcely 0.05 inch wide, but has a border of dark bluish green (chloritic) or brown (limonitic), 0.25 inch wide on either side. (See further p. 123.) The "sap" is from 8 to 12 inches thick on the lower surfaces of sheets and is conspicuous in the headings.

The plant of this and the four other quarries operated by this company includes a 75-ton wooden derrick, one of 50, three of 40, four of 30 to 35, one of 25, two of 20, two of 10, and one of 5 tons; two hoisting engines (capacity, 15 tons on straight rope and 25 tons with multiplied power); two Blondin carriers (capacty 15 and 5 tons) and engines; an air compressor (compound Corliss, 640 cubic feet of air per minute); 33 steam rock drills; 57 air plug drills; 18 steam pumps; and a stone crusher.

Transportation is effected by siding and connections with the Central Vermont and the Montpelier and Wells River railroads.

The product is all for monumental use, and its market is general. A specimen of the product from all the quarries of this firm is the Joseph Smith memorial at South Royalton, Vt.

BRUCE QUARRY.

The Bruce quarry adjoins the Boutwell on the southwest and lies about south of the top of Millstone Hill, in Barre. (See Pl. XXI, No. 2). Operators, A. E. Bruce & Sons, Barre, Vt.

The granite (specimen D, XXIX, 12, a), "dark Barre," is a biotite granite of dark inclining to medium bluish-gray shade, and of even-grained fine texture, with feldspar up to 0.2 inch and mica to 0.1 inch. Its constituents, in descending order of abundance are translucent bluish-gray to milk-white potash feldspar (orthoclase, kaolinized and micacized, and a little clear microcline, one such orthoclase inclosing a fresh microcline); light smoky quartz, with cavities in sheets and with cracks parallel to them (the quartz shows optical effects of strain); milk-white soda-lime feldspar (oligoclase-albite), more or less altered, rarely with bent twinning planes; biotite (black mica); and a little muscovite or bleached biotite. Accessory: Titanite, magnetite, pyrite. Secondary: Not a little calcite within the orthoclase, kaolin, one or two white micas. The stone effervesces slightly with cold dilute muriatic acid.

Its mineral contrasts are feeble owing to fineness of texture and the lightness of quartz. There is some contrast between the polished and cut face along the hard way.

The quarry, opened in 1890, is about 250 feet in a N. 80° E. direction by 125 feet north-south and from 60 to 100 feet in depth.

The sheets are from 4 to 10 feet thick, and dip 5°-10° N. At the bottom is a mass 48 feet thick without sheets. There are three sets of joints: (a), striking N. 80° E., with varying dip, forms the south wall and an 8-foot heading on the north wall, spacing 10-20 feet, but makes wedge-shaped masses owing to varying dip; (b), diagonal, "slide," strikes N. 40° E., vertical, at northwest corner, with uneven slickensided face; (c), striking N. 20° W., dipping 70° N. 70° E., one in center. The rift and grain are as at Boutwell quarry. A heavy north-south compressive strain is reported.

The plant comprises three derricks (50 and 15 tons), one steam and one electric engine, three large rock drills, nine air plug drills, and two steam pumps. Compressed air is obtained from the plant of Jones Brothers.

Transportation is by siding, as shown on the map (Pl. XXI).

The product is used for monuments, and its market is general. Examples are the Calhoun Monument, Lexington, Ky., and 18 regimental monuments in the national cemetery at Chattanooga, Tenn.

MILNE & WYLIE QUARRY.

The Milne & Wylie quarry adjoins the Bruce quarry on the south, and lies about south of the top of Millstone Hill, in Barre. (See Pl. XXI, No. 3.) Operator, Boutwell, Milne & Varnum Company, Barre, Vt.

The granite (specimens D, XXIX, 11, a, b, c), "dark Barre" is a biotite granite of dark bluish-gray shade, a trifle darker than that of the Bruce quarry, and of even-grained fine inclining to medium texture with feldspars up to 0.3 inch and mica to 0.12 inch. Its constituents are the same as those of the Bruce and Marr & Gordon quarry stone described on pages 126, 128, but it contains considerable soda-lime feldspar, more or less kaolinized and micacized and with calcite. Its strong contrasts of shade between cut and polished faces also indicate the presence of an unusual amount of soda-lime feldspar, for a biotite granite. It effervesces with cold dilute muriatic acid.

An estimate of the mineral percentages by the Rosiwal method yields the following results with a mesh of 0.2 inch and a total linear length of 66.6 inches:

Estimate of mineral percentages in Milne & Wylie "dark Barre" granite.

Feldspar	65.522
Quartz	26.578
Mica	7.900
	100.000

The average size of all the particles obtained from the same measurements, adding 50 per cent. to the number of feldspar particles for the unseparated second feldspar, proves to be 0.069 inch, that of the feldspar 0.074, the quartz 0.079, and the mica 0.033 inch.

The polished face shows a little pyrite and less magnetite. The cut or hammered hard-way face is as light as the cut face of the Jones "light Barre," thus affording a very marked contrast with the polished face. The mineral contrasts in the rough are weak, but stronger on the polished face, white, black, bluish gray and smoke color being easily distinguished in it within a distance of 2 feet. The polish is fair.

The quarry, opened about 1887, is about 400 feet east-west by 200 feet across, but with a mass 100 by 50 feet projecting into the quarry from the east wall.

The sheets, from 3 to 30 feet thick, dip 20° to 30° NW. Joints, one set only, strike nearly east-west, dip 60° to 70° S., form the north and south walls and a heading which constitutes the projecting mass on the east wall. These joints, being spaced 3 to 20 feet, cut up the sheets.

The plant is included in that of the Boutwell quarry, and the transportation and product likewise.

EMPIRE QUARRY.

The Empire quarry is southwest of the Milne & Wylie quarry and about south-southwest of the top of Millstone Hill, in Barre, just north of the Williamstown line (See Pl. XXI, No. 4.). Operator, Boutwell, Milne & Varnum Company, Barre, Vt.

The granite is like that described from the Bruce quarry (p. 128).

The quarry, opened about 1888, is about 375 feet in a N. 75° E. direction by 200 feet across and from 75 to 120 feet in depth.

The sheets, from 3 to 18 feet thick, are somewhat irregular, dipping low, rarely 40° to 45° N. There are two sets of joints: (a), striking N. 65° to 70° E., dipping 65° to 70° S. 15° E., is spaced 4 to 25 feet, forms a heading on the north wall, a 10-foot one on the south wall, and a 25 foot one in the middle. This set exceptionally dips 65° to 70° N. 15° W., forming with the rest a V-shaped heading in the center of the quarry, as shown in figure 14. The faces of (a) are coated with limonite and bordered with its stain. The other set (b) is exceptional, striking N. 15° W., vertical. The rift and grain are as at adjoining quarries. There are three shist inclusions on the east wall, the largest 20 by 10 feet.

The plant, transportation, and product are covered by those items under the Boutwell quarry.

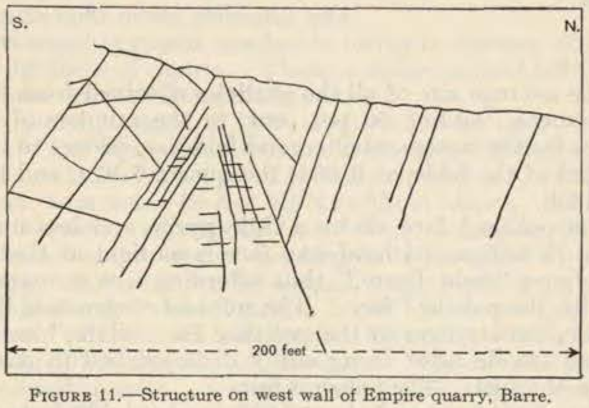


FIGURE 11.—Structure on west wall of Empire quarry, Barre.

MARR & GORDON QUARRY.

The Marr & Gordon quarry is east-southeast of the Empire quarry and about south-southwest of the top of Millstone Hill, in Barre, just north of the Williamstown line (See Pl. XXI, No. 5). Operator, Boutwell, Milne & Varnum Company, Barre, Vt.

The granite (specimens D, XXIX, 8, b, bb, d), "dark Barre" (derrick 9), is a biotite granite of dark bluish-gray shade and of even-grained fine texture with feldspars up to 0.2 inch and mica to 0.1 inch. Its constituents, in descending order of abundance, are: Bluish clear to translucent and milk-white potash feldspar (orthoclase, kaolinized and micacized, with a little clear microcline), some of it with minutely intergrown soda-line feldspar: light smoky quartz with cavities in sheets and showing marked optical effects of strain; translucent to milk-white soda-lime feld-

PLATE XXIV.

Sheet Quarry, Barre, E. L. Smith & Co.

spar (oligoclase to oligoclase-andesine) rarely with curved twinning lamellæ, more or less altered; biotite (black mica), rarely chloritized; very little muscovite or bleached biotite. Accessory: Pyrite, magnetite, zircon, titanite, apatite. Secondary: Calcite (in orthoclase), kaolin, one or two white micas, and chlorite.

The stone effervesces with cold dilute muriatic acid. W. T. Schaller, chemist, of the United States Geological Survey, finds that it contains 0.63 per cent. of CaO (lime) soluble in warm dilute (10 per cent.) acetic acid, which indicates a content of 1.12 per cent. of $CaCO_3$ (lime carbonate, calicite), the presence of which mineral is also shown by the microscope.

This granite is regarded by the firm as harder and darker than the "dark" from its other quarries. It resembles that of the Milne & Wylie quarry (p. 126), but when polished shows somewhat higher mineral contrasts. It takes a fair polish. The polished face shows some pyrite and magnetite.

At the west end of the quarry, near the contact of granite and schist, is a mass (so-called knot) of still darker granite of sufficient size for commercial use. This "very dark Barre" (Specimen D, XXIX, 8, a) is a biotite granite of very dark bluish gray shade, much darker than the "dark" and as dark as "dark Quincy*" and of fine inclining to medium, even-grained texture, with feldspars up to 0.2 inch and mica to 0.3 inch. Its constituents are the same as those of "dark Barre," specimen 8, b, etc., but the biotite is much more abundant. The second feldspar is oligoclase-albite. The stone effervesces with cold dilute muriatic acid.

In the main opening the sheets are unusually irregular. At the east end they are 18 to 20 feet thick, but in the northwest part for a depth of 80 feet there are none. In the small opening the sheets are more regular and from 4 to 14 feet thick. There is but one set of joints, striking N. 35° E. and vertical, forming a 20 to 25-foot heading on the northwest wall, also the northwest wall of the smaller opening, where it recurs at intervals of 3 to 10 feet. The heading in the main quarry branches off diagonally to the northwest, forming a band 20 to 30 feet wide, about halfway down the quarry. This unusual structure indicates complex strains. At the top of the west end the granite is in contact with a quartz-biotite schist spangled with biotite scales. The two rocks are firmly welded together in places across the foliation of the schist. Near this schist the granite is much darker from more abundant and larger biotite scales. (See p. 89.) The outline of the darker stone is quite irregular. The rift is reported as vertical, with N. 55° E. course, and the grain as horizontal.

The plant of these openings has been included in that of the Boutwell quarry, page 125.

Transportation is by sidings, as shown on the map (Pl. **XXI**).

*See Bull. U. S. Geol. Survey No. 354, p. 98.

BAILEY QUARRY.

The Bailey quarry is southeast of the Milne & Wylie quarry and about south of the top of Millstone Hill, in Barre. (See Pl. XXI, No. 6.) Operators, Woodbury & Bailey, Graniteville, Vt.

The granite, "dark Barre," is a biotite granite of dark shade and fine even-grained texture, similiar to that of the Bruce and the Milne & Wylie quarries.

The quarry is about 135 by 75 feet and from 10 to 35 feet in depth.

The sheets are imperfectly developed. There are two sets of joints: (a), striking N. 20° W., dipping 70° N. 70° E., is spaced 3 to 20 feet; (b), striking N. 60° E., dipping 75° S. 30° E., spaced 2 to 6 feet, occurs on the west side only. There the granite is in contact with schist which has a foliation strike of N. 60° E., dip of 35° N. 30° W., also one of N. 20° E., with vertical dip. At the northwest corner is a schist inclusion 26 by 5 feet, with a foliation striking N. 85° W. and a dip of 55° N. Dikes, large and minute, of pegmatite and aplite penetrate the schist capping and the inclusion, rendering the relations intricate. Some of the details are given on page 92.

The plant comprises a derrick and hoisting engine, an air compressor (capacity 150 cubic feet of air per minute) driven by a 30-horsepower electric engine, a large steam rock drill, six air plug drills, and a steam pump.

Transportation is by cart, over 4 miles to Barre.

The product is used for monuments.

BARRE GRANITE COMPANY'S QUARRY.

The Barre Granite Company's quarry consists of two openings adjoining the Bruce and the Milne & Wylie quarries in Barre. (See Pl. XXI, No. 7.) Operator, Barre Granite Company, Barre, Vt.

The granite, "dark blue," is a biotite granite of dark and dark inclining to medium bluish-gray shade and of even-grained fine or fine inclined to medium texture identical with the "dark Barre" of the Bruce and the Milne & Wylie quarries described on pages 126, 127.

The quarries, opened about 1884, are roughly estimated as measureing about 150 by 125 feet and 60 feet square, respectively, and as about 45 feet deep.

The sheets are irregular. The jointing is like that of the adjoining quarries.

The plant comprises two derricks, a double (four-drum) hoisting engine, and a steam pump.

These quarries have not been operated since 1904, owing, it is reported, to disagreement among the partners as to necessary improvements.

ANDERSON QUARRY.

The Anderson quarry is about S. 10° E. of the top of Millstone Hill, in Barre, 1,800 feet northeast of the Williamstown line. (See Pl. XXI, No. 8.) Operator, Granite City Quarry Company, Barre, Vt.

The granite, reported by the superintendent as "dark Barre," but entered in the legend of the original quarry map of Walker & Gallison as "medium," is a biotite granite of gray shade and fine even-grained texture.

The quarry, opened about 1892, measures about 200 feet in a N. 45° W. direction by 150 feet across and from 50 to 75 feet deep.

The granite on the southeast and northeast sides and on the southwest side for 50 feet west of the south corner is capped by schist and slate up to 15 feet thick, with a cleavage and schistosity striking N. 30° E. and dipping 55° N. 40° W. The relations of granite and slate are shown in figures 5 and 6, and the contact phenomena have been given on page 91. The sheets, from 1 to 15 feet thick, dip 20° NW. There are three sets of joints: (a), striking N. 50° W., dipping 75° N. 50° E., occurs on the southwest side only: (b), striking N. 5° E. and dipping 70° E., is spaced 6 to 15 feet; (c), striking N. 60° E. and dipping 75° is spaced 3, 15, and over 25 feet. The rift is reported as vertical, with N. 60° E. course; the grain as dipping with the sheets 20° NW., and as easier than the rift. A 1-foot pegmatite dike borders one of the schist masses, as shown in figure 5. At the east side there are two schist inclusions, measuring 10 by 2 to 3 feet and 6 by 2 feet, respectively, besides minor fragments.

The plant consists of a derrick, a Blondin carrier, two engines, an air compressor (capacity about 200 cubic feet of air per minute) driven by the Blondin engine, two large rock drills, four air plug drills, and a steam pump.

Transportation is by cart, over 4 miles to Barre.

The product is used entirely for monuments.

STEPHEN & GERRARD QUARRY.

The Stephen & Gerrard quarry is 600 feet north of the Anderson quarry and from south to south-southeast of the top of Millstone Hill, in Barre. (See Pl. XXI, No. 9.) Operators, Stephen & Gerrard, Barre, Vt.

The granite, reported by the firm as "medium Barre," but entered on Walker & Gallison's original map as "light," is a biotite granite of gray shade and of even-grained fine texture. For descriptions of "medium Barre" and "light Barre," see pages 132, 137. The quarry measures about 175 feet in a N. 30° E. direction by 150 feet across and from 20 to 50 feet in depth.

The sheets are undeveloped in the west half of the quarry, but the closely spaced joints there serve the quarrymen instead. Rift and joint courses are shown in figure 12 and the complex relations on the north wall in figure 16. There are four sets of joints: (A) dips 35° S. 40° E., and is spaced 3 to 17 feet; (B), vertical, is spaced 30, 40 to 90 feet and forms the south wall; (C), diagonal, dips 35° E., one only in east half; (D), vertical, forms heading on south wall. The granite is in contact on the west side and southeast corner with schist which has a foliation striking N. 30 E. and dipping 50° N. 60° W. Rusty stain is from 1 to 6 inches thick on sheet and joint faces.

The plant consists of two derricks (one of 40 tons), two hoisting engines, a small air compressor, two large rock drills, five air plug drills, and a steam pump.

Transportation is by cart, 4½ miles to cutting sheds.

The product is used entirely for monuments.

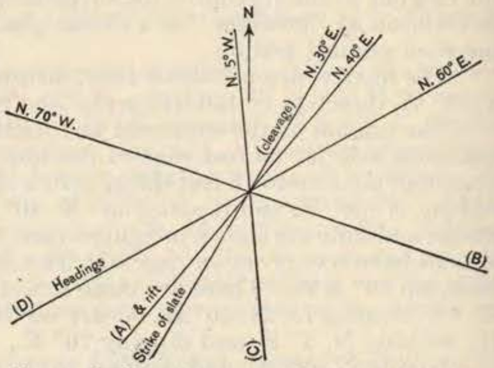


Figure 12—General structure at Stephen & Gerrard quarry, Barre, Vt.

JONES LIGHT QUARRY.

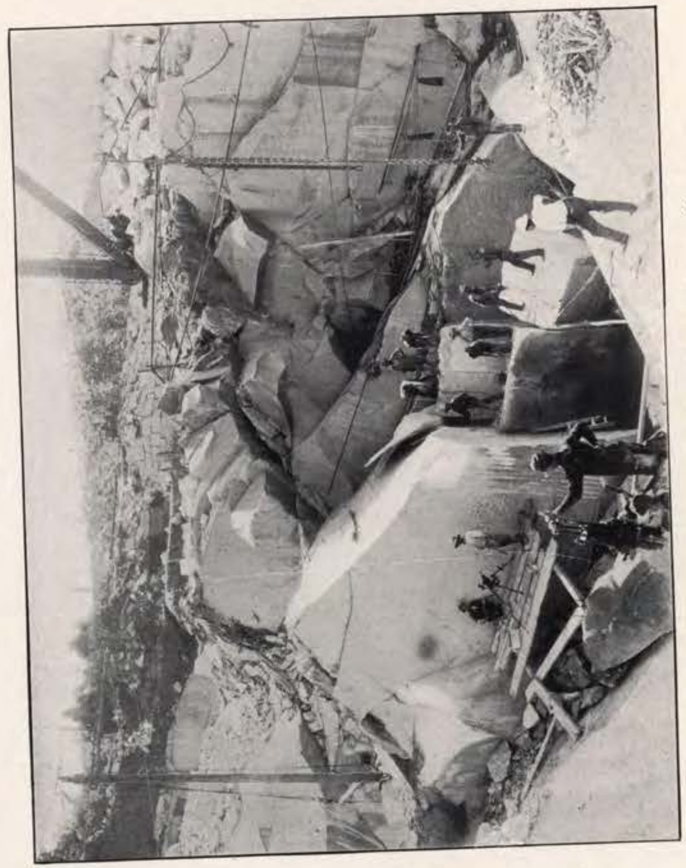
The Jones Light quarry is about northeast of the last and south-southeast of the top of Millstone Hill, in Barre. (See Pl. XXI, Nos. 10 and 11.) Operator, Jones Brothers Company, Barre, Vt.

The granite (specimen D, XXIX, 27, b), "light Barre," is a biotite granite of light, very slightly bluish gray shade. Its position among the light granites is between that of North Jay, Me., which is very light gray, and that of Hallowell, Me., which is light, inclining to medium.* Its texture is even-grained, fine inclining to medium, with feldspar up to 0.2 inch, rarely 0.3 inch, and mica to 0.1 inch. Its constituents, in descending order of abundance, are: Clear, colorless to bluish translucent and milk-white potash feldspar (orthoclase, kaolinized and micacized, with fresh microcline); very light smoky quartz with sheets of cavities with brightly polarizing rift or grain cracks parallel to or coinciding with them; translucent to milk-white soda-lime feldspar (oligoclase-albite, more or less altered), rarely with bent twinning planes; biotite (black mica), some of it chloritized; very little muscovite or bleached biotite. Accessory: Magnetite (very little) and zircon. Secondary: Calcite, usually in the orthoclase, kaolin, one or two white micas, and chlorite.

The stone effervesces with cold dilute muriatic acid. W. T. Schaller, chemist, of the United States Geological Survey,

*See Bull. U. S. Geol. Surv. No. 313, 1907, pp. 80, 117.

Plate XXV.


Boulder Quarry, Barre. Boutwell-Milne-Varnum Co.

finds that it contains 0.49 per cent. of CaO (lime) soluble in warm dilute (10 per cent.) acetic acid, which indicates a content of 0.87 per cent. of $CaCO_3$ (lime carbonate, calcite), the presence of which is also shown in thin section.

The mineral contrasts are feeble and so are those between cut and polished faces. The stone is used for rough, hammered and carved monumental work.

The quarry consists of two openings. The main and older one measures over 550 feet in a N. 35° E. direction by 60 to 200 feet across, and 40 to 90 feet in depth. The new one, which lies 300 feet N. 30° E. from the north end of the other, is about 200 feet square and 50 feet deep.

Joint, rift and dike courses are shown in figure 13. Sheet structure is hardly developed or very irregular. Traces of sheets dip 10° W. On account of this much horizontal channeling has to be done. There are six sets of joints: (A), diagonal and vertical; (B), also vertical, spaced 20 to 30, 50 feet and over; (C) dips 45° S. 45° E., discontinuous, occurs here and there in north part of quarry; (D) dips 45° W., undulating occurs with (C); (E), in new opening, dips 45° N. 65° E., spaced 3 to 50 feet, forms a heading at northwest corner; (F), in new opening, dips steeply N. 58° E., several at north end. There is a schist capping on the west wall of the main opening 10 to 20 feet and more thick, and on part of east wall, and also forming the east wall of new opening. Its foliation strikes N. 35° E. and dips steeply west to 90°. The schist is said so continue indefinitely on the east and also to be at least 150 feet wide on the west. Rift is vertical and good, the grain horizontal. A vertical diabase dike, 8 feet thick, crosses the north half of the main quarry diagonally, and also the schist capping. (See, further, p. 123.) Thirty feet below the granite surface is a schist inclusion 30 feet long and up to 3 feet thick, tapering.

The plant, for both openings, includes two 65-ton derricks, two 40-ton ones, and two smaller; a 125-horsepower hoisting engine, one of 50, and two of 40; an air compressor (capacity 750 cubic feet of air per minute; 11 large rock drills, 20 air plug drills, and two steam pumps.

The cutting plant, which is in Barre, includes an outside 100-ton derrick, two pneumatic 3-ton hoists, three overhead 20-ton cranes, an air compressor (capacity 1,200 cubic feet of air per minute), six air plug drills, 180 air hand tools, seven surfacers, seven polishers, two cutting lathes for stones 25 by 3 feet, a polishing lathe for stones of the same size, two gangs of stone saws for stones 12 by 7 feet, two MacDonald rotary surfacers, an automatic polishing carriage with bed 18 by 4 feet, a Cavecchi polishing machine and three granite-boring machines. Power is supplied by a 150-horsepower Corliss engine and also by Stephen Brook.

Transportation is effected by sidings from the quarry and the cutting plant, which are several miles apart.

Transportation is by cart, 4 miles to Barre.

The product is used for monuments and memorial chapels. Specimens are the Robert Burns statue and pedestal, Barre, First North Dakota soldiers' memorial St. Paul, Minn.; Indian massacre memorial, Serena, Ill.; Wade memorial chalpel, Cleveland, Ohio; Hancock (canopy) memoria, San Francisco, Cal.; Doctor Kimball memorial, Concord, N. H.; General Thomas (shaft) memorial, Springfield, Ohio; Senator Dillon shaft, Davenport, Iowa.

ACME GRANITE QUARRY.

The Acme granite quarry is about 600 feet west-southwest of the Jones Light quarry in Barre. (See Pl. XXI, No. 13.) Operator, C. N. Scott, East Barre, Vt.

The granite, "dark medium Barre," is a biotite granite of medium bluish-gray shade and even-grained fine texture.

The quarry consists of two openings, the smaller of which, made in 1905, is alone now in use. It measures about 20 feet N. 60° E. by 30 feet across and 10 to 25 feet in depth.

The sheets, 1 to 20 feet thick, dip 20° NNE. There are two sets of joints: (a), striking N. 50° to 55° E., dipping 65° to 90°, forms the south wall and a heading on the north wall; (b) strikes N. 35° W., is vertical, one only. The rift is reported as vertical and parallel to (a).

The plant comprises one horse derrick, two steam derricks, and a 45-horsepower hoisting engine, a large rock drill, and a steam pump.

Transportation is by siding, as shown on Plate XXI.

The product is used for monuments.

WETMORE & MORSE QUARRY.

The Wetmore & Morse quarry, 1,007 feet above the city, lies in a saddle about south-southeast of the top of Millstone Hill and about 200 feet below it. (See Pl. XXI No. 14.) Operator, Wetmore & Morse Granite Company, Montpelier, Vt.

The granite (specimen D, XXIX, 19, b), "light Barre," is a biotite granite of light, medium, slightly bluish gray shade (darker than that of the Jones Light quarry and that of Hallowell, Me., but lighter than that of Concord, N. H., "Concord granite") and of even-grained fine inclining to medium texture, with feldspar up to 0.3 inch and mica not over 0.1 inch. Its constituents, qualities, etc., are identical with those of specimen 18, a, from the Smith Upper quarry described on page 136. The quarry yields also some "medium."

The stone effervesces with cold dilute muriatic acid. W. T. Schaller, chemist, of the United States Geological Survey, finds that it contains 0.49 per cent. of CaO (lime) soluble in warm dilute (10 per cent.) acetic acid, indicating a content of 0.87 per cent. of $CaCO_3$ (lime carbonate, calcite), the presence of which mineral is also shown in thin section.

The quarry, opened about 1875, measures about 610 feet in a N. 60° E. direction by 100 to 200 feet across and from 50 to 75 feet in depth.

The sheets are from 1 to 28 feet thick. The quarry cuts the axis of the hill so as to show the arching of the sheets on the north-northwest wall. They are horizontal in the center at the top and dip 10° E. and W., but in the center at the bottom they dip 15° SSW., showing the dome structure of the hill. There are four sets of joints: (a) Striking N. 60° E., vertical and steep S. 22° E., forms part of the south-southeast wall; (b) striking N. 82° E., dipping almost 90°, forms part of the north-northwest wall: (c) striking N. 35° W., vertical, occurring only in the north half of the quarry, are coated with chlorite and sericite (one of these dies out on the south in such a slickensided plane dipping low south); (d) striking N. 30° E. and dipping 45° N. 60° W., greenish, slickensided. The quarry is somewhat difficult to work on account of scarcity of joints. The rift is reported as vertical with northeasterly course and the grain as horizontal. Rusty stain is up to 2 feet thick on upper sheets, but disappears entirely below.

The plant consists of two 60-ton, one 50-ton and one 30-ton derricks, three electric hoisting engines of 55, 30 and 20 horsepower, an air compressor (capacity 840 cubic feet of air per minute) driven by a 150-horsepower electric motor, 10 large air rock drills, 15 air plug drills, and three steam pumps.

Transportation is by a siding, as shown on the map (Pl. XXI).

The product is used for monuments, 75 per cent. of it reaching the market through local cutting sheds. Specimen: The J D. Rockefeller monument at Cleveland, Ohio.

SMITH UPPER QUARRY.

The Smith Upper quarry, southwest of and below the last, is S. 32° W. of the top of Millstone Hill, in Barre. (See Pl. XXI, No. 15.) Operators, E. L. Smith & Co., Barre, Vt.

The granite (specimen D, XXIX, 18, a), "light Barre," is a biotite granite of light, medium, slightly bluish gray shade (darker than the "light" of the Jones quarry and that of Hallowell, Me., which are light inclining to medium gray, but lighter than that of Concord, N. H., which is medium gray) and of even-grained fine inclining to medium texture with feldspar up to 0.3 inch and mica not over 0.1 inch. Its constituents, in descending order of abundance, are: Clear, colorless to bluish translucent and milk-white potash feldspar (orthoclase, kaolinized and micacized, with a little fresh microcline); light smoky quartz with cavities in sheets with cracks parallel to or coinciding with them; translucent to milk-white soda-lime feldspar (oligoclase-albite more or less altered) rarely with flexed twinning planes; biotite (black mica), some of it chloritized and with epidote; a little muscovite or

PLATE XXVII.

Sheet Quarry. E. L. Smith & Co., Barre.

bleached biotite. Accessory: Pyrite, magnetite, titanite, apatite, zircon. Secondary: Calcite, generally in the orthoclase, kaolin, one or two white micas, chlorite and epidote. It effervesces slightly with cold dilute muriatic acid.

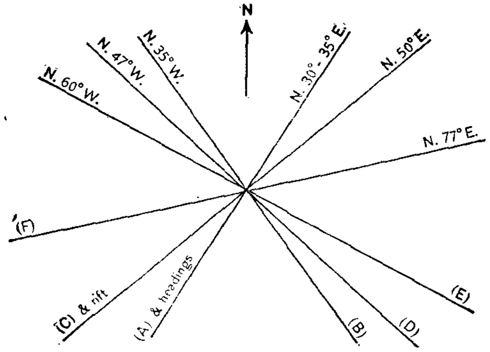


FIGURE 14—Structure at Smith Upper, Smith Lower, and Duffee quarries.

The mineral contrasts are feeble.

The quarry is very irregular in outline, measuring about 400 feet in a N. 30° E. direction by 200 feet across and 30 to 60 feet in depth.

The sheets, from 1 to 10, exceptionally 20 feet thick, are horizontal at the north end, but elsewhere bend over to the southwest 10° to 15°. Joint and rift courses of this and Duffee and Smith Lower quarries are combined in figure 14. There are two sets of joints: (A), vertical, forming headings on the northwest and southeast walls; (B), dipping 75° SW., is spaced 10 to 30 feet and over. The rift is reported as vertical and grain as horizontal. Rusty stain is from 1 to 18 inches thick, but there is little of it on the upper surfaces of sheets.

The plant for this and the two other Smith quarries comprises six 50-ton, four 20-ton and four smaller derricks, an air compressor (capacity 1,800 cubic feet of air per minute), 10 hoisting engines, a Blondin carrier and engine, 25 large air rock drills, 40 air plug drills and eight steam pumps. The firm's cutting plant at Barre includes two derricks, an overhead 20-ton crane, a hand crane, an air compressor (capacity 350 cubic feet of air per minute), four air plug drills, 50 air hand tools, three surfacers, three polishers, and two electric motors (50 and 10 horsepower) for derricks, cranes, compressor and polisher. Electricity is supplied by the Consolidated Lighting Company from falls on Winooski River, about 13 and 20 miles from Barre.

Transportation is by sidings, as shown on the map (Pl. XXI).

The product is monumental stone. Specimens of monuments from all the quarries of E. L. Smith & Co. are: Pedestal of equestrian statue of St. Louis, erected by W. R. Hodges in 1906, and Lemp mausoleum, St. Louis, Mo.; Cluett obelisk, with 44-foot shaft and pedestal, Troy, N. Y.; Smith obelisk, Old cemetery, Barre; the stone for Fleischmann mausoleum, Cincinnati.

DUFFEE QUARRY.

The Duffee quarry is west-northwest of and lower than the Smith Upper quarry and southwest of the top of Millstone Hill, in Barre. (See Pl. XXI, No. 16.) Operators, E. L. Smith & Co., Barre, Vt.

The granite (specimen D, XXIX, 17, a), "medium Barre," is a biotite granite of medium bluish-gray shade (a trifle darker than "Concord granite") and of even-grained fine texture with feldspars up to 0.2 inch and mica rarely to 0.1 inch. Its constituents, in descending order of abundance, are: Bluish translucent to milk-white potash feldspar (orthoclase, kaolinized and micacized, with a little fresh microcline); light smoky quartz with cavities in sheets and with cracks parallel to them, also showing optical effects of strain; translucent to milk-white soda-lime feldspar (oligoclase-albite, more or less altered), some of it with curving twinning planes; biotite (black mica), some of it chloritized; a little muscovite or bleached biotite. There are microscopic veins of epidote, of quartz, and of calcite. Accessory: Allanite, zircon, probably also magnetite and pyrite, although not in section. Secondary: Calcite, usually in orthoclase, kaolin, one or two white micas, epidote, quartz, chlorite. The stone effervesces slightly with cold dilute muriatic acid. The quarry produces some "dark" also.

The mineral contrasts are weaker than in the "dark" or in the "light" of the Jones or Smith Upper quarries, because of greater fineness of mica and more bluish cast of feldspar.

The quarry is estimated as about 400 feet east to west on one side and 300 on the other by 200 feet across and about 40 feet in depth.

The sheets, 2 to 12 feet thick, are somewhat regular, dipping 15° SW., with the rock surface. There are four sets of joints (see fig. 14): (A), dipping 75° S. 60° E., forms a 15-foot heading through the center of the quarry, and is spaced 10 to 100 feet; (B) dips 60° N. 55° E., one only in southwest part; (C) dips 60° S. 40° E., one on south wall; (D) dips S. 43° W., one on southeast wall. The rift is reported as vertical and the grain as horizontal.

The plant and product have been given in connection with the Smith Upper quarry, page 136. Transportation is by siding, as shown on Plate XXI.

SMITH LOWER QUARRY.

The Smith Lower quarry is west-northwest of the Duffee quarry near the foot of Millstone Hill and S. 60° W. from its top, in Barre. (See Pl. XXI, No. 17.) Operator, E. L. Smith & Co., Barre, Vt.

The granite, "medium Barre," is identical with that of the adjoining Duffee quarry described above. The quarry also yields some "dark."

The quarry is estimated as about 250 feet east to west by 200 feet across and from 50 to 100 feet in depth.

The sheets, from 1 to 15 feet thick, dip 20° to 30° SW., but in the lower part is a mass 58 feet thick without sheets. Joint and rift courses are shown in figure 18: (A), dipping 80° S. 60° E., forms the east wall and a heading on the southeast wall, and recurs 20 feet south of the north wall; (B) dips 50° NNW. (two of this set, 8 feet apart, are in the southeast corner); (C) dips 40° N. 55° E., one only, discontinuous, on northeast wall. Rift and grain as at adjacent quarries.

The plant and product are given in connection with Smith Upper quarry. Transportation is by siding, as shown in Plate XXI.

SANGUINETTI QUARRY.

The Sanguinetti quarry is about three-fifths mile north of the top of Millstone Hill, in Barre. (See Pl. XXI, No. 18.) Operator, Joseph Sanguinetti, Barre, Vt.

The exact shade of biotite granite obtained here was not determined. The quarry was temporarily idle in 1907.

The quarry is about 100 feet by 50, and from 10 to 20 feet deep. The sheets, 8 to 10 feet thick, are imperfectly developed. Joints (a) strike N. 35° E., dip S. 55° E., and are spaced 10 to 20 feet; joints (b) strike N. 75° W., dip 65° to 80° S. 15° W., and are spaced 10 to 50 feet. There are some biotitic flowage streaks, also a pear-shaped concentrically banded mass 1 to 2 feet across. A schist outcrop between the quarry and railroad has a foliation strike north and a dip 55° W.

The plant consists of a derrick and small hoisting engine.

BOND & WHITCOMB QUARRY.

The Bond & Whitcomb quarry is N. 40° E. from the top of Millstone Hill and 200 feet below it, or 1,000 feet above the city, in Barre. (See Pl. XXI, 18, 19.) Operators, Bond & Whitcomb, Barre, Vt.

The granite (specimen D, XXIX, 26, a), "coarse light Barre," is a biotite granite of light-gray shade, owing to more biotite a trifle darker than the "light" of Jones quarry, and of even-grained medium texture with feldspars up to 0.3 inch, exceptionally 0.4 inch, and mica to 0.2 inch. Its constituents, in descending order of abundance are: Clear colorless to milk-white potash feldspar (orthoclase, kaolinized and micacized with a little fresh microcline, rarely inclosed by the former); light smoky quartz with cavities in sheets with rift cracks parallel to them, also showing optical effects of strain; whitish soda-lime feldspar (oligoclase to oligoclase-andesine) more or less altered; biotite (black mica), some of it chloritized; a little muscovite or bleached biotite. Accessory: Titanite. Secondary: Calcite, generally within the orthoclase, kaolin, one or two micas, chlorite. The stone effervesces with cold dilute muriatic acid.

This is a light constructional granite.

In a new opening a little north of the main one the stone (specimen D, XXIX, 26, b) "medium Barre," is a biotite granite of medium gray shade and fine texture with feldspars up to 0.2 inch, rarely 0.3 inch, and mica not over 0.1 inch. Its constituents are the same as in the coarser granite, excepting that the soda-lime feldspar is oligoclase and some of the orthoclase is fresh. The stone effervesces slightly with cold dilute muriatic acid.

This is a monumental granite.

The main quarry, opened in 1902, measures about 200 feet in a N. 35° E. direction by 150 feet N. 25° W., and is from 10 to 30 feet in depth.

The sheets are regular, 6 inches to 7 feet thick, and dip gently northeast. There are two sets of joints: (a) Striking N. 25° W., vertical, forms the northeast wall and a heading 75 feet from the southwest wall; (b) striking N. 35° E., vertical and steep N. 55° W., one only, forming the north wall. Some of the joint faces are coated with muscovite scales. The rift is reported as vertical with N. 35° to 40° E. course and the grain as horizontal. For spaces 1 to 2 inches wide the granite has very little biotite, and the average size of feldspars is there greater. A basic dike, described on page 123, runs parallel to the north wall and a little back of it. It is 2 feet thick but tapers out at heading (a). Rusty stain does not exceed 1½ inches on sheet surfaces.

The plant consists of two derricks, two hoisting engines, a small air compressor, three large rock drills, five air plug drills, and a siphon pipe.

Transportation is by siding, as shown on Plate XXI.

The product is used as dimension stone for buildings; that from the small opening is used for monuments.

BARNEY QUARRY.

The Barney quarry (formerly known as the Eclipse) is 360 feet north-northeast from the last and about N. 35° E. from the top of Millstone Hill, in Barre. (See Pl. XXI, No. 20.) Operator, Augusta Barney, Websterville, Vt.

The granite, "medium and light Barre," is a biotite granite of medium and light bluish gray shade and fine texture, like those already described.

The quarry is estimated as measuring about 300 feet in a northeast direction by 200 feet across and from 45 to 60 feet in depth.

The sheets, 1 foot to 3 feet 8 inches thick, are normal and dip about 10° NW. on the northwest side, but 10° SE. on the southeast side, with a S. 10° W. pitch of 10° and they are slickensided in a S. 50° W. direction. Joints, rift and dike courses are shown in figure 19. Joints (A), vertical, form a 3-foot heading on the southeast wall; (B) dip 80° N. 20° E., one only on southwest wall; (C) dip 40° N. 70° W., discontinuous, two near northwest wall, slickensided in direction of dip. There is a basic dike,

up to 2 feet thick, at the south corner back of heading (A). The rock within the heading is crossed by horizontal subjoints 1 to 3 inches apart, due to the dike. On the northwest wall the granite is in contact with schist that has a foliation striking N. 20° E. and dipping steeply west. There is a pegmatite dike or lens along the schist contact and the granite for a space of 15 feet from the contact is coarse and fine in alternating bands. There is also an inclusion of schist at the north corner, 15 feet by 1 foot, with a foliation striking N. 80° E.

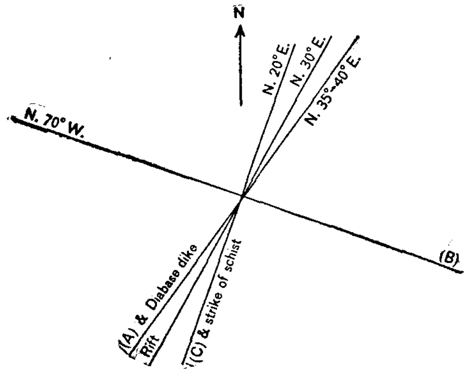


FIGURE 15.—Structure at Barney quarry. Barre.

The plant comprises a horse derrick, a steam rock drill, and a steam pump.

Transportation is by cart, 3½ miles to Barre.

The product is used for monuments.

CANTON QUARRY.

The Canton quarry is about 450 feet east-northeast from the Bond & Whitcomb quarry and northeast of the top of Millstone Hill, in Barre. (See Pl. XXI, No. 21.) Operator, Barre Granite and Quarry Company, Barre, Vt.

The granite, "medium and light Barre," is a biotite granite of medium and light bluish-gray shade, like those already described.

The quarry is estimated as measuring about 300 feet in a north-easterly direction by 200 feet across, and from 35 to 60 feet in depth.

The sheets from 1 to 14 feet thick, are normal and dip N. to 10°. There are two sets of joints: (a), striking N. 37° W. and dipping 80° N. 53° E., forms the east wall, and a heading on the west wall and is spaced 5 to 50 feet; (b), striking N. 35° E., dipping 55° S. 55° E., is spaced 10 to 25 feet and 200 feet and is slickensided in the direction of dip. The rift is reported as vertical with N. 42° E. course and the grain as horizontal. There are two quartz veins up to 1½ inches thick, one along heading (a), another in the middle of the quarry. A marked east-west compressive strain is shown in the faulting of channel cores.

The plant consists of two derricks, a four-drum hoisting engine, an air compressor (capacity 675 cubic feet of air per minute), four large rock drills, seven air plug drills, and two steam pumps.

Transportation is by siding. (See Pl. XXI.)

The product is used for monuments. Specimen: The soldiers' monument at Trenton, N. J.

O'HERIN QUARRY.

The O'Herin quarry is about 500 feet N. 35° E. of the Barney quarry, and in about that direction from the top of Millstone Hill, in Barre. (See Pl. XXI, No. 22.) Operators, Robert O'Herin & Co., Websterville, Vt.

The granite, "light Barre," is a biotite granite of light-gray shade like that previously described.

The quarry, opened in 1904, is estimated as measuring about 300 feet in a N. 22° E. direction by 150 feet across, and from 10 to 30 feet in depth.

The sheets, from 1 to 8 feet thick are normal and dip very low southeast. There are two sets of joints: (a), striking N. 15° E., vertical, and dipping 55° E. on the southeast and northeast walls is spaced 10, 20 to 100 feet; (b), striking N. 30° to 35° W., dipping 75° N. 60° E. and vertical is discontinuous, one on and one near the south wall. The rift is reported as vertical with N. 30° E. course and the grain as horizontal.

The plant comprises one horse derrick, a large rock drill, an air plug drill and a steam pump. Compressed air is obtained from the Barre Granite and Quarry Company.

Transportation is by cart, 3½ miles to Barre.

The product is used for monuments and buildings.

WALKER QUARRY.

The Walker quarry is east-southeast of the O'Herin quarry and N. 40° E. from the top of Millstone Hill, in Barre. (See Pl. XXI, No. 23.) Operators, George Walker & Sons, Barre, Vt.

The granite, "medium Barre," is a biotite granite of medium gray shade and fine texture like that already described.

The quarry, opened in 1902, is estimated as measuring about 150 feet in a N. 30° E. direction by 80 feet across and 30 feet in depth.

The sheets, from 1 foot to 8 feet 10 inches thick, are normal and dip gently east and northeast. There are two sets of joints: (a), striking N. 25° W., vertical, forming east and west walls only; (b), striking N. 40° E. and vertical, adjacent to the dike. The rift is reported as vertical with N. 50° E. course and the grain as horizontal. A 12-inch basic dike, the continuation of that in Barney quarry, page 140, has the course of joints (b). The granite on the north side of this dike is broken into vertical scales, 1 to 6 inches thick and a foot wide.

The plant at the quarry comprises a horse derrick, a large air rock drill, two air plug drills, and an air pump. Compressed air is obtained from the Barre Granite and Quarry Company. The plant at the cutting shed in Barre includes a derrick, a hoisting engine, a 35 horsepower electric motor and two air compressors (capacity 69 and 134 cubic feet of air per minute), two air plug drills, 25 air hand tools, a surfacer and two polishers.

Transportation is by cart, 300 feet to rail for rough stock, but 3½ miles to cutting shed for stock to be finished.

The product is small monuments.

WELLS-LAMSON QUARRY.

The Wells-Lamson quarry is 640 feet above the city and about northeast from the top of Millstone Hill. (See Pl. XXI, No. 24.) Operator, The Wells-Lamson Quarry Company, Barre, Vt.

The granite, "light and medium Barre," is a biotite granite of light medium, slightly bluish gray shade, or of medium bluish-gray shade, and of even-grained fine inclining to medium or fine texture. It is reported as identical in quality with the "light" and "medium" of the Smith Upper and Duffee quarries described on pages 136, 137. The following result of a microscopic examination of "dark" granite from this quarry, made by Whitman Cross, of the United States Geological Survey, was published in 1898:*

Messrs. Wells, Lamson & Co's dark granite is a fine, even-grained, typical granite containing two micas (biotite, muscovite) sometimes called granite proper. The constituents of importance are quartz, orthoclase, microcline, biotite and muscovite. The first three occur in wholly irregular grains interlocking in a very complex manner. The micas are in small leaves between and penetrating the other minerals to some extent. Muscovite apparently occurs in two forms, one corresponding to the biotite, as seemingly primary and the other in small flakes in the orthoclase and clearly a secondary mineral. Accesory constituents are oligoclase, albite (?), titanite (sphene), and apatite. There is an almost total absence of magnetite or other iron ore. Biotite is slightly changed to green and probably yields chlorite in some samples. The orthoclase gives way to an aggregate of fine muscovite leaves, also varying much in different samples, no doubt. Both quartz and biotite show that the rock has endured considerable pressure, the former by the "undulatory extinction" it exhibits and the biotite by the curved and bent ame The pressure did not extend to a crushing of the grains or any banded structure. In the feldspar is some calcite filling small cracks. On the basis of this examination I should estimate it at quartz 30 to 35 per cent., orthoclase 30 per cent., microcline 20 to 25 per cent. Much of the iron is present in the ferrous or unoxidized condition.

A chemical analysis of the "dark" from this quarry made by William C. Day at Swarthmore College, Pennsylvania, was published in the same work and on the same page, and is repeated here for reference.

*See Nineteenth Ann. Rept. U. S. Geol. Survey, pt. 6, continued, 1898, p. 224.

Analysis of "dark Barre" granite by William C. Day.

SiO_2 (silica)	69.56
Al_2O_3 (alumina)	15.38
Fe_2O_3 (iron sesquioxide)	2.65
MgO (magnesia)	Trace.
CaO (lime)	1.76
Na_2O (soda)	5.38
K_2O (potash)	4.31
Mn (manganese)	Trace.
Loss on ignition, CO_2, and moisture	1.02
	100.06

Doctor Day also made the following physical determinations of "dark" and "medium" from this quarry:* Specific gravity, dark, 2.672; medium, 2.662; per cent. of water absorbed, dark, 0.121 per cent. medium, 0.129 per cent.; crushing strength, dark 16,719 to 19,957 pounds; medium, 14,968 to 17,856 pounds.

The quarry, opened about 1885, is estimated as measuring about 400 feet in a N. 25° W. direction by 300 feet across and from 50 to 60 feet in depth.

The sheets, from 6 inches to 15 feet thick, dip gently southeast and N. 65° E. On the west side the lenses are very short. There is one sharply curving "toe nail" 10 feet high, intersecting the sheet structure. There are three sets of joints: (a), striking N. 65° to 70° E., dipping 40° to 60° N. 27° W., is spaced 25, 50 and 200 feet; (b), striking N. 30° E., vertical, forms a small heading on the south edge only; (c), striking N. 45° E., vertical, forms a heading on the north wall and is spaced 200 feet and over. The rift is reported as vertical (probably N. 30° E.) and the grain as horizontal A. 12 in. band of darker granite strikes N. 70° E. and dips 60° N. 20° W., marking the direction of the flow. Schist crops out close to the south wall and continues in that direction. A north-south compressive strain is reported.

The plant comprises a 100-ton and a 50-ton derrick, a 10-ton Blondin carrier, an air compressor (capacity 160 cubic feet of air per minute), six large rock drills, six air plug drills, and a steam pump.

Transportation is by siding, as shown on Plate XXI.

The product is used for monuments and buildings.

PRUNEAU QUARRY.

The Pruneau quarry is N. 75° E. from the top of Millstone Hill, in Barre. (See Pl. XXI, No. 25.) Operators, Pruneau & Co., Websterville, Vt.

The granite, "dark medium," is a biotite granite of medium bluish-gray shade and fine texture in composition like those already described.

The quarry is estimated as measuring about 200 feet in a northwest direction by 200 feet across and from 30 to 45 feet in depth.

*Op. cit., pp. 225, 226.

The sheets, from 6 inches to 9 feet thick, but thin for 10 feet down, are normal and dip 15° to 25° SSE. There are three sets of joints: (a), striking N. 10° to 15° E., dipping 65° S. 78° E., forms a heading in the south half of the quarry and is spaced 5 to 30 feet; (b), striking N. 60° E., dipping 60° N. 30° W., forms the south wall and a 4-foot heading in the north half. It is slickensided in the direction of dip; (c), striking N. 65° W., vertical, usually crosses one sheet only. A heading of (a) is coated with a slickensided mass up to 1.75 inches thick, largely of coarse muscovite scales with some kaolinized feldspar, possibly of pegmatitic origin. The rift is reported as vertical with N. 30° E. course and grain as horizontal. A one-half inch quartz vein strikes N. 12° E. Several schist inclusions at the top of the northwest wall measure up to 8 by 2 feet.

The plant consists of a derrick and hoisting engine hand derrick, small air compressor, large rock drill, three air plug drills and a steam pump.

Transportation is by cart, 3½ miles to Barre.

The product is used for monuments.

CONSOLIDATED MARR & GORDON QUARRY.

The Consolidated Marr & Gordon quarry is 860 feet above the city and N. 75° E. from the top of Millstone Hill, in Barre. (See Pl. XXI, No. 26.) Operator, Consolidated Quarry Company, Barre, Vt.

The granite, "light Barre," is a biotite granite of light medium slightly bluish shade like that of the Wetmore & Morse and Smith Upper quarries and of even-grained fine inclining to medium texture. (See p. 136.)

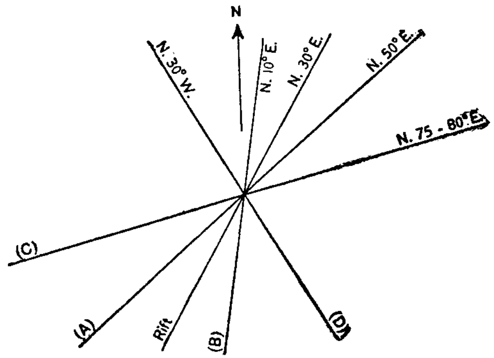


FIGURE 16.—Structure at Consolidated Marr & Gordon quarry Barry.

The quarry is estimated as measuring about 300 feet from north to south by as much across and from 50 to 70 feet in depth.

The sheets, from 1 to 15 feet thick, the thicker ones generally 5 to 10 feet, in places irregular, dip 15° E. There are four sets of joints, as shown in figure 16: (A) dips 35° N. 40° W., one on the west wall, and a heading at the southeast corner; (B) dips 75° W., one at the southeast corner; (C) dips 50° to 80° N. 20° W. forms north and south walls and small heading 30 feet west of the south wall; (D) dips 75° N. 60° E., one crosses the quarry from the northeast corner. The rift is reported as vertical and the grain as horizontal.

The plant consists of three derricks, two hoisting engines, an air compressor (capacity, 600 cubic feet of air per minute), three large rock drills, three smaller ones, seven air plug drills, and a steam pump.

Transportation is by siding, as shown in Plate XXI.

The product is used for monuments, but stones with only one clear face go into buildings.

McDONALD & CUTTER QUARRY.

The McDonald & Cutter quarry is east-northeast of top of Millstone Hill, east of the main street of Websterville in Barre. (See Pl. XXI, No. 27.) Operator, Consolidated Quarry Company, Barre, Vt.

The granite of this and the four adjoining quarries of this firm is mostly "light Barre" with some "medium." It is a biotite granite of light medium or medium, slightly bluish-gray shade and of even-grained fine inclining to medium texture, like those described on pages 132, 139.

The quarry is estimated as measuring about 200 feet in a N. 22° W. direction by 175 feet across and from 65 to 110 feet deep.

The sheets, in places imperfectly developed, from 3 to 30 feet thick, undulate horizontally. There are masses 40 feet thick without sheets. There are three sets of joints: (a), striking N. 10° to 15° W., vertical, forms the east and west walls and is spaced 10 to 30 feet; (b), striking N. 40° to 45° E., vertical, is spaced 1 to 30 feet; (c) forms an irregular rusty heading at the northeast end, striking N. 15° E. and dipping 70° E., but undulating along the strike. "Sap" is up to 14 inches thick.

The plant of this and the four adjoining quarries of this firm comprises seven derricks, two Blondin carriers, nine hoisting engines, an air compressor (capacity 730 cubic feet of air per minute), seventeen large rock drills, twenty-eight air plug drills, and six steam pumps.

Transportation is by siding, as shown on Plate XXI.

The product is used for monuments, but stones with only one clear face are used for buildings.

INNES & CRUIKSHANK QUARRY.

The Innes & Cruikshank quarry is about 100 feet north-northeast of the last. (See Pl. XXI, No. 28.) Operator, Consolidated Quarry Company, Barre, Vt.

For the granite, see under that of the McDonald & Cutter quarry.

The quarry is estimated as measuring about 350 feet in a north-northeast direction by 250 feet across and 90 feet in depth.

This is a "bowlder" quarry. The sheets, 2 to 12 feet thick, dip 45° NW., but some in the northeast part dip 25° E. and 35° NW. There are two sets of joints: (a), striking N. 80° to 85° E., dipping 50° to 70° S. 20° E., forms the southeast and part of the northwest walls and is spaced 10, 30, 50 and 200 feet; (b), striking east-west, dipping 35° S., one only on southeast side. The rift is reported as vertical with N. 30° E. course and the grain as horizontal to 15° NW. Owing to erosion there is no parallelism here between the rock surface and sheet structure. Sand up to 2 inches thick occurs between the sheets and the joints are also generally loose. The "sap" is from 6 to 16 inches thick.

For transportation and product, see those of the McDonald & Cutter quarry (above).

CAPITAL QUARRY.

The Capital quarry is 750 feet south-southeast of the McDonald & Cutter quarry and southeast of Millstone Hill, in Barre. (See Pl. XXI, No. 29.) Operator, Consolidated Quarry Company, Barre, Vt.

For the granite, see under that of the McDonald & Cutter quarry (p. 146).

The quarry is estimated as measuring 150 feet in a northeast direction by 100 feet across and 50 feet in depth.

This is a "bowlder" quarry. The sheets, from 6 inches to 4 feet thick, but extending to a depth of only 20 feet, dip about 10° SE. There are three sets of joints: (a), striking N. 65° E., dipping 55° S. 25° E., spaced 3 to 10 feet, on south side only; (b), striking N. 35° E., dipping steep N. 55° W., is discontinuous; (c), striking NW., dipping 70° NE., is spaced 5 to 20 feet. A basic vertical dike, 2 to 6 feet thick, with northeast course, forms the northwest wall. It weathers spheroidally. The rift is reported as varying in different blocks.

For the plant, transportation and product, see those of the McDonald & Cutter quarry (p. 146).

COUYELLARD QUARRY.

The Couyellard quarry is about 200 feet southeast of the McDonald & Cutter quarry and southeast of the top of Millstone Hill, in Barre. (See Pl. XXI, No. 30.) Operator, Consolidated Quarry Company, Barre, Vt.

For the granite, see under that of the McDonald & Cutter quarry (p. 146).

The quarry is estimated as measuring about 275 feet in a N. 70° E. direction by 200 feet across, and from 50 to 70 feet in depth.

This is a "bowlder" quarry. Sheet structure is hardly present. There are masses 20 feet thick. There are three sets of joints: (a), striking N. 75° E., dipping 65° S. 15° E., forms the north and south walls and one joint in the center; (b), striking northwest, dipping 45° NE., is spaced 5 to 20 feet and over; (c), striking N. 30° E., dipping 65° N. 60° W. to 90°, forms a heading at the east corner, and is spaced 5 to 40 feet and over. The rift is reported as vertical with N. 55° to 60° E. course and the grain as horizontal.

The plant, transportation, and product are given in connection with the McDonald & Cutter quarry (p. 146).

McIVER & MATHESON QUARRY.

The McIver & Matheson quarry is about 1,500 feet east-southeast of the Websterville main street and in same direction from the top of Millstone Hill in Barre. (See Pl. XXI, No. 31.) Operators, McIver & Matheson, Barre, Vt.

The granite, 'light and medium Barre,'' is a biotite granite of light medium and medium bluish-gray shade and of even-grained fine inclining to medium texture like that described on page 138.

The quarry is estimated as measuring about 250 feet in a northeast direction by 200 feet across and from 30 to 65 feet in depth.

This is a "bowlder'' quarry. The sheet structure is very irregular, owing to "growing on.'' There are two sets of joints: (a), striking northwest, vertical, forms a 15-foot wide heading across the middle of the quarry and is spaced 4 to 44 feet; (b), striking N. 40° E., vertical is spaced 10 to 50 feet. A diabase dike, the continuation of that in Jones Light quarry (p. 132), is here 9 feet thick, vertical and parallel to joint (b). The granite for a foot next to the dike breaks off in vertical scales, 1 to 6 inches thick. The rift is reported as vertical with N. 4° E. course and the grain as horizontal. Rusty stain is 12 inches thick along joint and some sheet faces.

The plant includes a derrick and hoisting engine, a large rock drill and a steam pump.

Transportation is by cart, either 4 miles to Barre or a few hundred feet to a siding at an adjoining quarry.

The product is used for monuments. Specimens: The Governor Goebel monument in Kentucky and the Holthaus monument at St. Louis, Mo.

MANUFACTURERS' QUARRY.

The Manufacutrers' quarry, south of and adjoining the last, is in Barre. (See Pl. XXI, No. 32.) Operator, Manufacturers' Quarrying Company, Barre, Vt.

The granite, "medium Barre,'' is a biotite granite of medium bluish-gray shade and of even-grained fine texture. (See p. 132.)

The quarry is estimated as measuring 250 feet in a northwest direction by 200 feet across and from 50 to 60 feet in depth.

This is a "bowlder'' quarry. The sheets, in places 1 to 10

feet thick, die out laterally in the center of the quarry, so that masses 30 feet thick can be obtained at the same level as thin-sheeted ones. There are three sets of joints: (a), striking N. 40° W., vertical, is spaced 8 to 30 feet; (b), striking N. 80° E. to 80° W., dipping 75° S. and 90°, is spaced 30 feet and over; (c), striking N. 15° E., vertical, is spaced 30 to 100 feet. The rift is reported as vertical with N. 50° to 60° E. course and the grain as horizontal. There are three schist inclusions on the southeast wall, measuring 25 by 10 by 10 feet; 20 by 8 by 8 feet; and 3 by 2 feet. The foliation of the largest strikes N. 30° W. The schist is injected with minute dikes of granite and the granite within 7 feet of the inclusion is slightly darker. One of the (a) joints is coated with quartz over an inch thick with large scales of muscovite probably of pegmatitic origin. Rusty stain is 12 inches thick on sheet surface, but 24 inches on joint faces.

The plant comprises a 30-ton derrick, a hoisting engine, a Blondin carrier and engine, a small air compressor, three large rock drills, seven air plug drills and a steam pump.

Transportation is by siding, as shown on Plate XXI. The product is monumental granite, but the waste is used for paving and curbing.

BARRE QUARRY.

The Barre quarry is N. 40° E. from the McIver & Matheson quarry, 800 feet northeast of the southern road from East Barre to Websterville and about four-fifths of a mile east of the top of Millstone Hill in Barre. (See Pl. XXI, No. 33.) Operator, Barre Quarry Company, Barre, Vt.

The granite, "light and medium Barre,'' is a biotite granite of light medium and medium bluish-gray shade and even-grained fine inclining to medium texture. Its feldspars are slightly more bluish than those of the corresponding shades from the other quarries.

The quarry, opened in 1905, measures about 100 by 60 feet and 30 feet in depth.

This is a "bowlder'' quarry, without sheet structure. There are two sets of joints: (a), striking N. 30° E., vertical; (b) striking N. 65° to 75° E., dipping 40° to 50° S. 25° E., forms the north and south walls and is spaced 3 to 50 feet. The rift is reported as varying in different blocks. Biotitic knots are 1.5 by 0.5 inches. There is "sap'' up to 6 inches thick on joint faces.

The plant comprises a derrick, an electric motor, an air compressor (capacity 200 cubic feet of air per minute), and a steam pump.

Transportation is by cart, over 4 miles to Barre.

The product is used for monuments and buildings.

MILNE QUARRY.

The Milne quarry is on the south side of the southern road from Websterville to East Barre and about nine-tenths of a mile east-southeast of top of Millstone Hill, in Barre. (See Pl. XXI, No. 34.) Operator, Alexander Milne Barre, Vt.

The granite, "light and medium Barre,'' is a biotite granite of light medium and medium bluish-gray shade and of even-grained fine inclining to medium texture. (See pp. 132, 138.)

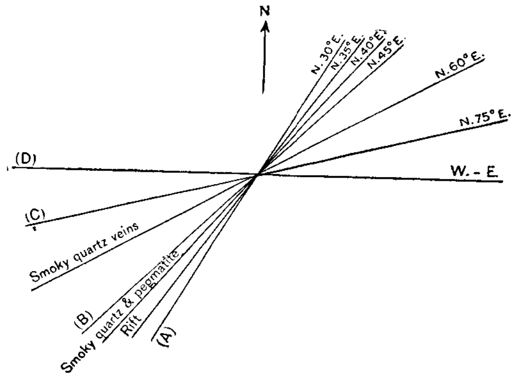


FIGURE 17—Structure at Milne quarry, Barre.

The quarry is estimated as measuring about 250 feet in a north-northwest direction by 250 feet across and from 55 to 70 feet in depth.

The sheets, from 1 to 6 feet thick, are about horizontal or dip 20° E., but disappear 25 feet below the rock surface, where low-dipping joints (D) are used by the quarrymen instead. There are four sets of joints, as shown in figure 17: (A), vertical, dipping 2° and 40° N. 60° W., forms the east-southeast wall, is spaced 3 to 150 feet, coated with coarse scales of muscovite; (B), dipping 40° northwest, discontinuous, is spaced 15 to 150 feet; (C), dipping 70° S. 15° E., is spaced 2 to 20 feet and over, but stops 20 feet down; (D), dipping 75° S., one only, at the south corner. The rift is reported as vertical with N. 35° E. course and the grain as horizontal. There are veins of smoky quartz up to 2 inches thick in the south corner, at intervals of about 3 feet, dipping 60° S. 40° E. Some with another strike are part pegmatite. The microscopic structure of this quartz has been described on page 124.

The plant comprises two derricks, a hoisting engine, an air compressor (capacity 200 cubic feet of air per minute), four large rock drills, six air plug drills and a steam pump.

Transportation is by cart, over 4 miles to Barre.

The product is used for monuments and buildings.

BARRE MEDIUM QUARRY.

The Barre Medium quarry is about 500 feet southeast of the Milne quarry. (See Pl. XXI, No. 35.) Operator, Barre Medium Granite Company, Barre, Vt.

The granite, "medium and light Barre,'' is a biotite granite of medium and light medium bluish-gray shade and even-grained fine inclining to medium texture like that described on pages 132 and 138.

The quarry, opened in 1906, is estimated as measuring 200 feet north-south by 150 feet across and from 10 to 25 feet in depth.

Sheets from 6 inches to 5 feet thick, increasing in thickness downward, dip low southeast. No joints have yet been found. The rift is reported as vertical with N. 60° E. course, and the grain as horizontal. Rusty stain is up to 4 inches thick on sheet surfaces.

The plant comprises a derrick, a hoisting engine, an air compressor driven by a 20-horsepower engine, two large rock drills, four air plug drills and a steam pump.

Transportation is by cart, over 4 miles to Barre.

The product is used for buildings and monuments. Specimen of the "light:'' The trimmings in the Aldrich public library, Barre, Vt.

EMPIRE GRANITE COMPANY'S QUARRY.

The Empire Granite Company's quarry is about 800 feet east-southeast of the Milne quarry on the north side of the southern road from Websterville to East Barre. (See Pl.XXI, No. 36.) Operator, Empire Granite and Quarrying Company, Northfield, Vt.

The granite, "light and medium Barre,'' is a biotite granite of light medium and medium, slightly bluish-gray shade, and of even-grained fine inclining to medium texture. (See pp. 132, 138.)

The quarry, opened about 1889, is estimated as about 375 feet by 200 and from 10 to 50 feet deep.

The sheets are normal, from 1 to 16 feet thick, dipping 10° SE. There are two sets of joints: (a), striking N. 70° E., dipping 53° S. 20° E., is spaced 10 to 50 feet and over; (b), striking northwest, dipping 75° SW., discontinuous, is spaced 100 feet and over. The rift is reported as vertical with N. 35° E. course and the grain as horizontal. The "sap'' is up to 3 inches thick. At a smaller opening (not being worked) the sheets dip about 10° N. 60° E. and are also normal.

The plant comprises two derricks and two hoisting engines, an air compressor (capacity 650 cubic feet of air per minute), two large rock drills, five air plug drills, and a steam pump.

Transportation is by cart, over 4 miles to Barre.

The product is used for monuments and buildings.

STRATTON QUARRY.

The Stratton quarry is 400 feet east of the last, and about $1\frac{1}{4}$ miles east-southeast of the top of Millstone Hill, in Barre. (See Pl. XXI, No. 37.) Operator, George Stratton Quarry Company, Barre, Vt.

The granite, "light and medium Barre," is a biotite granite of light medium and medium gray shade, and of even-grained fine inclining to medium texture like that previously described.

The quarry, opened in 1905, measures about 100 feet square and averages 10 feet in depth.

The sheets, from 1 to 5 feet thick, vary from horizontal to a dip of 10° about south. There is but one set of joints, which strikes N. 65° E., dips 55° S. 25° E., and is spaced 1 to 20 feet. The "sap" is 6 inches thick and under.

The plant consists of one horse derrick.

Transportation is by cart, over 4 miles to Barre.

The product is used for buildings and monuments.

JONES DARK QUARRY.

The Jones Dark quarry is in Williamstown (Orange County), but adjoins the Emipre quarry in Barre. (See Pl. XXI, No. 38). Operators, Jones Brothers & Co., Barre, Vt.

The granite (specimen D, XXIX, 13, a), "dark Barre," is a biotite granite of dark bluish-gray shade, a trifle darker than that of the Bruce quarry, and of even-grained fine inclining to medium texture with feldspars up to 0.3 inch and mica to 0.1 inch. Its constituents are identical with those of the Milne & Wylie quarry stone described on page 127. It effervesces with cold dilute muriatic acid.

The polished face shows pyrite and a little magnetite. The polish is fair. Its cut hard-way face is as light as that of the "light Barre," and thus in marked contrast to its polished face. Its mineral contrasts and qualities are identical with those of the Milne & Wylie quarry stone (p. 127), but its texture, particularly its mica, appears to be a little finer.

The quarry, opened about 1886, is estimated as measuring about 300 feet in a N. 80° E. direction by 250 feet across and from 50 to 100 feet in depth.

The sheets, 2 to 20 feet thick, are irregular and undulating. There is one mass 28 feet thick. There are four sets of joints: (a), striking N. 80° E., vertical, forms headings on north and south walls, is spaced 5 to 30 feet, and has rusty faces; (b), striking N. 15° W., vertical, usually discontinuous vertically, is spaced 10, 20, 30 and 200 feet; (c), striking east-west, dipping 55° S., discontinuous, one only in south part; (d), striking N. 50° to 55° E., dipping 37° S. 37° E., forms a small heading north of the south wall. The rift is reported as vertical, with course of about N. 55° E., and the grain as horizontal. A schist inclusion in the west wall is 30 feet long with a foliation striking N. 50° E. There are also masses of darker granite of roundish outline up to 3 feet in diameter, like those in the Marr & Gordon quarry (p. 127). Rusty stain is up to 6 inches thick on sheet surfaces.

The plant comprises a 20-ton and a 30-ton derrick, two hoisting engines, an air compressor (capacity 700 cubic feet of

air per minute), four large rock drills, 12 air plug drills, and two steam pumps.

Transportation is by siding to the cutting shed at Barre, which is on another siding. (See Pl. XXI.)

The product is monumental granite. Specimens are included in the list on page 134.

JONES SMALL DARK QUARRY.

Jones Small Dark quarry is over 100 feet S. 20° W. from the last, in Williamstown. (See Pl. XXI, No. 39.) This is an old opening which was being worked anew in 1907. Operators, Jones Brothers & Co., Barre, Vt.

The granite is identical with that of the last quarry. The sheets are very irregular. Joints (A) and (B) of the other quarry recur. There is a schist inclusion, 4 by 2 feet in the north wall. The darker granite also occurs here, but associated with irregular masses of aplite (specimen D, XXIX, 14, a) of light medium bluish-greenish gray color, and very fine even-grained texture described more fully on page 122.

PIRIE QUARRY.

The Pirie quarry is in Williamstown (Orange County), nearly 1½ miles south-southwest of the top of Millstone Hill. (See Pl. XXI, No. 40.) Operator, James K. Pirie, Graniteville, Vt.

The granite, "dark Barre," is a biotite granite of dark, slightly bluish gray shade and of even grained fine inclining to medium texture like that of the Barre quarries described on page 126.

The quarry, opened in 1882, is estimated as measuring 350 feet in a northeast direction by 100 and 250 feet across, and from 30 to 100 feet in depth.

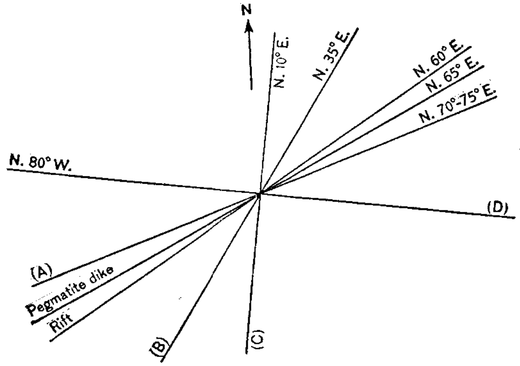


FIGURE 18–Structure at Pirie quarry, Williamstown, near Barre.

The sheets are normal, from 1 to 12 feet thick, and dip 10° to 30° NNW. Joint, rift and dike courses are shown in figure 22. Joint set (A) dips 60° S. 27° E., forms part of the west wall, and a rusty heading across the center of quarry; (B) dips 55° S. 55° E., forms the east wall, is spaced 1 to 20 and over 50 feet. This is also very rusty; (C) dips 55° E., only three, spaced 10 feet; (D), about vertical, discontinuous, is spaced 30 feet. The rift is reported as vertical and the grain as dipping about 35° N. 30° W. A 3 foot 6 inch pegmatite dike dipping 65° S. 25° E. crosses the center of the quarry and sends out tapering branches up to a foot in length. (See, further, p. 122.) "Sap" up to a foot thick is mostly confined to the underside of sheets.

The plant comprises four derricks, four hoisting engines, an air compressor (capacity 565 cubic feet of air per minute), four large air rock drills, 14 air plug drills, and three steam pumps.

Transportation is by siding, as shown on Plate XXI.

The product is used for monuments. Specimens: Soldiers and Sailors' monument, Bennington, N. Y.; columns and capitals for the Flood mausoleum, San Francisco; memorial to persons killed by flour-mill explosion, Minneapolis, Minn.

WHEATON QUARRY.

The Wheaton quarry is 2⅛ miles east of the city, 620 feet above it, and north-northwest of the top of Cobble Hill, in Barre. Operator, Barre White Granite Company, Barre, Vt.

The granite (specimen D, XXIX, 29, a), "white Barre," is a biotite granite of very light-gray shade (lighter than "light Barre" and as light as that of North Jay, Me.), and of even-grained medium texture, with feldspars up to 0.4 inch and mica to 0.2 inch. Its constituents, in descending order of abundance, are: Bluish translucent to milk-white potash feldspar (orthoclase, kaolinized and micacized, with a little fresh microcline); light smoky quartz with hairlike crystals of rutile, and with cavities in sheets with rift cracks parallel to them, intersected at right angles by shorter and fewer sheets of cavities; whitish soda-lime feldspar (oligoclase-albite) more or less altered; biotite (black mica) more sparse than in "Barre granite" generally, some of it chloritized; a little muscovite or bleached biotite. Accessory: Titanite, zircon, apatite, rutile. Secondary: Calcite, largely in orthoclase, kaolin, one or two white micas, chlorite. The stone effervesces with cold dilute muriatic acid.

This is a constructional granite of very light shade, medium texture, and strong mineral contrasts.

The quarry is estimated as about 325 feet north-south by 325 feet across and from 5 to 20 feet deep. It was opened on a surface rising 50 feet in 325.

The sheets, 1 to 4 feet thick and normal, dip 10° NW. and NNE. There are two sets of joints: (a), striking N. 7° to 85° E., vertical, is spaced 2 to 200 feet and over; (b), striking N. 20° E., vertical forms a heading on the south side.

The plant comprises a derrick and hoisting engine and two smaller hand and horse derricks.

Transportation is by cart, 2½ miles to Barre.

The product was used for buildings and the bases of monuments.

The quarry not operated in July, 1907.

WILDBUR QUARRY.

The Wildbur quarry is on the west side of Cobble Hill, 600 feet above the city and N. 35° E. from the top of Millstone Hill, in Barre. Operators, Wildbur Brothers & Bessey, Barre, Vt.

The granite (specimen D, XXIX, 31, a), "light Barre," is a biotite granite of light medium gray shade (like Jones "light Barre") and of even-grained fine inclining to medium texture, with feldspars up to 0.2 inch and mica to 0.1 inch. The mica is finer and more abundant than in the stone of Wheaton quarry. Its constituents are identical with those of Jones "light Barre" described on page 132. A clear microcline incloses an altered orthoclase. The quartz shows effects of strain and conspicuous rift cracks parallel to or coinciding with sheets of cavities. Some of these cracks polarize brightly and continue into the feldspars, where they are clearly filled with fibrous muscovite. The stone effervesces with cold dilute muriatic acid.

The quarry is estimated as measuring 100 feet east-west by 75 feet across. It has a working face 80 feet high on the east.

The sheets, 1 to 8 feet thick, becoming thicker eastward, appear to belong to the outside of an arch or dome striking here N. 10° to 20° W. and dipping 60° S. 75° W. One set of joints only, striking N. 75° E. and dipping 70° S. 15° E., is spaced 8 to 30 feet and over. The rift is reported as vertical, with N. 75° E. course and the grain as horizontal.

The plant consists of a derrick and hoisting engine.

Transportation is by cart, 3 miles to Barre.

The product is used for monuments and buildings.

BIANCHI QUARRY.

The Bianchi quarry is on the west side of Cobble Hill near its southwest end, about 600 feet above the city (southwest to Bond & Whitcomb quarry on Millstone Hill), in Barre. Operator, Charles B. Bianchi, East Barre, Vt.

The granite, "light Barre," is a biotite granite of light medium gray shade and of even-grained fine inclining to medium texture, identical with that of the Wildbur quarry.

The quarry measures about 70 feet north-south by 60 feet across and has a high working face on the east.

The sheets, 10 to 18 feet thick, strike N. 40° W., and dip 35° S. 50° W. There are two sets of joints: (a), striking N. 50° E., vertical, is spaced 1 to 20 feet; (b), striking N. 30° W., vertical, discontinuous, is spaced 10 to 30 feet. The rift is reported as vertical with N. 50° E. course and the grain as horizontal. Flow structure shown by vertical biotitic planes strikes about north. A basic dike, up to 6 inches thick, crosses the center of the quarry with N. 55° E. course.

The plant consists of a horse derrick. The firm has a cutting plant in Barre, which receives granite mostly from other quarries.

Transportation is by cart, 3 miles to Barre.

The product is used for bases and hammered monumental work.

HYLAND QUARRY.

The Hyland quarry is in Barre, on the west side of Cobble Hill, a little north of the Wildbur quarry and at the same level. It was just being opened in July, 1907.

Besides the above quarries a number of openings shown on the quarry map (Pl. XXI) were either temporarily or permanently abandoned in 1907.

CABOT.

The town of Cabot adjoins that of Woodbury on the southeast and of Walden on the northeast. Lambert's prospect is in the northern corner of the township, on the east side of a north-south ridge, roughly about 4 miles east of Robeson Mountain in Woodbury and about 700 feet above Woodbury Pond. (See fig. 5.) It is on the farm of Myron Goodnough, near the Walden line, on the South Walden road which leads from Cabot to Hardins. Operator, Joseph Lambert, Macksville, Hardwick, Vt.

The granite (specimen D, XXIX, 59, a), dark gray, is a quartz monzonite of dark bluish gray color (as dark as "dark Barre") and of even-grained fine texture, with feldspars and mica up to 0.4 inch, the latter rarely 0.3 inch. Its constituents, in descending order of abundance, are: Clear quartz with fluidal and other cavities in sheets and with rift cracks parallel to them filled with fibrous muscovite and extending into the feldspars; bluish gray to milk-white soda-lime feldspar (oligoclase) but little kaolinized, micacized and with calcite; bluish-gray potash feldspar (orthoclase, kaolinized and micacized, with microcline); greenish biotite (black mica); and a little muscovite or bleached biotite. Accessory: Pyrite, titanite, apatite and allanite (a crystal 0.33 by 0.09 millimeter rimmed with epidote). Secondary: Calcite, epidote, kaolin, and one or two white micas. It effervesces slightly with cold dilute muriatic acid.

This stone is a little finer textured than some of the "dark Barre," and more micaceous. Its mineral contrasts are more marked owing to its feldspars being whiter and less bluish and its quartz not smoky. It ought to hammer light.

The quarry, opened in 1904, consists of several small preliminary openings. A little work was done in 1907.

The sheets are not yet sufficiently exposed to show their thickness. There are five sets of joints: (a), striking N. 85° E., dipping 75° N.; (b), striking N. 55° W., dipping 55° S. 35° W.; (c), striking N. 65° E. dipping 25° NNW.; (d), striking N. 5° E., vertical; (e), striking N. 60° E. and dipping 75° S. 30° E.

CALAIS.

General Statement.

The town of Calais adjoins that of Woodbury on the southwest. The quarries are at Adamant (formerly known as Sodom) in the west corner of the town and 6 miles north-northeast of Montpelier. The quarries lie along a N. 30° E. line on the southeast side of a granite ridge. The granite is a biotite granite of medium and light gray shade and fine texture. Of geologic interest is the absence of sheet structure and the occurrence of graphite in connection with quartz veins. Schist crops out below the quarries at the village with a foliation striking N. 20° E. and dipping 55° W.

PATCH QUARRY.

The Patch quarry is within one-half mile of Adamant, in Calais. Operators, Patch & Co., Montpelier, Vt.

The granite (specimen D, XXIX, 52, a) "medium gray," is a biotite granite of medium, slightly bluish gray color and of even-grained medium texture, with feldspars up to 0.3 inch, rarely 0.4 inch, and mica up to 0.1 inch. The larger feldspars are crystallized about the quartz and mica and give the stone something of a porphritic texture. Its constituents, in descending order of abundance, are: Clear colorless potash feldspar (orthoclase, somewhat kaolinized and micacized, with microcline) with inclusions of the other constituents; clear, colorless quartz with but few cavities; bluish to milk-white soda-lime feldspar (oligoclase-albite more or less altered); biotite (black mica); and a little muscovite or bleached biotite. Accessory: Apatite, zircon. Secondary: Kaolin, calcite and white mica. It effervesces slightly with cold dilute muriatic acid.

This granite is of the same shade as "medium Barre" but of less bluish and more greenish tinge. Its mineral contrasts are stronger and its texture a little coarser. Its large clear feldspars give brilliancy to its rough surface.

The quarry, opened about 1893, is estimated as measuring 250 feet from north to south by 150 feet across and from 20 to 50 feet in depth.

Sheet structure is absent. There are two sets of joints: (a), utilized as sheets in quarrying, striking N. 85° E., dipping 50° S., is spaced 2 to 17 feet and slickensided in a southwest direction; (b), striking like (a) but dipping 40° N. to 90°, is spaced 20 to 75 feet, in places discontinuous. The rift is reported as striking N. 30° E. and dipping 50° N. 60° W., and the grain as striking and dipping as joints (a). The "sap" is 4 inches thick on joint faces. A small vein of smoky quartz parallel to joints (a) contains large limonite particles from the alteration of some iron mineral. The slickensided face of this vein is graphitic.

The plant comprises three 20-ton derricks, a hoisting engine, an air compressor (capacity 250 cubic feet of air per minute), five air plug drills, and a large rock drill.

Transportation is by cart, 7 miles to Montpelier.

The product is used for monuments and finds a market chiefly in the Middle West.

LAKE SHORE QUARRY.

The Lake Shore quarry is about 1,200 feet S. 32° W. from the Patch quarry near Adamant in Calais. Operator, Lake Shore Quarry Company, Montpelier, Vt.

The granite (specimen D, XXIX, 53, a), "gray granite," is a biotite granite of light inclining to medium gray shade and of even-grained fine texture with feldspars up to 0.2 inch and mica to 0.1 inch, rarely 0.2 inch. The larger feldspars are crystallized about the quartz and mica, giving the stone something of a porphyritic texture. Its constituents are identical with those of the Patch quarry stone, except that it contains secondary epidote in particles up to 0.5 millimeter. It effervesces slightly with cold dilute muriatic acid.

This stone is a trifle darker than "light Barre" and a trifle lighter than 'medium Barre." Its shade corresponds to that of the granite of Hallowell, Me., but its contrasts are stronger. Its other qualities are identical with those of the Patch quarry stone.

The quarry, opened in 1902, is about 300 feet long in a N. 60° W. direction by 250 feet across and from 20 to 40 feet deep.

Sheet structure is undeveloped. There are three sets of joints: (a), utilized as sheets in quarrying, striking N. 80° E., dipping 80° S., is spaced 1 to 18 feet; (b), striking N. 75° E., dipping 30° N., 15° W., only two on south wall; striking N., 20° E., dipping 30° W., discontinuous, at intervals of 20 feet and over. The rift is reported as having a N. 20° E. course and dipping 70° N. 20° W. A 3-inch quartz vein is parallel to joints (a).

The plant comprises a derrick, hoisting engine, air compressor (capacity 200 cubic feet of air per minute), a large rock drill, three air plug drills, and a pulsometer pump.

Transportation is by cart, 7 miles to Montpelier.

The product is used for monuments and buildings. Specimen: The Soldiers' Memorial building, Stowe, Vt.

EUREKA QUARRY.

The Eureka quarry is about 900 feet N. 30° E. from the Patch quarry, near Adamant in Calais. Operator, Eureka Granite Company (Clark Sibley), Montpelier, Vt.

The granite is presumably identical with that of the Patch quarry.

The quarry is about 350 feet from east to west by 80 feet across, with a working face on the north 105 feet high.

Incipient sheet structure is from horizontal to inclined 20° S. There is only one set of joints and that strikes N. 75° E. and dips 55° S. 15° E.; spacing 2 to 10 feet. A quartz vein with limonite is parallel to the joints.

The plant comprises a derrick, hoisting engine, air compressor, large rock drill and two air plug drills.

Transportation is by cart, 7 miles to Montpelier.

The quarry was temporarily idle in 1907.

WOODBURY.

Topography.

The township of Woodbury lies northeast of Calais, northwest of Cabot and southwest of Hardwick. Its principal quarries are on the southeast flank of Robeson Mountain, about a mile east of Woodbury Center and 3 miles north-northeast of Woodbury (Sabins) Pond. (See map, fig. 5.) Robeson Mountain is a ridge about a mile long with an axis curving from N. 80° E. to S. 70° W. Its top is from 300 to 400 feet above the hollows on either side and 930 feet above Woodbury Pond and about 1,100 feet above the railroad at Hardwick. Granite has also been quarried on the ridges on the northwest and southeast sides of Buck Pond and is now quarried on the rising ground at the head of the hollow on the north side of Robeson Mountain. This mass is continuous with the ridge southeast of Buck Pond. Granite has also been quarried on the north and northeast foot of Nichols Ledge, a bold cliff about 3 miles N. 70° E. from Robeson Mountain and 740 feet above Woodbury Pond, in the east corner of the town, east of Nichols Pond. The granite masses referred to are all within an area of about 3½ miles square, occupying the northeast part of the town.

General Geology.

Little is known of the geology of Woodbury. In the Vermont report of 1861 all the central and eastern part of the town appears as "calciferous mica schist." A belt of "clay slate" is represented as crossing the west part of the town in a north-northeast direction. Schist crops out on the northwest side of Robeson Mountain with a bedding strike of N. 70° W. and vertical dip and north pitch; also on the west-southwest side with a N. 67° E. strike and a dip of 55° N. 23° W. This would indicate a synclinal structure for the schist of this mountain. Schist also crops out near the quarries on the rising land north of the mountain, and appears also to cap the ridge east of the north end of Buck Pond. This is a muscovite-quartz-biotite schist with interbedded calcareous quartzite. The contact of schist and granite on Robeson Mountain has been described on page 23. The mountain appears to be an oblong dome in structure with an east-northeast to west-southwest axis, the sheets of which, horizontal at the top, bend over to 15° to 20° on the northwest and southeast sides, although in places still covered by schist. Nichols ledge is another conspicuous granite mass. The granite of the top is coarsely porphyritic with feldspars an inch long, but at its north and northeast foot there is a granite of very fine to fine texture, possibly a dike in the coarser. All the granite masses evidently protrude through the schist, but what parts of the intervening hollows are still occupied by schist is not determined. The foliation of a schist mass back of the Webber quarry, between Buck Pond and Robeson Mountain, strikes N. 20° E.

"Woodbury Granite."

The "Woodbury granites" are all biotite granites of more or less bluish gray shade, ranging from the dark to light (one very light cream color), and in texture from very fine to medium. They fall into four kinds, but, taking account of minor differences, into nine varieties. Most of them possess in large masses one general characteristic: They carry sparse, more or less incomplete, crystals up to an inch across of clear potash feldspar formed about the other minerals. There is some parallelism between these crystals, for seen at a certain angle the cleavage planes of adjoining crystals reflect the light alike.

The granites of Robeson Mountain vary from light to medium gray shade and from medium to fine, inclining to medium, porphyritic texture. Their constituents, in descending order of abundance, are: (a) Clear to translucent bluish potash feldspar (orthoclase and microcline), rarely somewhat kaolinized, its large particles with inclusions of biotite, quartz and soda-lime feldspar; light to medium smoky quartz with hairlike crystals of rutile and fluidal and other cavities in sheets in two rectangular sets parallel to rift and grain cracks, respectively (some of the rift cracks extend into the feldspars and are filled with fibrous muscovite); milk-white soda-lime feldspar (oligoclase to oligoclase-albite), more or less kaolinized, micacized, and with calcite and in places epidote; biotite (black mica), some of it chloritized; a little muscovite or bleached biotite. Accessory: Pyrite, titanite, zircon, apatite, rutile. Secondary: Kaolin, a white mica, epidote, zoisite, calcite, limonite. Some of the feldspars are minutely intergrown with quartz in vermicular structure.

Two estimates of mineral percentages by the Rosiwal method average as follows:

Average estimate of mineral percentages in granite of Robeson Mountain.

Feldspar	64.35
Quartz	29.15
Mica	6.48

One chemical test (p. 163) shows it to contain 0.16 per cent. of CaO (lime), soluble in warm dilute (10 per cent.) acetic acid, indicating a content of 0.28 per cent. of $CaCO_3$ (lime carbonate, calcite).

The general differences between the three varieties of granite on Robeson Mountain are these: In the stone from the Fletcher quarry the feldspar and quartz areas are rather large and well defined by differences of shade. In the stone from the Woodbury Lower quarry the quartz areas are finer, fewer and less smoky. In the "Bashaw" the texture is finer and contrasts weaker than in either of the others.

The fine dark gray of the new Drenan and Webber openings and of another near Buck Pond (pp. 168-169) is of dark bluish-gray shade and fine texture, with feldspars to 0.2 inch and mica to 0.1 inch. Its composition is identical with that of the granite of Robeson Mountain, but its quartz is clear and its feldspar is albite to oligoclase-albite. Its general shade is like that of "dark Barre," but its texture is finer.

The stone from the Nichols Ledge quarry is of light inclining to medium bluish-gray shade and of very fine texture, with feldspar to 0.15 and mica to 0.1 inch, with a few larger porphyritic clear feldspars. This is lighter and finer than the last. Its quartz is clear with apatite needles and its second feldspar is oligoclase to oligoclase-andesine.

Finally, there is the very light, slightly cream-colored constructional granite of the prospect between Robeson Mountain and Buck Pond (p. 170), which is of medium texture and speckled with black. Its quartz is smoky.

The minor differences, which make the varieties in the granites described above, will appear in the detailed descriptions of the stone of each quarry.

Geology of Woodbury Quarries.

The usual range in thickness of sheets is from 2 to 8 or 20 feet; the extremes are 1 to 40 feet. The double sheet structure at the Fletcher quarry has already been described on page 87. The secondary, nearly horizontal, set is from 5 to 9 feet thick. It recurs in the lower part of main quarry of the Woodbury Granite Company. There is a northeast to southwest compressive strain at the Fletcher quarry near the axis of the mountain, parting and extending the upper sheets.

The joints divide themselves into six sets: (a), striking N. to N. 10° E., with its complementary set; (b), N. 85° to 90° E.; (c), striking N. 20° to 30° E., with its complementary set; (d), N. 50° to 65° W.; (e), striking N. 20° to 30° W., with its complementary set (f), N. 60° to 65° E. The spacing of these joints ranges from 2 to 200 feet, but mostly 10 to 20 to 40 feet. Headings, 3 to 30 wide, of set (a) are spaced 30 to 50 feet on Robeson Mountain. The rift is reported as vertical with courses of N. 15°, 26°, 35°, and

60° E., and the grain as uniformly horizontal. At one quarry the rift has to be followed closely in winter, but the rock is reported as splitting with equal facility in any direction in summer.

Flow structure appears with a dip of 50° SW. There is an irregular banding at the old Drenan quarry caused by unequal distribution of biotite. The schist capping is exposed at another of the Drenan openings and the 100-foot mass of schist at the back of the Webber quarry is either part of the same or a very large inclusion. The schist inclusions on Robeson Mountain, 25 and 8 feet long, have been referred to on page 166. A small light-greenish calcareous inclusion at the Ainsworth quarry proves to be chiefly crystalline calcite with quartz particles under 0.1 millimeter, together with apatite and scondary epidote and zoisite, and has veinlets of epidote, quartz and calcite. This appears to have originally been a quartzose marble, and its interest lies in its evidence of the presence of calcareous rocks here prior to the granite intrusion.

There are biotitic segregations up to 2 feet in diameter. Small pegmatite dikes at the Chase quarries, near Buck Pond, strike about north and a 4-inch quartz vein on the northwest side of Robeson Mountain strikes N. 35° to 40° E.

FLETCHER QUARRY.

The Fletcher quarry is on Robeson Mountain near its west-southwest end and on its southeast side in Woodbury. (See fig. 5.) Operator, E. R. Fletcher, Hardwick, Vt.

The granite (specimens D, XXIX, 56, a, c), "Woodbury gray," is a biotite granite of light-gray shade (between "light Barre" and the granite of Hallowell, Me.) and of medium texture with feldspars up to 0.3 inch and mica to 0.1 inch. Its constituents, in descending order of abundance are: Clear to translucent bluish potash feldspar (orthoclase, some of it minutely intergrown with plagioclase, also microcline), the larger particles with inclusions of biotite and soda-lime feldspar; medium smoky quartz with hairlike crystals of rutile and cavities in two sets of rectangular sheets with rift and grain cracks parallel to them; milk-white soda-lime feldspar (oligoclase-albite) much kaolinized, somewhat micacized and epidotized and with calcite; biotite (black mica) some of it chloritized; and a little muscovite or bleached biotite. Accessory: Pyrite, titanite, zircon, apatite, rutile. Secondary: Kaolin, a white mica, epidote, zoisite, calcite, limonite.

An estimate of the mineral percentages by the Rosiwal method yields these results with a mesh of 0.5 inch and a total linear length of 46.5 inches:

Estimated mineral percentages in granite of Fletcher quarry, Woodbury

Fledspar	63.11
Quartz	31.22
Mica	5.67
	100.00

The average diameters of the particles by the same calculation are: Feldspars (adding 20 per cent. to number for plagioclase) 0.103 inch; quartz, 0.1 inch; mica, 0.029 inch.

The stone effervesces very slightly with cold dilute muriatic acid. W. T. Schaller, chemist of the United States Geological Survey, finds that it contains 0.16 per cent. of CaO (lime) soluble in warm dilute (10 per cent.) acetic acid, which indicates a content of 0.28 per cent. of $CaCO_3$ (lime carbonate, calcite), the presence of which mineral is also shown by the microscope.

This is a brilliant granite with marked mineral contrasts. The quartz and feldspar areas are rather large and well defined. The polish is poor owing to the large size of the micas. The polished face shows some pyrite.

The quarry, opened about 1887, is estimated as measuring 300 feet in a northwest direction or across the ridge, by 300 along it, and from 20 to 40 feet in depth. It is practically the beginning of a cross section of the ridge and dome.

The complex sheet structure here has already been described (p. 86). The primary sheets, 1 to 5 feet thick, are horizontal at the northwest and upper side of the quarry, but gradually bend over and dip 20° to 30° SE. at the lower southeast side. The secondary set, 5 to 9 feet thick, dips 5° to 10° about W. across the other. There are three sets of joints: (a), striking N. 30° E. vertical is spaced 6 to 30 feet and over; (b), striking N. 65° E., dipping 75° N. 25° W., one only in southeast part; (c), striking N. 20° W., vertical, is spaced 2 to 15 feet. There are no headings. Some of the joint faces are greenish, probably from chlorite. The rift is reported as vertical with N. 35° E. course and the grain as horizontal. Flow structure consists of biotitic streaks of irregular course. Biotitic knots from 1 to 3 inches across are reported. There is a marked northeast-southwest compressive strain in the upper part of the quarry, raising the sheets and even forming new sheet partings. There is no rusty stain whatever on sheet surfaces.

The plant comprises, at the quarry two derricks (one of them of 40 tons) and a large rock drill; at the cutting shed at Hardwick a 10-ton and a 15-ton derrick, a hoisting engine, a 10-ton locomotive crane, a 40 horsepower engine, and three polishers.

Transportation is effected by siding from the Hardwick and Woodbury Railroad, which brings the stone 8 miles to the cutting shed and to the St. Johnsbury and Lake Champlain Railroad. (See fig. 5.)

The product is used for monuments and buildings. Specimens: Base of the General Sherman monument, Washington, D. C.; Homewood Cemetery entrance, Allegheny, Pa.; Crandall monument, Crandall Park, Glens Falls, N. Y., (this is a pentagonal shaft 36 feet by 4 feet 10 inches by 5 feet); base courses, approaches and steps to post-offices at Atlantic City, N. J., and Jacksonville, Ill.

WOODBURY GRANITE COMPANY'S QUARRIES.

The Woodbury Granite Company's quarries are on Robeson Mountain, roughly from 1,400 to 2,100 feet N. 80° E. from the Fletcher quarry in Woodbury. (See fig. 5.) Operator, Woodbury Granite Company, Hardwick, Vt.

The granite is of two sorts. Specimen D, XXIX, 57, b and c, "Woodbury gray," is a biotite granite of medium gray shade and medium texture with feldspar up to 0.3 inch and mica to 0.1 inch. Its constituents, in descending order of abundance are: Clear to bluish translucent potash feldspar (microcline and orthoclase) somewhat kaolinized; light smoky quartz with hairlike crystals of rutile, and cavities in sheets with rift and grain cracks parallel to or coinciding with them; milk-white soda-lime feldspar (oligoclase) considerably kaolinized but not micacized or epidotized in places intergrown with quartz in vermicular structure; biotite (black mica); and a little muscovite or bleached biotite. Accessory: Pyrite, apatite, zircon, rutile. Secondary: Kaolin and zoisite. Carbonate and epidote were not detected. There is no effervescence with cold dilute muriatic acid.

An estimate of the mineral percentages by the Rosiwal method with a mesh of 0.3 inch and a total linear length of 38.1 inches yielded these results:

Estimated mineral percentages in granite in Woodbury Granite Company's lower quarry.

Feldspar	65.6
Quartz	27.1
Mica	7.3
	100.0

The average diameters of all the particles by the same calculation is 0.084 inch; that of the feldspar (adding 20 per cent. to the number for the plagioclase as in calculation for average diameter), is 0.105 inch; quartz, 0.074 inch; and mica, 0.025 inch.

This stone to the eye is like that of the Fletcher quarry, except that its quartz particles are a little finer, less numerous and less smoky. Its mineral contrasts are, therefore, weaker. The polish is poor, owing to abundant and rather large mica scales, but the contrasts on the polished face are strong. It shows a little pyrite.

The other sort (specimens D, XXIX, 57, a and d), "Woodbury Bashaw," is a biotite granite of medium-gray shade (about like that of "Concord granite" but more bluish and with more contrasts), and of fine inclining to medium texture with feldspars up to 0.2 inch and mica to 0.1 inch. Its constituents, in descending order of abundance are: Clear to translucent bluish potash feldspar (microcline and orthoclase), light smoky quartz with cavities in two sets of rectangular sheets, with rift and grain cracks parallel to them, respectively. The rift cracks extend into

the feldspars and are filled with fibrous muscovite; milk-white soda-lime feldspar (oligoclase) much micacized with epidote and calcite, also intergrown with quartz in vermicular structure; biotite (black mica), some of it chloritized; a little muscovite or bleached biotite. Accessory: Pyrite, zircon, crystals, apatite. Secondary: A white mica, epidote, calcite, chlorite. The stone effervesces slightly with cold dilute muriatic acid.

This is a monumental granite. Its mineral contrasts are not as marked either in the rough or the polish as in the "Woodbury gray." This is due to the feldspars being less kaolinized and thus less white. Its texture is finer and it polishes better. The polished face shows a little pyrite.

Three compression tests of the "Woodbury gray" made for the firm at the United States Arsenal at Watertown, Mass. (test No. 13,261), yielded these results:

Compressive strength of "Woodbury gray" granite.

	Pounds per square inch.
First crack, 199,000 pounds; ultimate strength	22,460
First crack, 181,000 pounds; ultimate strength	19,850
First crack, 168,000 pounds; ultimate strength	20,110
Average	20,806

The quarries consist of four openings: The main and western one, made in 1880, beginning at the south foot of the ridge, extends about 500 feet along it and 40 feet northward up its side, with an average depth of 50 feet. The "upper quarry," above and north of the main one, is about 200 feet square, and its north side is at the top of the hill nearly 300 feet higher than the lower edge of the main quarry. The third opening, about 800 feet east of the main one, made in 1906, is about 125 by 70 feet and from 10 to 30 feet deep. This produces the finer monumental granite, "Woodbury Bashaw," described on page 164. The four this a small opening made in 1907, about 200 feet northwest of the third.

The sheets at the top of upper quarry and of the ridge are horizontal. In the third opening they are from 2 to 13 feet thick, ill defined, and about horizontal. In the main quarry they range from 2 to 18 feet, exceptionally 23 feet and even 40, curving over from the horizonal to dip 20° S. They are intersected by a horizontal set. (See pp. 87, 162.) The joint courses (shown in fig. 19) are four: (A) dips 60° to 65° N., 35° E. (some vertical, discontinuous), spaced 20 to 40 and 200 feet; (B), vertical or dipping 75° W., discontinuous along the dip, in third opening spaced 10 to 30 feet, but in main quarry mostly headings, five in all 3 to 30 feet wide and 30 to 50 feet apart; (C) is vertical, discontinuous, and much more open than (A) or (B); (D) is spaced 2 and 10 to 40 feet. The rift is reported as vertical and the grain as horizontal, but not marked. The rift has to be followed closely in winter, but in summer the rock splits almost any way. There are two schist inclusions in the main quarry, 25 by 10 feet and 8 feet by (?), also some smaller ones. Rusty stain measures from 1 to 18 inches on sheet surfaces.

The plant at the quarries comprises a 75-ton, a 50-ton, three 40-ton, a 30-ton, and two 20-ton derricks, seven hoisting engines, three Blondin carriers with two engines and cables 1,200, 800 and 700 feet long to carry waste to the dumps in the valley, an air compressor (capacity 1,160 cubic feet of air per minute), five large rock drills, twenty-four air plug drills, and eight hollow-steel drills ("bull machines") for blowing out powdered granite. The plant at the cutting sheds at Hardwick comprises three derricks, two overhead 20 and 40 ton cranes, an outdoor overhead traveling 30-ton crane operated on a trestle 575 feet long and of 75-foot span to facilitate storage of finished stones and rapid loading of cars, two air compressors (capacity 1,000 and 500 cubic feet of air per minute), eleven air plug drills, 65 air hand tools, six surfacers, a polisher, four lathes for stones 35 by 4 feet, 13 feet by 2 feet 6 inches, 12 by 2 feet, and 13 feet by 1 foot, two polishing lathes for stones 25 by 5 and by 3 feet, two saws for stones 10 by 8 by 6 feet and 16 by 6 by 7 feet, two MacDonald combined planers and surfacers. The firm in 1908 was engaged in equipping its electric power station with a 4-foot tubular steel penstock to secure a higher head, and two motor generator sets of capacity of 250 kilowatts each. The power line was being extended 6 miles to the quarry plant, in order to run it by electricity also and do away with steam engines.

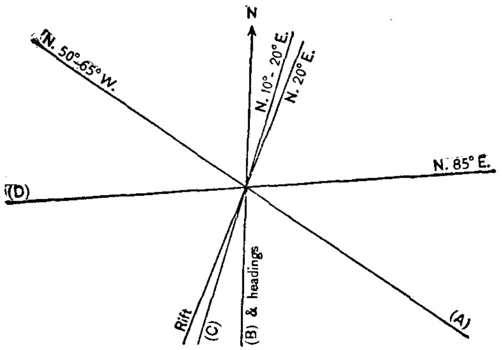


FIGURE 19—Structure at Woodbury Granite Company's quarries, on Robeson Mountain.

Transportation is by siding from the Hardwick and Woodbury Railroad (see map, fig. 5), which brings the stone 8 miles to the cutting shed, and the St. Johnsbury and Lake Champlain Railroad.

The product is used both for buildings and monuments. Specimens of buildings: Pennsylvania capitol, Harrisburg; Cook County court-house, Chicago; base course and 36 interior polished columns of Kentucky capitol, Frankfort; post-office and custom house, Providence, R. I.; Carnegie Library, Syracuse, N. Y.; Homeopathic Hospital, Pittsburg, Pa.; Bank of Ohio Valley, Wheeling, W. Va.; Hotel Pontchartrain, Detroit, Mich.; Mandell residence, Boston, Mass. Specimens of monuments: Soldiers' and sailors' monument, Scranton, Pa.; soldiers' monument, Manchester, Vt.; memorial archway, Port Huron, Mich.; and the Flower memorial, Watertown, N. Y. The adaptability of the granite for carving is shown in Plate IV, A, representing a panel on the Cook County court house.

CARSON QUARRY.

The Carson quarry is on the northeast foot of Robeson Mountain, in Woodbury. (See map. fig. 5). Operators, Carson Brothers, Woodbury, Vt.

The granite is a biotite granite similar to that of the main quarry of the Woodbury Granite Company, page 164.

The quarry was barely opened in 1907. The sheets are thick.

Transportation is by cart, one-third of a mile to the Hardwick and Woodbury Railroad.

AINSWORTH QUARRY.

The Ainsworth quarry is on the northeast foot of Robeson Mountain in Woodbury, about 1,000 feet northeast of the railroad. (See fig. 5.) Operators, Ainsworth & Ainsworth, Woodbury, Vt.

The granite is a biotite granite similar to that of the main quarry of the Woodbury Granite Company, page 164.

The quarry consists of two openings: One 50 by 35 feet and 15 feet deep; the other, about 500 feet west of the first, is 50 by 20 and 10 feet deep.

The sheets are from 15 to 20 feet thick. There are very dark gray knots up to 2 feet by 1 foot, with half-inch porphyritic feldspars, much fine biotite and not a little pyrite. A small inclusion of fine-grained quartzose marble was noticed on page 162.

The plant comprises a hand and a horse derrick.

The stone has to be carted 1,000 feet or more to rail. The quarry is not worked in haying time.

MILLER QUARRY.

The Miller quarry is about 500 feet west-southwest of the last. Operator, G. F. Miller, Woodbury, Vt.

This is a small opening of recent date. A flow structure dipping 50° SW. was noticed.

DRENAN QUARRIES.

The Drenan quarries are in Woodbury, on the rising land north of the east end of Robeson Mountain and about 150 feet above the north spur of the Hardwick and Woodbury Railroad.

(See map, fig. 5.) Operators, Drenan, Brown & Raycraft, Woodbury, Vt.

The granite of the new opening now worked (specimen D, XXIX, 65, a), "Woodbury fine dark gray," is a biotite granite of dark bluish-gray shade and fine texture with feldspar up to 0.2 inch and mica to 0.1 inch, but with some large, clear, sparse feldspars formed about the other minerals. As many of these have their cleavage parallel, the rough rock face seen at a certain angle has a brilliant sheen. Its constituents, in descending order of abundance, are: Clear colorless to translucent potash feldspar (microcline and orthoclase) slightly kaolinized, with inclusions of biotite, quartz, and soda-lime feldspar; clear, colorless quartz with cavities in sheets; bluish milk-white soda-lime feldspar (albite to oligoclase-albite) kaolinized and micacized, also with calcite; biotite (black mica); and a little muscovite or bleached biotite. Accessory: Pyrite, apatite, zircon. Secondary: Kaolin, a white mica, calcite, zoisite. The stone effervesces with cold dilute muriatic acid.

This is a monumental granite of the same shade as "dark Barre" but of finer texture. It is darker than any of the granites of Robeson Mountain.

The quarry consists of three openings, two of which are abandoned. The last, made in 1907, is 200 by 100 feet and shallow.

The structure at the new opening is insufficiently exposed. Rift is reported as vertical with N. 60° E. course and the grain as horizontal. The area of this fine granite is said to measure about 200 feet square, with coarser granite around it. At one of the older openings, a few hundred feet south, a medium gray granite is banded with a less biotitic, very light gray granite (specimen D, XXIX, 65, b). This is even grained and fine textured, with feldspar up to 0.2 inch and mica to 0.05 inch. Its quartz is very pale smoky; its feldspar very light cream color. The second feldspar is oligoclase-albite, kaolinized and micacized and with some grains of epidote and zoisite. There are dark biotitic knots 12 by 6 inches. At the third opening, a few hundred feet west of that last described, the granite is capped on the west by schist 20 feet thick.

The plant consists of three hand derricks, an air compressor (capacity 125 cubic feet of air per minute) run by a gasoline engine.

LIGHT GRANITE PROSPECT.

Within a few hundred feet west of the old Drenan openings there is a considerable ledge which has been prospected for building granite.

This is a biotite granite of very light, slightly buff or cream-tinted gray shade and of medium texture with feldspars up to 0.3 inch and with sparse black mica to 0.15 inch. Its quartz is pale smoky. The mica is in strong contrast to the quartz and feldspar.

WEBBER QUARRIES.

The Webber quarries are in Woodbury, still farther north of Robeson Mountain, on a mass which is continuous with that on the southeast side of Buck Pond. (See map, figure 5.) Operator, Webber Granite Company, Hardwick, Vt.

The granite of the main and older opening (specimen D, XXIX 68, a), "Woodbury gray," is a biotite granite of light bluish-gray shade and of medium inclining to fine texture, with feldspars up to 0.3 inch and mica to 0.15 inch. It is slightly more bluish and finer textured than the gray of the main quarry of the Woodbury Granite Company and lighter in shade than their "Bashaw," and a trifle darker than "light Barre." Its constituents in descending order of abundance, are: Clear to bluish translucent potash feldspar (microcline and orthoclase), slightly kaolinized with inclusions of biotite, quartz and soda-lime feldspar; light smoky quartz with hairlike crystals of rutile and cavities in sheets; milk-white soda-lime feldspar (oligoclase-albite) kaolinized and micacized and with calcite, with rims radially intergrown with quartz; biotite (black mica), some of it chloritized; a little muscovite or bleached biotite. Accessory: Magnetite, rutile. Secondary: Kaolin, a white mica, calcite, chlorite, epidote. There is scarcely any effervescence with cold dilute muriatic acid.

The stone of an opening made in 1907 (specimen D, XXIX, 67, a), "Woodbury fine dark gray," is a biotite granite of dark bluish-gray shade and of fine texture with feldspar up to 0.2 inch and mica to 0.1 inch, and with sparse clear porphyritic feldspars up to 0.3 inch, with inclusions of quartz and mica. This granite, as to its constituents, is identical with that of the Drenan quarry (specimen 65, a) described on page 167, and it has the same peculiar sheen. Its soda-lime feldspar is oligoclase-albite. It effervesces in cold dilute muriatic acid.

This is a monumental granite of dark bluish-gray color corresponding to "dark Barre" but of finer texture.

The main opening is about 150 feet in a N. 65° W. direction, by 75 feet across, and from 10 to 25 feet deep.

The sheets, 8 feet thick, are horizontal or dip northwest. There are four sets of joints: (a), striking N. 60° to 65° W. and vertical, forms the northeast wall, is spaced 50 feet; (b), striking N. 25° to 30° W. and vertical, is discontinuous; (c), striking N. 60° E. and vertical, forms the northeast and southwest walls; (d), striking N. 20° E. and vertical, discontinuous, is spaced 25 feet and over. The rift is reported as vertical with N. 15° E. course and the grain as horizontal. There is a mass of mica slate on the east wall 100 feet long and 10 feet wide with a foliation striking N. 20° E. and dipping 55°E. It is veined by granite.

The plant comprises one hand and two horse derricks, an air compressor (capacity 110 cubic feet of air per minute), a large rock drill, and three air plug drills.

Transportation is by a siding from the Hardwick and Woodbury Railroad.

FRYATT & CARR PROSPECT.

Fryatt & Carr, of Woodbury, in 1907 were quarryingbowlders and possibly surface sheets a little south of the Webber quarries, near the railroad switch on the south side of the track.

BUCK POND QUARRIES AND GRANITES.

Between the southwest end of Buck Pond and the new Webber quarry, roughly 500 feet north of the latter, is an abandoned quarry of biotite granite of dark bluish-gray shade and fine texture (specimen D, XXIX, 69, a) identical with specimens 65, a, and 67, a, of the new Drenan and Webber openings described on pages 168, 169. (See fig. 8.) The sheets, 5 to 8 feet thick, dip gently south. There is an east-west working face 100 feet long and 35 feet high without headings. Two sets of joints strike east and north, respectively.

On the southeast side of the pond, possibly 1,000 feet roughly northwest of the above quarry and on the west side of a granite ridge, is another abandoned opening. The rock (specimen D, XXIX, 70, a) is a biotite granite of light bluish-gray shade but of medium texture, with feldspar to 0.3 inch. It is more bluish than any of the granites of Robeson Mountain. Its texture is slightly coarser than that of the old opening of the Webber quarry (specimen 68, a), and also than the granites on the other side of the pond.

CHASE QUARRIES.

The Chase quarries are on the first high bluff northwest of Robeson Mountain, over 500 feet northwest of Buck Pond and 200 feet above it. (See fig. 5.) They have been idle for several years. The stone is a biotite granite of light bluish-gray shade and medium inclining to fine texture, identical with specimen 68, a, of the Webber main quarry described on page 169. There is a working face on the west 150 feet long and 40 feet high. The sheets, up to 8 feet thick, dip gently northeast. Pegmatite dikes, 2 inches thick, cross the granite beyond the face with 30° W. dip.

Near the southwest end of the pond, but on the west side of its outlet and on the ridge, are two small recent openings. One was operated by Elmer Leach. The granite is of dark bluish-gray shade and medium inclining to fine texture. It resembles that of the Webber and Chase quarries, but is darker. The sheets from 4 to 5 feet thick, are about horizontal.

NICHOLS LEDGE CARTER QUARRY.

The Nichols Ledge Carter quarry is at the northeast foot of Nichols Ledge in the east corner of the town of Woodbury. It is near the A. Dutton house, now occupied by A. D. Kimball. (See fig. 5.). Operator, J. H. McLeod, Hardwick, Vt. It was not worked in 1907.

The granite (specimen D, XXIX, 61, b) is a biotite granite of light inclining to medium bluish-gray shade and of fine to very fine texture, with feldspars up to 0.2 inch and mica to 0.1 inch, also with larger porphyritic clear feldspars formed about the other minerals. It is finer textured than the stone of the new Drenan and Webber openings (pp. 168, 169) and of lighter shade. Its constituents, in descending order of abundance, are: Clear, colorless potash feldspar (orthoclase and microcline); clear quartz with apatite needles and some cavities in sheets; bluish to milk-white soda-lime feldspar (oligoclase to oligoclase-andesine), but little kaolinized; olive-colored biotite (black mica) and a little muscovite or bleached biotite. Some of the feldspar is minutely intergrown with quartz. Accessory: Titanite, apatite. Secondary: Kaolin, epidote, calcite. It does not effervesce with cold dilute muriatic acid.

The sheets are up to 2 feet thick. There are some biotite knots. A similar granite is reported as once quarried by L. C. Fisher on the north side of Nichols Ledge.

WINDHAM COUNTY..

DUMMERSTON.

General Statement.

The Dummerston granite area lies 5 and 6 miles north-northwest of Brattleboro and is shown on the state geologic map of 1861 as surrounded by "calciferous mica schist," with a belt of "clay slate" east of it along the Connecticut. The quarries and prospects are in the southwest part of the town on the sides of Black Mountain and also half-a-mile south-southwest of it. Black Mountain, as shown on the United States Geological Survey reconnaissance topographic map (Brattleboro sheet), is on the east side of West River, 4 miles west of Connecticut River. This is a roundish granite mass, probably of dome structure, a square mile in area and from 900 to 950 feet above West River and 1269 feet above sea level. The sheets on its southwest side dip 30° to 40° about west and in its northwest part, about 350 feet above the river, 30° N. 30° W. There is a mass of sheets, about 35 feet thick at the foot of the mountain, does not appear to be normally related either in the thickness of its sheets or their attitude to the sheets above it. These thin sheets may either be of more recent origin than the others, or may be separated from them by a fault. The effect of compressive strain upon sheets in part of this quarry has been referred to on page 87 and illustrated in Plate VIII, B, of Bulletin 354.

The granites of Dummerston are quartz monzonites of very light gray and light bluish-gray shade and of even-grained medium or medium inclining to fine texture.

BLACK MOUNTAIN QUARRY.

The Black Mountain quarry, Plate XX, is at the southwest foot of Black Mountain, three-fourths mile south-southeast of the village of West Dummerston, in Dummerston and 5 miles north-northwest of Brattlebroo. Operator, George E. Lyons Company, West Dummerston, Vt.; main office, Monson, Mass.

The granite, of two sorts, chiefly "West Dummerston white" (specimen D, XXIX, 90, b), is a quartz monzonite of very light gray shade, speckled with bronze-colored mica (muscovite and biotite), and of even-grained medium texture with feldspars up to 0.3 inch and mica to 0.1 inch. Its constituents, in descending order of abundance are: Clear to pale smoky quartz, showing effect of strain, with hairlike crystals of rutile and a few fluidal cavities in sheets; milk-white soda-lime feldspar (oligoclase to oligoclase-albite), some of it with flexed twinning planes, kaolinized and micacized; clear potash feldspar (microcline and orthoclase); muscovite and less biotite apparently intergrown and bent or twisted with fibrous muscovite stringers extending out from them into and between the other particles. Accessory: Apatite, rutile. Secondary: Kaolin, white micas, epidote, zoisite, calcite. There are crush borders about the quartz and feldspar particles.

This stone effervesces slightly with cold dilute muriatic acid. W. T. Schaller, chemist of the United States Geological Survey, finds that it contains 0.07 of CaO (lime) soluble in warm dilute (10 per cent.) acetic acid, which indicates a content of 0.125 per cent. of $CaCO_3$ (lime carbonate, calcite), the presence of which mineral is also shown by the microscope.

A compression test, made on a 4-inch cube at the United States Arsenal at Watertown, Mass., in 1905, showed the first crack at 308,000 pounds and an ultimate compressive strength of 27,810 pounds per square inch.

This is a building granite of medium grain and very light shade, between that of North Jay, Me., and that of Bethel, Vt., in whiteness.

The other granite (specimen D, XXIX, 90, a), "dark blue," is a quartz monzonite of light inclining to medium bluish-gray color, and of even-grained fine inclining to medium texture with feldspars up to 0.2 inch and mica to 0.1 inch. Its constituents are identical with those of the "white" specimen, 90, b, but its oligoclase-albite is bluish and less altered, and its mica nearly

all muscovite. It shows less calcite in thin section and does not effervesce with cold dilute muriatic acid.

This is a monumental granite of light bluish-gray tint and without mineral contrasts.

The quarry, opened about 1877, is estimated as measuring about 1,200 feet in a N. 20° W. direction along the base of the mountain, by 200 feet across and from 15 to 50 feet deep.

The sheets for a thickness of 25 to 35 feet above the road level, and for a length of 100 feet, are from 6 inches to 2 feet thick and are horizontal or slightly inclined west. Below the road level they measure up to 14 feet in thickness and dip 20° W., although horizontal for short spaces. Above this thin-sheeted mass they dip 30° to 40° W., and are considerably thicker. At the north end of the quarry compressive strain forms new thin sheets and parts them. (See p. 87.) There are two sets of joints: (a), striking N. 15° E., vertical, is spaced 7 to 30 feet; of (b), striking N. 20° W., dipping 80° N. 70° E., there is only one, at the south end. Flow structure strikes N. 22° E. and dips 80° N. 80° W. The rift is reported as vertical with N. 15° E. course and parallel to the mica plates and the grain as horizontal. Both are good. Pegmatite dikes from 0.25 to 3 inches thick, with large light bluish-gray unstriated feldspars, strike N. 10° E., etc. The light bluish granite occupies 350 feet of the north end of the quarry, the rest of it being "white." Knots are rare and up to 6 inches across. Rusty stain, up to 3 inches wide on the upper sheets, is generally absent from the lower ones.

The plant comprises thirteen derricks, one of them of 20 tons, five hoisting engines, an air compressor, four large rock drills, a channel bar drill, and four air plug drills.

Transportation is by two sidings from the Vermont Central Railway. Stones for finishing are shipped to the firm's cutting plant, at Monson, Mass.

The product is used for buildings, monuments and street work. Specimens: Post-office at Troy, N. Y.; Diamond Bank, Pittsburg, Pa.; McFadden Building, Chicago, Ill.; Royal Baking Powder building and Plaza Hotel, New York.

CLARK QUARRIES.

The Clark quarries are east of West Dummerston village, on the northwest side of Black Mountain. Operator, James Clark, West Dummerston, Vt.

The granite (specimen D, XXIX, 91, a) from the lower quarry, is a quartz monzonite of very light gray shade, with conspicuous black mica and of even-grained medium inclining to fine texture with feldspars up to 0.25 and 0.3 inch and mica to 0.15 inch. Its constituents, in descending order of abundance are: Light smoky quartz showing effect of strain and with some cavities in sheets; milk-white soda-lime feldspar (oligoclase-albite), kaolinized, micacized and with calcite, also intergrown with quartz in vermicular structure; clear, colorless potash feldspar (microcline and orthoclase), with inclusions of the other feldspar and mica; biotite (black mica); muscovite or bleached biotite.

This differs from the "white" of the Black Mountain quarry in that the biotite is more prominent and the fibrous muscovite is absent.

The stone from the upper quarry appears to be exactly like the "white" of the Black Mountain quarry, page 172.

The lower opening is about 150 feet above the river bank and the upper about 330 feet. Both are small.

The sheets of the upper opening are from 6 inches to 2 feet 6 inches thick; those of the lower 10 to 12 feet. They strike N. 60° E. and dip 30° N. 30° W.

There is no plant. The product, which is used for paving and curbing is carted 1¼ to 1½ miles to the railroad on the west bank of West River.

BAILEY PROSPECTS.

The Bailey prospects are on the west side of West River about one-half mile south-southwest of the Black Mountain quarry in Dummerston. Owner, David J. Bailey, R. F. D., Brattleboro, Vt.

The granite from an opening about 200 feet above the road to Brattleboro is a quartz monzonite of light-gray shade and medium inclining to fine even-grained texture, with feldspars up to 0.25 inch and mica mostly under 0.05 inch, and more thickly disseminated than in the "white" of the Black Mountain quarry. Its constituents are the same as in that stone, but the quartz is more smoky, the mica mostly biotite. The fibrous muscovite and crush borders are lacking.

This stone is of slightly finer texture and, owing to the smokiness of its quartz and the distribution and amount of its biotite, it is of slightly darker shade than the "white." It is lighter than "light Barre."

The opening represented by this specimen is 200 by 15 feet, with a working face of 10 feet.

The sheets, up to 8 feet thick, dip 20° to 25° N. 35° W. A granite ledge a little north-northwest of this is crossed by a dike of fine granite, 30 feet wide, with a N. 10° W. course and dip of 50° W. It is of medium bluish-gray shade and of very fine even-grained texture, with feldspar and mica up to 0.05 inch. In thin section its particles range from 0.074 to 1.1 millimeters in diameter. It is a quartz monzonite of similar composition to that of West Dummerston. Its mica is chiefly biotite. Feldspar and quartz are intergrown and have crush borders. The soda-lime feldspar is bluish gray and scarcely altered.

This fine granite, although probably harder than ordinary granites, may be found of economic value.

WINDSOR COUNTY.

The quarries of Windsor County are in the towns of Bethel, Rochester and Windsor.

BETHEL.

Topography and General Geology.

The state map of 1861 represented a small granite area in the east corner of the town of Bethel, surrounded by "calciferous mica schist," with a north-south belt of "clay slate" a little west of it. This granite is on Christian Hill, an elongated mass rising

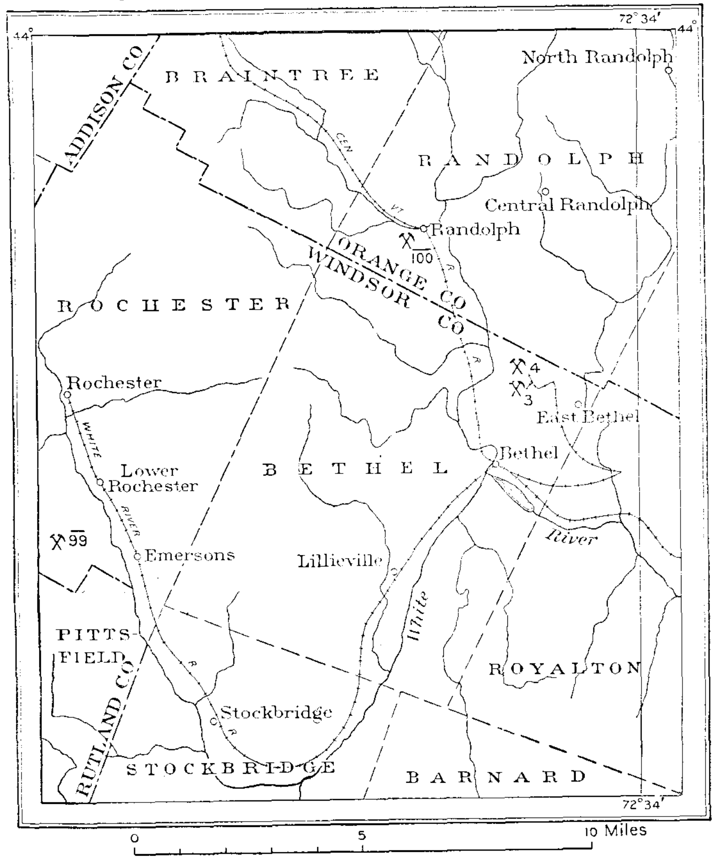


FIGURE 20.—Map of Bethel, Randolph and Rochester from Beers's Atlas. No. 3, Woodbury Granite Company's quarry; No. 4, Ellis quarry; No. 99, Liberty Hill quarry No. 100, Beedle's prospect.

about 350 feet above the adjacent hollows, about 2 miles north of Bethel village and east of White River. Its general position is shown on the map (fig. 20).

The granite exposure is reported as at least one-half mile long from north to south. Its width at the quarries is about 550 feet, with a border of finer, less whitish granite on either side about 40 feet wide. The entire width between the schist on the east and west is not far from 625 feet, but there is said to be another narrower belt of granite several hundred feet east of the main one protruding through the schist. The mica schist immediately west of the granite strikes N. 10° W. and dips 57° E.; that east of the granite (a garnetiferous mica slate), with 12-inch calcareous beds, strikes north to N. 5° E. and is vertical. The mica schist, in places chloritic, north of and near Bethel, strikes N. 10° to 15° W. and is vertical. While the main granite mass from its lateral zones of finer granite would appear to be a truncated arch or dome, its sheet structure all dips east from 15° to 45° on the east and 30° on the west. The vertical north-south flow structure with its aligned discoid nodules of muscovite has been described on page 94, and the details of the contact of granite and schist given on page 89, and shown in figures 1 and 2. Neither of the quarries has as yet removed all the thin surface sheets, although they have furnished material for several very large buildings.

"BETHEL GRANITE."

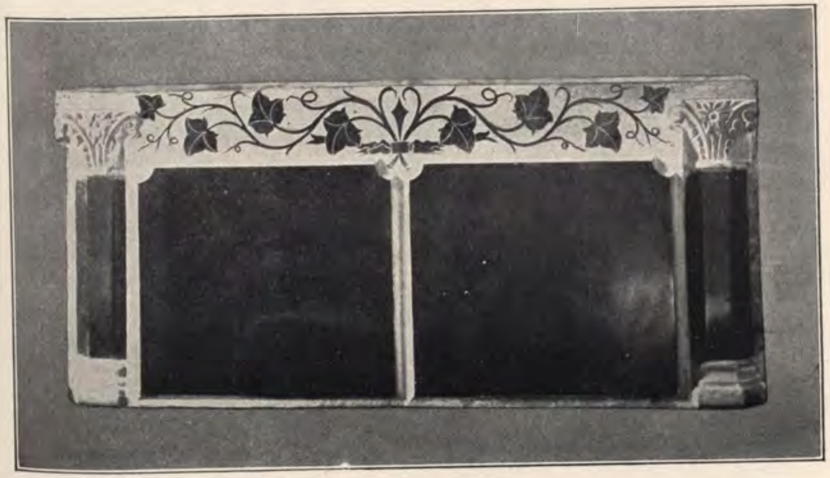
The granite known under the commercial name "Bethel white granite," which has been copyrighted and the granite consequently called by another firm "Hardwick white granite," from the location of its main office, are one and the same. The two quarries, but a few feet apart are excavations in granite of one mass of contemporaneous origin and of identical composition and texture. The following description is based on specimens, rough and polished and thin sections from both quarries.

The granite of Bethel (specimens D, XXIX, 3, n, p and 4, a, b), "Bethel white" or "Hardwick white," is a quartz monzonite of slightly bluish milk-white color, with grayish spots up to 0.3 inch, and of coarse inclining to medium texture, with feldspars up to 0.4 and 0.5 inch and mica to 0.3 inch. Its constituents, in descending order of abundance are: Clear, colorless, rarely bluish quartz with hairlike crystals of rutile and with fluidal and other cavities in sheets, with rift cracks parallel thereto; bluish milk-white soda-lime feldspar (oligoclase) slightly kaolinized and micacized; clear potash feldspar (orthoclase, slightly kaolinized, with very little microcline); muscovite (white mica); and very little biotite (black mica). The accessory minerals are apatite, titanite, zircon and rutile. No magnetite or pyrite was detected. The secondary minerals are kaolin, a white mica, epidote, zoisite in some abundance and very little calcite.

The stone does not effervesce with cold dilute muriatic acid. W. T. Schaller, chemist, of the United States Geological Survey finds that is contains 0.07 per cent. of CaO (lime) soluble in dilute (10 per cent.) acetic acid, which indicates a content of

a. Carved Eagle of Coarse White Quartz Monzonite From Bethel Over Entrance to American Bank Note Company's Building, New York.

Spread of wings, 32 inches; height from base of medallion to top of head, 7 feet 8 inches; depth of carving, 18 inches. The whiteness of the cut rock has counteracted the effect of its coarseness.



b. Monument of Mount Ascutney Dark-Green Hornblende Augite Granite (*Syenite*)

Showing contrast between polished (black) and hammered (white) surfaces. Size about 5 feet 8 inches by 2 feet 6 inches.

0.125 per cent. of $CaCO_3$ (lime carbonate), which is very slight.

A chemical analysis made for the E. B. Ellis Granite Company by Charles F. McKenna of New York, in 1903, is given here for reference.

Analysis of "Bethel granite," by Charles F. McKenna.

SiO_2 (silica)	77.52
Al_2O_3 (alumina)	16.78
FeO (iron oxide)	.84
MgO (magnesia)	.32
CaO (lime)	2.56
Na_2O (soda)	1.21
K_2O (potash)	.62
Loss on ignition	.33
	100.18

Three compression tests (No. 13261) made at the United States Arsenal at Watertown, Mass., yielded these results (direction of rift in blocks not stated):

Compressive strength of white granite of Bethel.

	Pounds per square inch
First crack, 287,000 pounds; ultimate strength	33,120
First crack, 301,000 pounds; ultimate strength	34,350
First crack, 272,000 pounds; ultimate strength	31,990
Average	33,153

The stone is regarded as relatively hard by workmen. Its grade of whiteness is shown by these comparisons: The "white" of North Jay, Me., is, technically, *very light gray*. The "white" of West Dummerston is a trifle lighter, that of Randolph lighter yet, and that of Bethel still lighter, strictly white *mottled with gray*. Its white is more blue than ordinary Vermont white marble, but is closely allied to its blue variety, but not its bluish gray. Owing probably to the abundance of its soda-lime feldspar, its hammered face is considerably whiter than its rough face and the hammering also diminishes the prominence of the gray micaceous spots. It takes a high polish, but the effect is to make the mica spots more conspicuous than they are even on the rough face. The polished specimens handled by the writer do not show any pyrite or magnetite. Plate XXVIII, representing a carved eagle, shows how the whiteness of the stone has overcome the effect of the coarseness of its texture. Although this granite is remarkably free from iron, its recent use in large edifices shows that extreme care should be exercised in handling it to prevent its absorbing rusty water or other discoloring liquids.

Leonard P. Kinnicutt of the Worcester Polytechnic Institute, in December, 1908, made the following determinations of absorption in Bethel and other granites by W. F. Hillebrand's method, for Norcross Brothers Company of Worcester, Mass.

Water absorbed by 100 pounds of various granites.

	Pound
Bethel granite	0.470
"New Westerly," Milford, N. H.	.420
Hallowell	.405
Concord	.371
Westerly	.340
Milford, Mass	.340
Barre	.294

ELLIS QUARRY.

The Ellis quarry is on the east side of Christian Hill, about 2 miles north of Bethel village in Bethel township. (See fig. 20.) Operator, E. B. Ellis Granite Company, Northfield, Vt.

The granite has been described above.

The quarry, permanently opened in 1902, but in a small way many years earlier and abandoned, is estimated as being about 1,000 feet long north-south and for the southern three-fifths of its length 150 feet wide, but for the remainder 400 feet wide. Its depth is from 5 to 40 feet, averaging about 15 feet. Its western edge is about 80 feet higher than its eastern.

The sheets, from 6 inches to 12 feet thick, but mostly 1 to 2 feet, strike N. 10° W. and on the west side of the north end dip 30° E., but on the east side 15° E. For some not apparent reason the sheets thicken more rapidly at the east side and south end than in any other part of this or the adjoining quarry. Joint, grain, and flow courses are shown in figure 21, Joint set (A) is vertical, forms a heading at north end, recurs at two intervals of 80 feet; (B) is diagonal to the quarry and vertical, one only, about the middle of the side, but discontinuous. Compressive strain affects east-west channels more than north-south ones. Flow structure marked at the east side and south end, consists of micaceous (muscovite) streaks up to 0.5 inch wide, and sheets of discoid nodules of muscovite, also of a branching mass, 12 inches thick, largely mica and is vertical with north course. (For details see p. 87 and Pl. XXII *a*.) The rift is reported as horizontal and the grain as vertical, with N. 17° E. course thut intersecting the flow structure at an acute angle. A few pegmatite

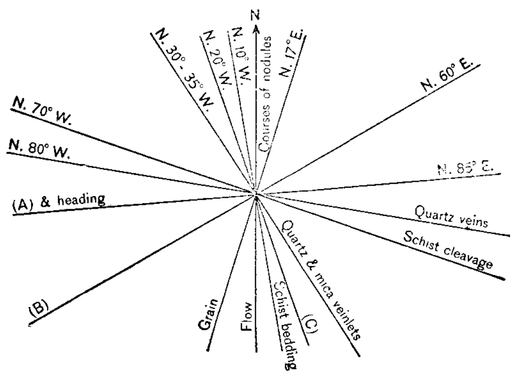


FIGURE 21—Structure a Ellis and Woodbury granite com sanies' quarries, Bethel.

dikes, up to 5 inches thick, have an east-west course. A quartz vein up to 1.5 inches wide strikes N. 80° W. and dips 65° S. 70° W. Some minute muscovite and quartz veins strike N. 30° to 35° W. and dip 60° S. 58° W. There is one light-gray knot, 10 by 8 by 2 inches; also an inclusion, 21 by 12 by 5 inches, of fine-grained syenite gneiss consisting of orthoclase, biotite, epidote, and a little oligoclase, with titanite and leucoxene but with little or no quartz. There is no rusty stain on sheet surfaces. The relations of the coarse white granite to the fine, light-buff gray, and the contact of the latter with the schist have been described on page 89 and shown in figures 1 and 2.

The plant at the quarry comprises ten derricks of 15 to 30 tons capacity, nine hoisting engines, an air compressor (capacity 750 cubic feet of air per minute), eleven large air rock drills, twenty-eight air plug drills and four steam pumps.

The cutting plant at Northfield, Vt., comprises a 25-ton derrick and engine, a 50-ton derrick and electric motor, two 20-ton and one 10-ton overhead crane, three air compressors (capacity, two of 800 and one of 300 cubic feet of air per minute), six air plug drills, one hundred and fifty air hand tools, eleven surfacers, two lathes for stones 25 by 3 by 2 feet; one Dietrich Harvey Company turning and fluting machine for columns 40 by 7 feet. The cutting plant is run by five electric engines, two of 100, two of 75, one of 35 and one of 15 horsepower. Electricity is brought 14 miles from Mad River.

Transportation is effected by siding, as shown in figure 20. Blocks destined for cutting are brought 5 miles to Bethel and thence 28 miles to the cutting shed at Northfield.

The product is used for buildings, monuments and statuary. Specimens are the Union Station, with six monolithic statues 17 feet high, also with four eagles 8 feet high with spreading wings nearly 12 feet from tip to tip, and the first and second stories of the National Museum, Washington, D. C.; all the superstructure above water table in the State Library and Supreme Court Building, Hartford, Conn.; Hopper Monument, Woodlawn Cemetery, New York; Miller mausoleum, Poughkeepsie, N. Y.; Congdon residence, Duluth, Minn.

WOODBURY COMPANY'S QUARRY.

The Woodbury Company's quarry is 50 feet north of the Ellis quarry, on the east side and top of Christian Hill, about 2 miles north of Bethel village, in Bethel township. (See fig. 20.) Operator, Woodbury Granite Company, Hardwick, Vt.

The granite has been described on page 176.

The quarry, opened in 1902, is estimated as measuring about 500 feet north-south by 200 feet across and from 5 to 30 feet in depth.

The sheets, from 6 inches to 8 feet thick, are normal, dipping about 15° E. At a recent small opening about 300 feet north of the main one and on the east side of the highest part of the hill, the sheets dip 45° E. There are two sets of joints (courses in fig. 25): (a), vertical, forms a 10-foot heading on the south wall between this and the Ellis quarry; (C), also vertical, is discontinuous and spaced 10 to 40 feet. An east-west compressive strain is reported by the foreman. The rift is reported as dipping less than 15° E., and the grain as vertical, with nearly east-west course. Very few of the discoid micaceous nodules referred to (p. 178) occur. About 40 feet of fine buff-gray granite with schist farther east correspond to the same rocks on the west side of Ellis quarry. There is no rusty stain on sheet surfaces except near the heading.

The plant at the quarry comprises five derricks (one with 90-foot mast, the rest with 50 to 70 foot masts), a Blondin carrier, two air compressors (capacity 556 and 450 cubic feet of air per minute), four large rock air drills, 12 air plug drills and two steam pumps.

The cutting plant at the firm's shed one-half mile south of Bethel village comprises one derrick, a 30-ton, a 20-ton and a 10-ton overhead electric crane, two air compressors (capacity 1,200 and 260 cubic feet of air per minute), four air plug drills, 52 air hand tools, three surfacers, a polisher, and a 300-horsepower dynamo. Electricity is brought 5 miles from White River for this plant and sent 4 miles farther to the quarry.

Transportation is by cart, 4 miles to the cutting shed near Bethel, which is on a siding.

The product is used for buildings. Examples are the new capitol of Wisconsin at Madison; American Bank Note Building, New York (Pl. XXVIII, A, represents a carving of this granite over the entrance to this building); Importers and Traders' National Bank, New York; Harry Payne Whitney residence, New York; Mary Ann Brown Memorial Library, Providence, R. I.; grammar and high school buildings, Hartford, Conn.; entrance to Majestic Building, Detroit, Mich.

ROCHESTER.

LIBERTY HILL QUARRY.

The Liberty Hill quarry is 3 miles south of Rochester village (the west terminal of the White River Valley Railroad) and on the Rochester-Pittsfield town line. The outcrop extends in the town of Pittsfield in Rutland County. (See fig. 20.) Operator, Liberty Hill Granite Corporation, Rochester, Vt.

The granite (specimens D, XXIX, 99, a, b), "coarse white granite," is a quartz monzonite of slightly greenish-white color with conspicuous brilliant muscovite spots up to 0.5 inch across and of coarse texture with feldspars up to 0.5 inch. These mica spots being collections of mica scales, have a peculiar sheen. As they are not over 0.04 inch thick and lie with their flat sides roughly parallel, the rock has a somewhat gneissoid texture. Its constituents, in descending order of abundance are: Milk-white to slightly greenish soda-lime feldspar (albite to oligoclase-albite), somewhat kaolinized and with thickly disseminated white mica scales to 0.15 millimeter long and not a few plates of calcite; clear colorless to pale bluish quartz rarely with hairlike crystals of rutile and with fluidal and other cavities in two rectangular sets of sheets, one set with many more cavities than the other; orthoclase may be present in small amount, but was not detected. There is no microcline; muscovite (white mica) in large flakes and aggregates.

An estimate of the mineral percentages by the Rosiwal method yields these results with a mesh of 0.5 inch, total linear length of 35.5 inches, and on face at right angles to gneissoid structure:

Estimated mineral percentages in white granite of Rochester.

Feldspar	62.1
Quartz	29.6
Muscovite	8.3
	100.0

The average diameter of all the particles obtained from the same measurements proves to be 0.34 inch; that of feldspar, 0.194; quartz, 0.106; and mica, 0.538 inch.

The stone effervesces with cold dilute muriatic acid. W. T. Schaller, chemist of the United States Geological Survey, finds that it contains 1.38 per cent. of CaO (lime) soluble in warm dilute (10 per cent.) acetic acid, which indicates a content of 2.46 per cent. of $CaCO_3$ (lime carbonate, calcite), the presence of which mineral is also shown in thin section.

This is a building granite of very light pale greenish-gray color, with striking contrasts produced by large mica spots, the brilliancy of which on the fresh rift face is almost metallic. Whether its somewhat gneissoid texture and its content of nearly $2\frac{1}{2}$ per cent. of lime carbonate are serious obstacles to its use for building can only be determined by compression tests and by continued exposure to the weather.

The quarry, opened after the completion of the author's manuscript, was not visited.

In 1909, the corporation was filling a contract for the base course for the new gymnasium for Dartmouth College at Hanover, N. H.

Although the outcrop is 3 miles from Rochester station, its distance from the nearest point on the railroad is only about a mile and a siding is reported as having been constructed.

WINDSOR.

Topography and General Geology.

The state map of 1861 shows a granite area in the southern parts of Windsor and West Windsor and the northern part of Weathersfield. The geology of this area has been made known by R. A. Daly in an elaborate report already referred to.* His map shows that Mount Ascutney, which lies about 5 miles southwest of Windsor village and rises 2,800 feet above the Connecticut and 3,100 feet above sea level, consists mainly of a mass, about 2½ miles square, of greenish hornblende-augite granite (syenite) intrusive in schists which crop out along its base. But adjoining this syenite on the west is an area of still older gneisses, which are intruded by a mass of gabbro and diorite about 2 by 1½ miles in area. That this intrusion is older than that of the syenite is shown by the fact that dikes of the syenite penetrate it. The syenite of Mount Ascutney was itself in turn intruded by a very irregular mass of biotite granite characterized by abundant dark segregations (knots) and covering about a square mile. This granite was formerly quarried and monuments of it can be seen in the Windsor cemetery.

"WINDSOR GRANITE."

"Windsor granite" (syenite, nordmarkite phase of Daly) is a hornblende-augite granite which, when first quarried, is of dark bluish-gray color, but after very brief exposure becomes dark olive green. Its texture is medium to coarse, with feldspars up to 0.3 and 0.5 inch and black silicates to 0.2 inch. Its constituents, in descending order of abundance, as made out from the study of four thin sections, two from each quarry are: (1) Dark olive-green potash feldspar (orthoclase) minutely or obscurely intergrown with soda-lime feldspar (certainly oligoclase in two of the slides), with cleavage planes stained with limonite; (2) dark smoky quartz with cavities (apparently without vacuoles, some of them of quartz crystal form) in streaks and sheets and crossed by intersecting cracks filled with limonite stain; (3) green hornblende; (4) augite, associated with or inclosed by (3); (5) biotite in very small quantity, in three slides none. The accessory minerals observed are titanite, magnetite or ilmenite, zircon apatite and allanite. The secondary are limonite and white mica in the feldspar.

The cause of the change in the color of the feldspar and thus of the granite upon exposure has already been referred to (p. 83). It does not effervesce with cold dilute muriatic acid. It is very hard and has a metallic ring under the hammer. It is brilliant in the rough from the cleavage faces of the large feldspars. Their shade is so dark that the black silicates only appear on close inspection. Owing to its extremely small content of mica it takes a very high polish, quite as high as that of the granite of Quincy. Its polished face is much darker than its rough face, but the hammered or cut face, being of medium greenish gray, is much lighter than either, so that lettering or carving stands out boldly on the polished face. (See Pl. XXVIII, B.) It is best adapted for internal decorative use.

*Bull. U. S. Geol. Survey No. 209, 1903.

MOWER QUARRY.

The Mower quarry is on the west side of Mount Ascutney, nearly 1¼ miles south of Brownsville and 580 feet above it, in West Windsor. Operator, Ascutney Mountain Granite Company, Windsor, Vt.

The granite, already described, has received the trade name of "bronze vein green,"

The opening, made in 1906, is about 50 feet square, and averages 10 feet in depth.

The sheets, 10 feet thick, are horizontal or dip 5° W. There are three sets of joints: (a) Striking N. 85° E. and vertical, is spaced 2 to 18 feet; (b) striking N. 30° E., dips 75° S. 60° W., one forming the east wall; (c) striking N. 55° W., dips 65° N. 35° E., one forming the south wall. The rift is reported as vertical with N. 85° E. course and the grain as horizontal. There is a black bronzy streak dipping 45° E., possibly of the black silicate, and showing the direction of flow. Light rusty brown and cream-colored discoloration is 0.5 inch thick on the joint faces. In thin section some of the limonite stain of this rim proceeds clearly from magnetite (or ilmenite), augite and allanite particles.

The plant at the quarry comprises three derricks (one of 20 tons and one hand), and two hoisting engines. At the cutting shed in Windsor it includes two hand derricks, an overhead 8-ton crane, a 50-horsepower engine, an air compressor (capacity 125 cubic feet of air per minute), a cutting and a polishing lathe for stones 5 feet 6 inches by 1 foot 6 inches and a set of twelve chilled shot saws for blocks 12 feet long.

Transportation is by gravity track 600 feet long and 30 per cent. grade from the quarry to road and thence by cartage 8½ miles to Windsor.

The product is used mainly for dies, wainscoting and indoor columns. Specimens: The two monolithic sarcophagi in the McKinley mausoleum at Canton, Ohio. When finished these measured 8 feet 10 inches by 4 feet 4 inches by 2 feet 6¾ inches. The covers measured 9 feet 4½ inches by 4 feet 8¾ inches by 1 foot 3¾ inches. The polishing of these stones was done by another firm. The monument (Pl. XXVIII, B) shows the contrast between cut and polished faces, somewhat exaggerated in photographing, the black representing what is a dark olive green and the white what is a medium greenish gray.

NORCROSS QUARRY.

The Norcross quarry is on the north side of Mount Ascutney on the 1,350-foot level, about 950 feet above Windsor village, and a little over a mile east-southeast of Brownsville in Windsor. Operator, Windsor Green Granite Company, Worcester, Mass. This quarry is only operated occasionally.

The granite has been described on pages 182, 183.

The quarry is about 200 feet east to west by 40 feet across and has a working face 60 feet high on the south, with a rugged cliff above it, making a total face of 80 to 90 feet above the quarry bottom and road.

The sheets, from 2 to 10 feet thick, are horizontal or dip 10° N. There are two sets of joints: (a), striking N. 75° to 80° E., vertical, is spaced 2 to 10 feet; (b), striking N. 5° W., vertical, is spaced 5 to 30 feet, with a 10-foot wide heading through the center of the quarry. The splitting has been done in the direction of (a), which is the rift direction at the Mower quarry and presumably here also. There are many dark streaks. A 4-foot dike crosses the quarry parallel to and within heading (b). This appears to be also a hornblende-biotite granite. It is of medium greenish-gray color and of medium inclining to fine texture with feldspars mostly under 0.2 inch, rarely 0.4 inch, and black silicates mostly under 0.1 inch. Its constituents, in descending order of abundance are: Greenish medium-gray potash feldspar with obscurely intergrown soda-lime feldspar, kaolinized; smoky quartz, more of it than in the adjacent granite; finely striated soda-lime feldspar (oligoclase-albite); hornblende; a little biotite. Accessory: Magnetite or ilmenite, titanite and allanite. Secondary: Kaolin.

The sheet surfaces, chiefly owing to the kaolinization of the feldspar, are discolored to a medium slightly greenish gray and the joint faces are similarly discolored, but with a limonitic border. The discoloration is from 1 to 1.5 inches thick.

The plant consists of three derricks, a hoisting engine and steam drill.

Transportation is by cartage to rail at Windsor.

The product has been used for monumental and decorative purposes. Specimens: Sixteen polished columns (24 feet 9½ inches by 3 feet 7 inches) in Columbia University Library, New York; monument to General Gomez in Cuba; a die in the Bennington monument; 34 large columns in the Bank of Montreal; columns and die W. C. T. U. fountain, Orange, Mass.

CHARACTERISTICS AND ADAPTATIONS OF VERMONT GRANITES.

Although differing widely in their characteristics Vermont granites do not include a great variety of colors or texture. They are gray, whitish and pinkish constructional granites of medium to coarse texture, gray monumental granites of fine to medium

texture and one dark-green polish and inscriptional granite of medium to coarse texture. Those which have thus far proved of principal economic importance are the gray monumental granites and the whitish constructional granite. The adaptability of "Barre granite" to sculpture is shown in the Burns statue. The suitableness of the green granite of Windsor for indoor decorative use and for inscriptions is shown in the polished and cut monument (Pl. XXVIII, B).

Among the notable buildings and monuments made of Vermont granite are the capitols of Vermont, Pennsylvania and Wisconsin, the State Library and Supreme Court Building at Hartford, Conn., the Union Station and the first and second stories of the National Museum at Washington, D. C., the Cook County court-house at Chicago, Ill., the prison-ship martyrs' monument in Brooklyn, N. Y., and the sarcophagi for President and Mrs. McKinley at Canton, Ohio.

CLASSIFICATION OF VERMONT GRANITES.

In the following table all the granites described in this bulletin, except that of the Parmenter quarry, near Beebe Plain, are grouped by their economic uses. The trade name, the scientific name, the real general color and shade (without reference to spots or spangles), and the texture of each stone are given in separate columns and page references to the descriptions of the stone and quarries are also added.

CLASSIFICATION OF VERMONT GRANITES.

Economic group.	Locality.	Trade name.	General color and shade.	Texture.	Petrographic name.	Described page—
Constructional...	Derby		Light bluish gray	Medium-fine	Quartz monzonite with both micas.	113
	Calais. (See under Monumental.)					
	Woodbury (Robeson Mountain).	Woodbury gray (Fletcher).	Light gray	Medium	Biotite granite	161
	......do	Woodbury gray (Woodbury Granite Co.).	Medium gray (contrasts medium).	......do	......do	163
	Woodbury (prospect)		Very light, slightly buff gray	......do	......do	168
	Dummerston (Black Mountain).	White West Dummerston	Very light gray	......do	Quartz monzonite	172
	Dummerston (Bailey)		Light gray	Medium-fine	......do	174
	Bethel (Ellis)	Bethel white	Slightly bluish milk-white, mottled.	Coarse-medium	......do	178
	Bethel (Woodbury Co.)	Hardwick white	......do	......do	......do	179
	Rochester (Liberty Hill		Slightly greenish white, large micas.	Coarse	......do	180
	Randolph (prospect)	Fine white	Extremely light gray	Fine	......do	111
	Newark (prospect)	Newark pink	Light pinkish gray	Coarse	Biotite granite	102
	Barre (Bond & Whitcomb)	Coarse light Barre	Light gray	Medium	......do	139
	Barre (Wheaton)	White Barre	Very light gray	......do	......do	154
Monumental.....	Hardwick (Buffalo Hill)	Dark blue Hardwick	Dark gray	Medium	Quartz monzonite	96
	Kirby (Grout quarry)		Light to medium, slightly bluish gray.	Medium-fine	Biotite granite	98
	Kirby (Kearney Hill)		Light gray	Medium-coarse	Quartz monzonite	100
	Kirby (Burke quarry)		Light to medium gray	Medium-fine	......do	101
	Ryegate (Gibson, etc.)		......do	Medium	......do	104,107
	Ryegate (Rosa quarry)	Fine gray	Medium gray	Fine, inclining to medium	Biotite granite	107
	......do	Coarse gray	Medium bluish gray	Medium	......do	107
	Ryegate (Frazer quarry)		Light-medium gray (contrasts marked).	Medium-coarse	Quartz monzonite	108
	Groton	Vermont blue	Medium quite bluish gray	Medium-fine	......do	109
	Topsham (Ricker)		Medium bluish gray	Medium	......do	109
	Barre (Jones, Wetmore & Morse).	Light Barre	Light-medium slightly bluish gray	Fine, inclining to medium	Biotite granite	111
	Barre	Medium Barre	Medium bluish gray	Fine	......do	135
	Barre (Bond & Whitcomb, new quarry).	......do	Medium gray	......do	......do	139
	Barre (Smith upper quarry)	Medium Barre	Light-medium slightly bluish gray	Fine-medium	......do	138 136

Economic group.	Locality.	Trade name.	General color and shade.	Texture.	Petrographic name.	Described page—
Monumental.....	Barre	Dark Barre	Dark-medium bluish gray	Fine or fine to medium	Biotite Granite	125,126 et seq.
	Barre (Milne & Wylie and Jones dark quarries).	......do	Dark bluish gray	Fine-medium	Biotite granite, but quite a little plagioclase and cuts light.	126,152
	Barre (Marr & Gordon,	Very dark	Very dark bluish gray	......do	Biotite granite	128
	Cabot (Lambert)	Dark	Dark bluish gray	Fine	Quartz monzonite	156
	Calais (Patch quarry)	Medium gray	Medium slightly bluish gray	Medium	Biotite granite	157
	Calais (Lake Shore quarry).		Light medium gray	Fine	......do	156
	Woodbury (Drenan & Webber, new quarries).	Woodbury fine dark	Dark bluish gray	......do	......do	167,168
	Woodbury (Robeson Mountain).	Woodbury Bashaw	Medium gray (contrasts weak).	Fine-medium	......do	161
	Woodbury (Webber (old) Chase).		Light bluish gray	Medium-fine	......do	169
	Woodbury (Leach)		Dark bluish gray	....do	....do	171
	Woodbury (Carter)		Light-medium bluish gray	Very fine to fine	......do	171
	Dummerston (Black Mountain).	Dark blue	......do	Fine-medium	Quartz monzonite	172
	Dummerston (Bailey)		Medium bluish gray	Very fine	......do	174
Polished and inscriptional	Windsor	Green Ascutney, bronze vein green.	Dark olive green	Medium-coarse	Hornblende-augite	182

COMMERCIAL VALUES OF VERMONT GRANITES.

It is not within the province of this paper to give price lists, but as the current commercial value of a stone is a measure of its quality and an indication of the possibilities of its use a few prices of Vermont granites for 1907 are added. These prices are all for the rough stone and f. o. b.

The whitish quartz monzonite of Bethel is sold for constructional use at $1 per cubic foot, ordinary sizes, and in selected blocks for monumental use at $2. The very light gray quartz monzonite of Dummerston is 50 cents per cubic foot, random stock; and the light medium bluish gray from the same quarry for monumental use is 75 cents per cubic foot, ordinary sizes. The "Woodbury gray" constructional granite is 50 cents and the monumental granite from Woodbury ("Bashaw") 75 cents. Monumental granites of Barre range as follows for blocks of 80 cubic feet and under: "Light," $1.15; "medium $1.25; "dark medium," $1.40; "dark," $1.50. Barre constructional, "coarse light" (Bond & Whitcomb) sells at 25 cents, dimension stone. The gray monumental granites of South Ryegate are 45 cents, ordinary sizes. The green polish and inscriptional syenite of Windsor sells for $1.50. In 1909 the very light of Beebe Plain was selling at 40 cents per cubic foot, f. o. b. cars at North Derby.

Summarizing, the constructional granites range from 25 cents to $1 per cubic foot; the monumental from 75 cents to $2. The polish and inscriptional are $1.50 per cubic foot.

STATISTICS OF GRANITE PRODUCTION IN VERMONT.

By Altha T. Coons.

The first statistical work on Vermont granite by the United States Geological Survey was done in connection with the Tenth Census and gave the output of granite for the year ending May 31, 1880. There were 12 quarries reporting for that year, and the total output was 187,140 cubic feet, valued at $59,675. The next figures available for Vermont granite were for 1886, when the output, chiefly monumental stone from the Barre quarries, was reported as 240,000 cubic feet valued at $180,000. The year 1887 represented a gain of 25 per cent. over the output for 1886, and was 300,000 cubic feet, valued at $225,000. The Eleventh Census gave the output of granite for the census year as valued at $581,870 and the Twelfth Census gave an output for the year 1902, the product of 68 quarries, valued at $1,570,423, an increase of 169.9 per cent. in thirteen years, or of 2,531.6 per cent. for the twenty-three years, represented by different census figures. From the time of the Eleventh Census, the statistics of Vermont granite production have been regularly collected, the entire output increasing steadily, although not regularly, as the years were more or less differently affected by labor troubles, chiefly in the building trades. The stone of the State was at first chiefly used for monumental work, but recently a large quantity has been used in building, a small quantity made into paving blocks, and equally small quantities were sold as crushed stone for road making, ballast, curbing, etc.

The following table shows the value of the granite produced in Vermont, as compiled by the United States Geological Survey from 1880 to 1907:

Production of granite in Vermont from 1880 to 1907.

Year.	Rough.		Dressed.		Paving.		Other purposes.*	Total value.
	Building	Monumental.	Building.	Monumental.	Number of blocks	Value.		
1880...	....	....	....	....	....	....	....	$ 59,675
1886...	....	....	....	....	....	....	....	180,000
1887...	....	....	....	....	....	....	....	225,000
1888...	....	....	....	....	....	....	....	279,000
1889...	....	....	....	....	....	....	....	581,870
1890...	....	....	....	....	....	....	....	610,963
1891...	....	....	....	....	....	....	....	700,000
1892...	....	....	....	....	....	....	....	675,000
1893...	....	....	....	....	....	....	....	778,459
1894...	$861,245				....	$ 32,711	....	893,956
1895...	977,016				....	30,702	....	1,007,718
1896...	864,526				....	30,990	....	895,516
1897...	$430,121		$ 283,167	$ 341,034	....	16,770	$ 3,208	1,074,300
1898...	531,634		113,922	416,878	....	4,446	17,338	1,084,218
1899...	563,475		125,775	509,358	....	3,500	10,859	1,212,967
1900...	526,370		49,763	527,053	....	225	10,377	1,113,788
1901...	$ 208,825	$ 534,755	16,343	354,563	....	16,304	115,038	1,245,828
1902...	28,845	756 007	289,567	453,187	....	2,855	39,962	1,570,423
1903...	103,353	828,508	346,293	481,346	....	28,839	21,840	1,810,179
1904...	83,148	797,830	912,801	615,057	382,758	14,745	24,398	2,447,979
1905...	188,391	778,681	1,093,688	471,093	413,898	16,628	23,369	2,571,850
1906...	47,154	993,220	1,422,862	451,222	282,930	9,557	10,810	2,934,825
1907...	29,764	1,122,063	1,009,353	515,859	171,000	5,330	11,520	2,693,886

*Includes stone for roads, curbing, ballast, etc.

The figures as given in the table show the values obtained free on board by the quarrymen for the stone quarried by them, and do not represent the stone sold by manufacturers. When quarrymen dress their own stone, the value of the dressed stone is given as representing the value of the material to the quarrymen. For the years 1906 and 1907, it has been possible to tabulate the quantity of stone sold for building and for monumental work. This is of interest as showing the proportion of stone sold for building and for monumental purposes, and also showing practically the number of cubic feet of granite sold in Vermont for these years, the quantity of stone for other purposes being almost negligible.

The following table shows the production of granite in Vermont in 1906 and 1907 by counties and uses, and also the total value for the United States for the same interval:

In 1907 the total value of the granite produced in the United States was $18,057,386, which, compared with the total value of Vermont of $2,693,889, shows that in this year Vermont produced 14.92 per cent. of the total value of granite sold in the United States. In 1907 Vermont ranked first in the value of output, followed by Massachusetts and Maine with productions valued at $2,934,825 and $2,162,277, respectively. In 1906 Vermont ranked second in the value of production, the value for this year of $2,934,825 being exceeded by Massachusetts with an output valued at $3,327,416 and followed by Maine with an output of $2,560,021, the total output of granite for Vermont in 1906 being 15.81 per cent. of the total of the United States.

The total value of granite sold, rough and dressed, by the quarrymen for building stone in the United States in 1906 was $8,430,022, of which Vermont's share was $1,470,016 or 17.44 per cent of the total. In 1907 the total for the United States was $6,033,362, with Vermont representing $1,039,117 or 17.20 per cent. of the total. The total value of granite, including rough and dressed stone as sold by the quarrymen in the United States for monumental work, was, in 1906, $4,115,665, Vermont's production being valued at $1,444,442, or 35.10 per cent. In 1907 this total was $4,338,719, Vermont representing $1,637,922, or 37.75 per cent. The value of the total granite output for Vermont decreased somewhat in 1907 as compared with 1906, or from $2,934,825 in 1906 to $2,693,889 in 1907, a decrease of $240,936. The principal decrease was in the value of the building stone sold, which, including rough and dressed stone, was from a value of $1,470,016 in 1906 to $1,039,117 in 1907, a loss of $430,899. The total monumental stone, however, increased from a value of $1,444,442 in 1906 to $1,637,922 in 1907, a gain of $193,480. The loss in building stone production was due to financial depression affecting general building conditions, especially in large cities.

In 1906, of the 1,849,045 cubic feet of stone sold for building and monumental work, the quantity for building purposes alone was 506,801 cubic feet or 27.41 per cent. of the total, while 1,342,244 cubic feet or 72.59 per cent. of the total was for monumental stone. The value, however, reported for the building stone, rough and dressed, was $1,470,016 or 50.44 per cent. of the total, and for the monumental stone $1,444,442 or 49.56 per cent. of the total, these percentages being nearly the same, while the quantity of monumental stone was over two and one-half times as much as the quantity sold for building work. This is accounted for from the fact that by far the greater part of the monumental stone was sold to the manufacturers to be dressed, while the producers of building stone dressed their own material. The average price per cubic foot of rough building stone in 1906 was 59 cents; dressed, $3.33. The average price per cubic foot of rough monumental stone in 1906 was 82 cents; dressed, $3.56.

In the same manner the total quantity of building and monumental stone for 1907 amounted to 1,689,826 cubic feet; 347,775 cubic feet, or 20.58 per cent. being building stone and 1,342,051 cubic feet, or 79.42 per cent. being monumental stone. The total value of building and monumental stone was $2,677,039, and of this $1,039,117, or 38.82 per cent., was the value for building stone, and $1,637,922, or 61.18 per cent., the value of monumental stone. The average price per cubic foot of rough building stone in 1907 was 69 cents; dressed stone, $3.31; and the average price per cubic foot of rough monumental stone was 93 cents; dressed stone, $3.71.

The total quantity and value of building and monumental stone sold in 1907 decreased 159,219 cubic feet in quantity and $237,419 in value as compared with 1906, or from 1,849,045 cubic feet, valued at $2,914,458 in 1906 to 1,689,826 cubic feet, valued at $2,677,039 in 1907. The decrease was in the quantity and value of building stone, which amounted to 506,801 cubic feet, valued at $1,470,016 in 1906 and 347,775 cubic feet valued at $1,039,117 in 1907, a decrease of 159,026 cubic feet in quantity and $430,899 in value. This is accounted for by the general depression in the building trade, fewer contracts being given to or taken by the quarrymen on account of the financial depression. In 1906 the output of monumental stone was 1,342,244 cubic feet, valued at $1,444,442 and in 1907 it was 1,342,051 cubic feet, valued at $1,637,922, a decrease of 193 cubic feet in quantity and an increase in value of $193,480.

The largest output is from Washington County, and includes the towns of Barre, Calais and Woodbury. Windsor County has the next largest production, the output being from Bethel, Chester and Windsor. The Caledonia County output ranks next and includes Kirby, Groton, Hardwick and Ryegate. The Windham County output comes from Dummerston. The other localities giving smaller outputs, representing not more than one firm, are in Williamstown, Orange County, and Derby, Orleans County.

METHODS IN THE USE OF EXPLOSIVES.

In Bulletin 313 (pp. 69–72) the methods in the use of explosives prevalent among Maine quarrymen were given and in Bulletin 354 (pp. 70–72) additional data of the same sort, gathered in the granite quarries of Massachusetts, New Hampshire and Rhode Island were published. There is but little to add on this subject from the Vermont quarries.

At Barre, wherever the sheets are imperfectly developed, this method is adopted: A thick rectangular block is obtained by channeling along a vertical rift, and also at two points along the hard way, at right angles to the rift, the fourth side being that of a joint or heading. An artificial sheet parting is then made by drilling divergent holes 10 feet deep along a horizontal grain. These holes taper from 1½ inches to 1 inch and are filled with but small charges of powder.

PRODUCTION OF GRANITE IN VERMONT IN 1906 AND 1907, BY COUNTIES.

COUNTY.	No. of firms reporting.	Building.				Monumental.				Paving.		Other purposes.	Total.
		Rough.		Dressed.		Rough.		Dressed.					
		Quantity (cubic feet).	Value.	Quantity cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (number of blocks).	Value.		
1906.													
Washington and Orange	32	66,762	$ 42,138	234,946	$ 771,169	1,006,436	$ 879,745	110,277	$ 428,035	112,930	$ 3,647	9,688	$ 2,134,422
Windsor	4	....	....	191,793	651,693	2,200	3,200	14,534	22,447	....	....	....	677,340
Caledonia, Essex and Orleans	14	2,000	1,000	....	....	206,947	110,275	1,850	740	....	....	700	112,715
Windham	3	11,300	4,016	....	....	....	....	....	....	170,000	5,910	422	10,348
Total Vermont	53	80,062	47,154	426,739	1,422,862	1,215,583	993,220	126,661	451,222	282,930	9,557	10,810	2,934,825
Total, United States	....	....	1,770,918	....	6,659,104	....	2,293,144	....	1,822,521	....	1,459,915	4,557,204	18,562,806
1907.													
Washington and Orange	39	35,543	$ 25,239	100,081	$ 234,583	1,144,263	$1,037,993	136,103	$ 503,759	5,000	$150	3,645	$ 1,805,369
Windsor	4	....	....	204,076	774,460	1,847	3,254	3,000	12,000	....	....	....	789,714
Caledonia and Orleans	9	3,300	1,400	....	....	143,427	77,816	....	....	....	....	1,751	80,967
Windham	3	4,450	3,125	325	310	3,371	3,000	40	100	166,000	5,180	6,124	17,839
Total, Vermont	55	43,293	29,764	304,482	1,009,353	1,202,908	1,122,063	139,143	515,859	171,000	5,330	11,520	2,693,889
Total, United States	....	....	1,280,769	....	4,752,593	....	2,239,227	....	2,099,492	....	1,928,308	5,756,997	18,057,386

BIBLIOGRAPHY OF ECONOMIC GEOLOGY OF GRANITE.

BUCKLEY, Ernest B. Building and ornamental stones of Wisconsin: Bull. Wisconsin Geol. and Nat. Hist. Survey, No. 4, Madison, Wis., 1898. Granite, pp. 88–100, 107–115, 121–160; tests, pp. 46–74, 358–415.

BUCKLEY, Ernest B., and BUEHLER, H. A. The quarrying industry of Missouri: Missouri Bureau of Geol. and Mines. 2d series, vol. 2. 1904. Granite, pp. 60–85.

CLARK, William B. and MATHEWS, Edward B. Report on the physical features of Maryland, together with an account of the exhibits of Maryland mineral resources by the Maryland Geol. Survey. Maryland Geol. Survey (special publication, vol. 6). 1906. The granites, pp. 115, 144, 173–177, Pl. VIII, fig. 1. Pl. XII.

COONS, Altha T. The stone industry in 1904: Min. Res. U. S. for 1904. 1905. Granite, pp. 17–32. (See also Min. Res. U. S. for 1905–1908.)

DALE, T. Nelson. The granites of Maine, with an introduction by George Otis Smith: Bull. U. S. Geol. Survey No. 313, 1907, pp. 63–189.

—— The chief commercial granites of Massachusetts, New Hampshire and Rhode Island. Bull. U. S. Geol. Surey No. 354, 1908, pp. 65–220.

DAW, A. W. and Z. W. The blasting of rock in mines, quarries and tunnels (etc.) Pt. I: The principles of rock blasting and their general application. London, 1898.

DAY, William C. Stone: Min. Res. U. S. Twenty-first and prior Ann. Repts. U. S. Geol. Survey. Granite.

GILLETTE, H. P. Rock excavations: Methods and cost. New York, 1904.

GILLMORE, Q. A. Report on the compressive strength, specific gravity and ratio of absorption of various kinds of building stones from different sections of the United States tested at Fort Tompkins, Staten Island, N. Y. Engineer Department, U. S. Army. 1874.

GUTTMAN, Oscar. Handbuch der Sprengarbeit. Braunschweig, 1892.

HARRIS, G. F. Granite and our granite industries. London, 1888.

HIRSCHWALD, J. Die Prufung der naturlichen Bausteine auf ihre Wetterbe standigkeit. Berlin, 1908. Abstract in Zeitschr. prakt. Geologie. July-Sept. and Nov., 1908. (See note at end of this bibliography.)

HENNING, G. C. Diamond tools. Trans. Am. Soc. Mech. Eng., vol. 26, 1904, pp. 409–417.

HERRMANN, O. Steinbruchindustrie und Steinbruchgeologie. Berlin, 1899.

—— Technische Verwerthung der Lausitzer Granite. Zeitschr. prakt. Geologie, November, 1895 (II), pp. 433–444.

HULL, Edward. A treatise on the building and ornamental stones of Great Britain and foreign countries. London, 1872.

HUMPHREY, Richard L. Fire-resistive properties of various building materials. Tests by U. S. Geol. Survey. Bull. U. S. Geol. Survey No. 370, 1909, pp. 69–72.

JULIEN, Alexis A. Building stones; elements of strength in their constitution and structure: Jour. Franklin Inst., Pennsylvania, vol. 147, No. 4. April, 1899, pp. 257–442.

JULIEN, Alexis A. Comparison of methods of graphic analysis of rocks. Bull, Geol. Soc. America, vol. 14, pp. 460–468. 1903.

LORD, E. C. E. Examination and classification of rocks for road building, including the physical properties of rocks with reference to their mineral composition and structure. U. S. Dept. of Agriculture, Office of Public Roads. Bull. 31, 1907. Physical properties of granite for road making. Table 2.

LUNDBOHM, Hjalmar. Summary of his various papers on granite and granite quarrying in Europe, by William C. Day: Min. Res. U. S. for 1893. U. S. Geol. Survey, 1894.

MATHEWS, Edward B. The granite quarries of Maryland: Rept. Maryland Geol. Survey, vol. 2, 1898, pp. 136–160.

MATHEWS, Samuel W. The granite industry of Maine: Sixteenth Ann. Rept. Bureau of Industrial and Labor Statistics for the State of Maine, 1902, pp. 7–51.

McCOURT, W. E. Fire tests of some New York building stones. N. Y. State Mus. Bull. No. 100, 1906. Granite and gneiss: pp. 13, 16–19, 26–27, 29–32, pls. 1–3, 9–11, 14–17.

—— The fire-resisting qualities of some New Jersey building stones. Ann. Rept. State Geologist, Geol. Survey of New Jersey. 1906. Granites and gneisses: pp. 26–28.

MERRILL, George P. On the collection of Maine building stones in the United States National Museum: Proc. U. S. Nat. Mus., vol. 6, 1883, pp. 165–183.

—— Collection of building and ornamental stones in the United States National Museum: Ann. Rept. Smithsonian Inst., 1886, pt. 2, 1889.

—— Physical, chemical and economic properties of building stones: Rept. Maryland Geol. Survey, vol. 2, 1898, pp. 47–123.

—— Stones for building and decoration, 3d ed. New York, 1903.

—— Stone (granite): Special reports of the Census Office, Twelfth Census; mines and quarries. (1902.) 1905.

NEWBERRY, J. S. Report on building stones of the U. S. and statistics of the quarry industry. Census U. S. 10th Rept. vol. 10, 1884, pp. 318–324.

PERKINS, George H. Report on the marble, slate and granite industries of Vermont, 1898. Granite, pp. 51–68.

—— Report of state geologist on the mineral resources of Vermont, 1899–1900. Granite, pp. 57–77.

—— Report of state geologist on the mineral industries and geology of certain areas of Vermont, 1903-4. Granite, pp. 23–44.

—— Report of state geologist on the mineral industries and geology of certain areas of Vermont, 1907–8. 1908. Granite, pp. 32–46.

REUSCH, Hans. Granite industrien ved Idefjorden, etc. Norges geologiske undersogelse: Aarbog for 1891. Kristiania, 1891.

RICH, George. The granite industry of New England: New England Magazine, February, 1892, p. 742.

RIES, Henrich. Economic geology of the U. S. New York, 1905. Chap. III: Building stones. Granite, pp. 75–78.

RIIBER, Carl C. Norges granit industri: Norges geologiske nudersogelse No. 12: Aarbog for 1893, with English summary.

ROSIWAL, August. Ueber geometrische Gesteinsanalysen. Ein einfacher Weg zur ziffermassigen Feststellung des Quantitatsverhaltnisses der Mineralbestandtheile gemengter Gesteine: Verh. der K. -k. geol. Reichsanstalt, vol. 32, 1898, pp. 143–175.

ROSIWAL, August. Ueber einige neue Ergebnisse der technischen Untersuchung von Steinbaumaterialien. Eine neue Methode zur Erlangung zahlenmassiger Werte fur die "Frische" und den "Vertwitterungsgrad" der Gesteine: Verhandl. K. -k. geol. Reichsanstalt, vol. 33, 1899, pp. 204–225.

—— Ueber weitere Ergebnisse der technischen Untersuchung zur Erlangung zahlenmassiger Werte fur die "Zahigkeit" der Gesteine: Verhandl. K. k-) geol. Reichsanstalt, 1902, pp. 234–246.

SCHMIDT. Naturliche Bausteine. (Vol. 76, Bibl. d. gesammten Technik., Hanover, 1908.

SMITH, Walter B. Methods of quarrying, cutting and polishing granite. Mineral Industries: Eleventh Census, U. S. (1892), pp. 612–618. Also Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 4, pp. 446–456.

SPEER, F. W. Quarry methods: Tenth Census, U. S., vol. 10, 1888, pp. 33 et seq.

TARR, Ralph S. Economic geology of the United States, with briefer mention of foreign mineral products, 2d ed., New York, 1895.

WATSON, Thomas Leonard. A preliminary report on a part of the granites and gneisses of Georgia: Bull. 9 A., Georgia Geol. Survey, 1902.

WATSON, Thomas Leonard and LANEY, Francis B., with the collaboration of George P. Merrill. The building and ornamental stones of grth Carolina: Bull. North Carolina Geol. Survey No. 2, 1906.

WEIDMAN, Samuel. The geology of north central Wisconsin. Bull. Wisconsin Geol. and Nat. Hist. Survey No. 16. Madison, 1907. Granite quarries, pp. 636–640. Analyses of granite from central and southern Wisconsin, p. 340; from northern Michigan and northern Minnesota, p. 341. Disintegrated granite for country roads, p. 643.

WILLIAMS, Ira A. The comparative accuracy of the methods for determining the percentages of the several components of an igneous rock: Am. Geologist, vol. 35, January, 1905.

WOLFF, John E. Details regarding quarries (granite): Tenth Census, vol, 10, 1888. See also the successive reports of the tests of metals and other materials for indusrial purposes made at Watertown Arsenal, published by the United States War Department.

The German periodicals named below also give results of tests of granite:

Mitteilungen der technischen Versuchsanstalten zu Berlin.

Mitteilungen der Anstalt zur Prufung von Baumaterialien am Polytechnikum in Zurich.

Mitteilungen aus dem mechanisch-technischen Laboratorium der Koniglichen technischen Hochschule in Munchen.

The substance of the paper by Merrill in vol. 10 of the United States Tenth Census, 1888, and by Merrill in the Proceedings of the U. S. National Museum, vol. 6, 1883, has reappeared in more modern form in his other works.

The work of Hirschwald in the above bibliography is of special interest, as its conclusions are based upon the microscopic study of specimens taken from buildings none of them less than fifty years old and a number several centuries old.

GLOSSARY OF SCIENTIFIC AND QUARRY TERMS.

ACCESSORY MINERALS in granite are original constituents of the rock, found only in small, often only in microscopic quantity.

ACIDIC. A term applied to rocks in which silicic acid (silica) or quartz predominates.

ALLANITE. An opaque black mineral (silicate), brown in thin section, one of the primary less common accessory constituents of granite, which contains from 12 to 17 elements, including 6 of the rarer ones. For analyses see Dana, E. S., System of Mineralogy, 6th ed. 1892.

ANTICLINE. A term applied to granite sheet or sedimentary beds that form an arch.

APLITE. Fine-grained granite, usually occurring in dikes and containing little mica and a high percentage of silica.

BASIC. A term applied to rocks in which the iron-magnesia minerals and feldspars with lime and soda predominate, such as diabase or basalts.

BLACK HORSE. Term used by quarrymen in Rhode Island to denote a dark biotite gneiss in contact with the granite.

BLIND SEAMS. Quarrymen's term for incipient joints.

BOWLDER QUARRY. One in which the joints are either so close or so irregular that no very large blocks of stone can be quarried.

CHANNEL. A narrow artificial incision across a mass of rock, which, in the case of a granite sheet, is made either by a series of contiguous drill holes or by blasting a series of holes arranged in zigzag order.

CLEAVAGE, when applied to a mineral, designates a structure consequent upon the geometrical arrangement of its molecules at the time of its crystallization.

CLOSE-JOINTED. A term applied to joints that are very near together.

CRINOID STEM. Part of the calcareous skeleton of a plantlike marine animal related to "starfishes" and "sea urchins," but rooted and provided with an articulated stem, bearing a cup containing the alimentary organs.

CROCUS. A term used in the Milford, N. H., quarries to denote gneiss or any other rock in contact with granite.

CRUSH-BORDER. A microscopic granular structure sometimes characterizing adjaceut feldspar particles in granite in consequence of their having been crushed together during or subsequent to their crystallization.

CUT-OFF. Quarrymen's term for the direction along which the granite must be channeled, because it will not split. Same as "hard way."

DENDRITES. Plantlike crystallization of iron or manganese oxides on the surfaces of fissures in any rock or mineral. Frost crystals on window panes are of like character.

DIKE. A mass of granite, diabase, basalt or other rock which has been erupted through a narrow fissure.

DIMENSION STONE. A term appied to stones that are quarried of required dimensions.

DIP. The inclination from the horizon, given in terms of degrees, of a sheet, joint, heading, dike, or other structural plane in a rock.

DRIFT. Sand and bowlders deposited by the continental glacier.
DRUMLIN. Oval hillock of clay and bowlders formed beneath the ice sheet of the glacial epoch.
EROSION. The wearing away of portions of a rock by such natural agencies as stream or ice action.
EXFOLIATION. The peeling of a rock surface in sheets owing to changes of temperature or other causes.
FAULTING. The slippage of a rock mass or masses along a natural fracture.
FLOW-STRUCTURE. The parallel arrangement of the minerals in granite or other igneous rock in the direction of its flowage during its intrusion.
GEODE. A rock cavity lined with crystals. Geodes in granite are attributed to steam or gas bubbles.
GRAIN in granite is practically the direction in which the stone splits "next easiest," the "rift" being that in which it splits most readily.
GRAPTOLITE. An extinct marine plantlike communal animal organism related to the early stage of certain "jelly fish." They were probably attached to seaweeds.
GROUT. A term applied to the waste material of all sizes obtained in quarrying stone.
GROW-ON. Quarrymen's term to designate the place where the sheet structure dies out, or the place where two sheets appear to grow onto one another.
HARD-WAY. The direction at right angles to both rift and grain in which granite does not split readily. (See Cut-off.)
HEADING. A collection of close joints.
HEADING-SEAM. See Joint.
HEMATITE. An oxide of iron (Fe_2O_3) which when scratched or powdered gives a cherry-red color.
IGNEOUS. A term applied to rocks that have originated in a molten condition.
JOINTS. More or less steeply inclined fractures which cross the granite sheets and which are attributed to various stresses.
KAOLIN. A hydrous silicate of alumina derived from the alteration of feldspar.
KAOLINIZATION. The process by which a feldspar passes into kaolin.
KNOTS. A term applied by quarrymen to dark gray or black objects, more or less oval or circular in cross-section, which are segregations of black mica or hornblende formed in the granite while in a molten state. English quarrymen call them ' heathen."
KNOX HOLE. A circular drill hole with two opposite vertical grooves which direct the explosive power of the blast.
LEWIS HOLE. An opening made by drilling two or three holes near together and chiseling out the intervening rock.
LIMONITE. A hydrous oxide of iron ($2Fe_2O_3, 3H_2O$); a hydrated hematite, which, when scratched or powdered, gives a brownish rust color.
MATRIX. The general mass of a rock which has isolated crystals; sometimes called groundmass.
MILLIMETER. French decimal lineal measure, the thousandth part of a meter or the tenth part of a centimeter. It is nearly equivalent to 0.04 inch, the meter being 39 10-27 inches.
MONOLITH. A column or monument of one stone.
MOTION. A term used in granite regions to designate small paving-block quarriesl
OPHITIC. A term applied to microscopic rock texture to designate a mass of longish interlacing crystals, the spaces between which have been filled with minerals of later crystallization.
OREI. A term applied in the Quincy quarries to granite which has been rendered valueless by the alteration of its ægirite particles.
PEGMATITE. A very coarse granite occurring in irregular dikes or lenses in granites and some other rocks.
PLAGIOCLASE. A term applied to all those feldspars that are not potash feldspars.
PNEUMATOLYTIC. A term used by geologists to designate those minerals which are formed by superheated mineral solutions associated with the intrusion or eruption of igneous rocks.
POLARIZED LIGHT. Light whose vibrations, unlike those of ordinary light, which are in all directions are in only one plane. Polarized light is used in the microscopic study of rocks.
PORPHYRITIC. A term applied to rock texture to designate the presence of isolated crystals in a general mass (matrix or groundmass) of finer material.

PSEUDOMORPH. Signifies false form, and designates a crystal in which, owing to various chemical changes, the original mineral has been more or less replaced by others. The form of the crystal no longer corresponds to the mineral.
QUARTZ MONZONITE. Technical designation for a granite in which the percentages of soda-lime and of potash feldspar are nearly the same or in which the former exceeds the latter. In ordinary granites the amount of soda-lime feldspar is relatively small.
RANDOM STONE. A term applied by quarrymen to quarried blocks of any dimensions. (See definition of dimension stone.)
RIFT. A quarrymen's term to designate an obscure microscopic cleavage in granite which greatly facilitates quarrying.
RUN. A term used by quarrymen in connection with "rift," apparently to denote the course of the deflection of the rift due to gravity, strain or other not yet understood cause.
SALT-HORSE. Quarrymen's term for aplite.
SAND SEAMS. Quarry term for more or less minute veins or dikes of muscovite (white mica) with some quartz, in cases also with feldspar.
SAND STREAKS. Same as sand seams.
SAP. Quarrymen's term for ferruginous discoloration along sheet or joint surfaces.
SCHIST. A rock made up of flattish particles arranged in rough parallelism, some or all of which have crystallized under pressure.
SCHISTOSITY. The quality of being like a schist.
SEAM. Quarrymen's term for joint.
SECONDARY MINERALS. Minerals whose presence is due to the alteration of the original minerals.
SEDIMENTARY. A term designating those rocks that consist of particles deposited under water.
SEGREGATION. The scientific term for "knot;" a collection of material separated from other material. A vein of segregation is one fromed by the filling of a fissure with mineral matter originating in the surrounding rock.
SERICITE. A more or less fibrous form of muscovite (potash mica), often resulting from the alteration of feldspar.
SHAKES. Quarrymen's term to designate a somewhat minute close-joint structure, which forms along the sheet surface as a result of weathering (?).
SHEET QUARRY. A quarry in which the granite lies in sheets, crossed by wide-spaced steep joints.
SLICKENSIDES. The polished and grooved faces of a joint or bed caused by motion and friction.
STRAIN-SHEET. Quarrymen's term for granite sheets produced by present compressive strain.
STRATIFIED. A term applied to rock consisting of originally horizontal beds or strata.
STRIKE. The direction at right angles to the inclination of a plane of beding, a sheet, or joint, etc.
STRIPPING. The material (sand, clay, soil, etc.) overlying a rock of economic value, which must be removed before quarrying.
SPECIFIC GRAVITY. The weight of a rock or mineral compared to that of a body of distilled water of the same bulk.
SUBJOINT. Minor joints diverging from or parallel to the regular joints.
SYNCLINE. A geological term for the trough part of a wave-like sheet or bed of rock.
TIGHTSET. Quarrymen's term, equivalent to blind seam, an incipient joint, in places associated with microscopic quartz veins.
TILL. A mixture of clay and bowlders deposited by glaciers.
TOEING-IN. Quarrymen's term for the wedging in of the end of a granite sheet under an overhanging joint, probably in consequence of the faulting of the sheets along the joint. It is also applied to the overlapping of lenticular sheets.
"TOE NAILS." Curved joints intersecting the sheet structure in most cases striking with the sheets, in some differing from them in strike 45° or more.
TWIN CRYSTALS. Two adjacent crystals which have formed with the poles of their main axes in opposite or different directions.
WEATHERING. The decomposition of a rock owing to the action of the weather.
WHITE HORSE. Term used by quarrymen to denote a light-colored gneiss, aplite or pegmatite.

Surfacial Geology of the Champlain Basin.

C. H. Hitchcock.

Since writing upon the Champlain deposits of Northern Vermont for the Fifth of the present series of reports in 1906, I have been able to visit portions of the area again. Finding a few matters of interest supplementary to what was then prepared, chiefly of a confirmatory character, I present them herewith without further comment.

In the Sixth Report, Mr. Herbert E. Merwin has described a part of the phenomena observed in this field under the title of "Some late Wisconsin and Post Wisconsin Shore-Lines of North-Western Vermont." Our reports agree in their essential features, but differ in terminology. I have preferred to use the earlier suggestion of Glacial Lake Champlain to that of Lake Vermont, while recognizing the correctness of Wordworth's subdivisions of the Upper and Lower Coveville and the Wood Creek stages of the same water-body. Many more observations will be needed to make our knowledge of the Pleistocene history complete.

STUDIES IN THE CHAMPLAIN BASIN.

Historically, the Champlain period embraces the happenings over this area since the ice began to melt after the culmination of the Glacial Age. The drainage being to the north and northwest gave rise to certain features in this region that are peculiar when compared with the phenomena developed where the waters flowed southerly. Where the slope is northerly the melting commenced at the headwaters of the streams, and ponds accumulated where levels were determined by the lowest point of discharge to the south over the rim of the watershed. With the continued melting of the ice the ponds became lakes, lower outlets were uncovered, beaches formed at the different levels, and rivers changed their courses. So long as stagnant ice filled the parts of the valley deposits of clay, sand and gravel accumulated in the several bodies of water, and the waves dashed against the shores, cutting into the rocks and softer earth. The barriers to the several lakes on the north consisted of the stagnant ice. In restoring the outlines of these ancient lakes the beaches may be followed from the outlets to the edge of the ice barrier. Nothing exists in the place of the ice to show its ancient limits except the absence of continuity for the ancient strands. So long as the ice persisted it provided an adequate support to the water, but when it melted there was nothing to prevent the sudden lowering of the level to the place where the next water body could be maintained.

GLACIAL LAKE MEMPHREMAGOG.

The highest lake thus indicated in northern Vermont was what I have called Glacial Lake Memphremagog. Nothing has been discovered to change our view of the limits of this body of water, as stated in the Fifth Report. It is with regret that only a very small portion of the area has been examined for these evidences, but those presented are adequate to exhibit the existence of the glacial lake. It may be noted that the whole of Stanstead district in Quebec is esteemed a part of this hydrographic basin, although the present drainage meets the outflow from the lake rather than discharges into it.

There are three elevated beaches, approximately 920, 1,060 and 1,220 feet above tide water. The outlet at Elligo Pond in Greensboro has been stated to be 894 feet above the sea, 196 feet above Lake Memphremagog as determined by De Witt Clinton, Jr. in 1826. There are two shelves here corresponding to the altitudes of the lower beaches, 933 and 1,015 feet.

The divide between the Lamoille and the Winooski rivers in Stowe is 645 feet, or 149 feet lower than the Elligo outlet. Hence if the lower Lamoille river were blocked by ice the outlet of the drainage of both the Lamoille and the Memphremagog glacial lakes would have been through Stowe. Mention was made of certain high beaches in Elmore, Morristown, Stowe and Waterbury that may have been made when the outlet of the Lamoille was obstructed. Further study of these beaches has been made in Stowe and Waterbury and the result is the establishment of the belief that a vast water body formerly existed here, high enough to be correlated with the Memphremagog glacial lake, and if the Winooski river were obstructed, to discharge the waters through the Williamstown summit into the Connecticut.

Dr. J. J. Stevenson, who has spent several summers at Waterbury Center, has taken great pleasure in exploring these high levels and refers them to an ancient water body —like the one suggested. He had hoped to present a more complete list of altitudes than those now enumerated; but

his absence from the country has rendered it impossible for him to do so.

The following figures give the altitudes along the trolley line, making the starting point 427 feet at Waterbury depot.

Waterbury depot	427
Colbyville	581
Center Waterbury	704
May's farm	738
Prescot	769
Buel's	890
Pardin's	897
Gold brook	657
L. Dillway's hotel	674
N. H. Thomas	703
Unity church	709
Mt. Mansfield hotel, Stowe	712

Five distinct lower beach or terrace levels have been recognized by Dr. Stevenson. Elevations above Waterbury, (barometric):

I. 133 to 158 at Colbyville.
II. 158 to 170.
IIa. 190 to 195 Near Cloverdale farm.
III. 218.
IV. 238. State farm, a broad flat extending to the level of Ayre's hill.
V. 428. Sand and pebbles composed of white quartz at river end of Perry Hill.

The following list gives the heights of a few of the higher levels, commencing with the south end of the Waterbury mountain.

Gravel bed near M. Turney's in Waterbury	960
The same upon the Middlesex side of the col.	
Kneelands flats, gravel to S. E.	677
Mouth of Fletcher branch to East	707
Fork in road farther east, heavy gravel	762
Morey's flat	997
Gravel at	1,022
Beach	1,087
Gravel flat, M. B. Green	1,247–1,257
Highest locality of sand, near north line of town	1,290

The above localities are on the west side of Waterbury mountain, proceeding northerly from Kneeland Flat.

A mile west of highest locality, near town line	1,182
Beach at Ayre's, farther south	1,062
Lower flat	847

The beach at Ayre's is composed of coarse gravel with well rounded stones, one and one-half miles north-east of Waterbury Center. These deposits are all in Waterbury. Some of them may be related to stream terraces or fans. Those best characterized are at levels comparable with the Memphremagog strands.

Near the north line of Waterbury adjacent to the trolley, and on all sides of the flat in Stowe, there is a marked terrace of sand estimated to be about 800 feet in height, which must have been deposited when there was a free passage across the divide near the village.

Higher up on the east side of the valley mention has been made of sand at H. C. M Sherwin's, 1,120 feet, which follows the west slope of Elmore mountain through the township, where the recorded elevation is 100 feet less. On the east flank of Mt. Mansfield there is a corresponding sand terrace that has not been measured.

The figures for the various beaches and outlets are approximate, and some allowance must be made also for the differential elevations. Viewed generally it seems that there is ground for believing in a glacial Lake Memphremagog with three phases; first, the higher level corresponding to outlets at Willoughby Lake, Glover and the Passumpsic R. R.; second, one corresponding to the passage near Island Pond to the upper Connecticut; and third, the outlets at Elligo pond and Stowe. Until greater accuracy can be determined for the various elevations it does not seem best to be more precise in the statement of the exact positions of the several water bodies.

Memphremagog Lake is twenty-eight miles long, and of variable width, one fourth of one to over two miles, and about fifty square miles in area. About one-fifth of it lies on the Vermont side of the International Boundary, 685 feet above the sea. The hydrographic area in Vermont exceeds 500 square miles, being thirty miles long from the state line to the Elligo pond, and thirty miles along the line for the distance where the drainage flows into the St. Lawrence or St. Francis. The principal Vermont tributaries are the Clyde, Barton and Black rivers. The lowest points in the southern rim are at Island Pond, 1,120 feet, at Willoughby Lake, 1,155 feet, and the divide south, 1,246 feet, at summit of the land near the Passumpsic R. R., 1,714, southern rim of Runaway Pond in Glover, 1,284 feet. Lowest level is at Elligo Pond in Greensboro, 893 feet.

The rocks are fossiliferous limestones, slates and igneous bunches adjacent to the lake. The course of the lake is partly with and partly across the stratification. At the outlet noledges are visible, and the substance holding in the water is probably till, there being no loose materials in sight for several miles. The southern end has the aspect of a drowned valley, but the lower part of the lake would have been classed by the earlier geologists as a rock basin excavated by the ice.

I found deposits of sand and gravel at about 870 feet, south from Owl's Head. Mr. Chalmers notices terraces of this sort 875 to 885 feet at the northern end, near Georgeville 920 to 925; near Magoon Point 960 and about 1,000 feet at Newport. The highest beaches I found in Stanstead slightly exceeded 1,000 feet. There were lower ones towards the railroad, even below the level of Lake Memphremagog.

In Newport, Prospect Hill and Pine Hill, Salem, are capped by sand resting upon what may have been a recessional moraine. The beaches extend westward into Coventry, one of them being capped by cobblestones. The village of West Derby is upon one of these beaches and there are others to the east considerably higher. There are three of these levels in Glover.

Professor J. W. Spencer has examined a part of this area and says that the sand levels represent true beaches and not fluviatile terraces. Not believing in their glacial origin he supposes that they were formed as the margin of the ocean when it stood at the several higher levels indicated by them.

THE LAMOILLE BASIN.

The Lamoille River occupies an irregular area rather in the outskirts of several counties. Starting at the east corner of Greensboro it may begin at the old Runaway Pond in Glover known as the East Branch in Greensboro, draining Walden and Hardwick with portions of Cabot and Woodbury. A diagonal line across Elmore from the southeast corner of the town to the north end of Elmore Center represents the southern line of the basin. It drains the west side of Elmore mountain and nearly the whole of Morristown. Sterling mountain sends its water into it, as does the whole of Cambridge up to the Mansfield chin.

Two-thirds of Greensboro belong to the basin, from Glover to the divide between the Elligo ponds at the west corner. Wild branch drains the west corner of Craftsbury. Eden and Belvidere belong to the basin. The north corner of Cambridge is to be taken out, with a part of Fletcher, but the larger western part of Fletcher with the most of Fairfax is a part of it. Underhill and the northern part of Jericho and Westford are in the basin. Only the southeast part of Georgia and most of Milton are drained by the river and its tributaries.

The mouth in Milton meets Lake Champlain at 95 feet elevation above the sea. As much as two miles inland there is little rise. There must be rapids and falls to 160 feet at the foot of the Great Falls, Milton. At head of Great Falls 228 feet, at the crossing of the R. R. in S. E. Georgia 254 feet, at the village of Fairfax, 382 feet. Cambridge R. R. (Junc.), 461 Johnson 531, Hyde Park 526, Morrisville 646, So. Hardwick 861, Walcott 690, Greensboro 1,146, Walden 1,656, Edge of Glover 1,284. From Elligo Pond the rim rises very high to the north edge of Eden and comes down to North Cambridge (424 at Fletcher). Water flows into it from the top of Mt. Mansfield on the west side.

The Lamoille basin is smaller and more irregular than either the Missisquoi to the north or the Winooski to the south. It first comes to our notice buried beneath the Memphremagog glacial waters and presumably its valley below Johnson was blocked by ice. After the Stowe strait had ceased to exist the Lamoille waterbody received the immense terrace deposits of Walcott, Hyde Park, Morrisville and Johnson, and the surplus waters must have found their way into Glacial Lake Champlain. North from Cambridge the land is low enough to have permitted water to flow into the Missisquoi. The sand deposits cease at Fairfax Falls near the mouth of Brown's river from the south, a delta deposit there reaching the altitude of 540 feet. The absence of sand in both Brown's river and the Lamoille between Fairfax and Georgia indicates the probable presence of ice. Mr. Marvin represents that Brown's valley was subsequently an arm of Glacial Lake Champlain extending northerly from the Winooski. The same might have been true of the Lamoille above Georgia, unless one prefers to accept the theory of stagnant ice.

Glacial Lake Champlain began with the disappearance of the Stowe Strait and terminated when the melting of the stagnant ice in the Lamoille basin allowed the incoming of the marine waters.

MISSISQUOI RIVER.

This river rises east of the Green Mountains in Orleans County, receives the drainage of Sutton mountain and other hills in Quebec, flowing for several miles in that province, and enters Vermont at Richford at an estimated elevation of 435 feet. At Enosburg Falls the railroad stands at 429 feet, and there is an important waterpower here. At Sheldon Junction the river is estimated to be 320 feet, at Olmstead's falls, 300, East Highgate 225, Highgate, P. O., 168, at the west line of the town, 81. And there is a waterpower at Swanton Falls before Lake Champlain is reached.

Ascending the river, there is noticeable a broad delta, slightly elevated above the lake in Swanton, called Hog Island, with six channels branching outwardly. More than half of the original width of Missisqoui Bay has been taken

up by this delta. A great bend in the river to the south of Swanton village incloses a higher sand flat, 156 feet high, which is an older delta than Hog Island. Two other sandy flats rise, perhaps 40 and 80 feet above the village, in going east into Highgate. It rises to the finest and most extensive of all these delta deposits at Highgate Center, 306 feet, and near its surface there are marine shells. With some variations it follows around to East Highgate; and upon the town line next to Sheldon, at a curve in the river, is the highest of all these sand levels—a borrow pit— 380 feet. The sand is very abundant, so that it is a conspicuous feature, and may mark the highest marine limit. Through Sheldon fluviatile deposits are scarce, save that considerable material has been brought down the Black Creek valley from the direction of the Lamoille overflow at Cambridge. The next important deposit is at Enosburg Falls, which may be due to transportation from the southeast down Tyler's branch.

At Richford streams have brought in sediment from three directions, so that this may afford us reliable measurements for the highest marine limit. The overlying sand must represent more than 100 feet thickness of the deposits brought down into the Glacial Lake Champlain. Further observations are required to give precision. Below Richford the deposits thin out, and there may have been much stagnant ice before coming to Enosburg.

THE WINOOSKI DELTAS.

Where the Winooski river discharged into Glacial Lake Champlain its volume was greatest, and there was an interesting side valley which must have given relief to the water body in its early history. In the 1861 Report (vol. 1, p. 131) I called attention to some elevated terrace deposits in the col between Huntington river and the beginning of Lewis Creek in the southeast corner of Huntington. At this height of land instead of marine beaches there were two rraces, each 50 feet high upon both sides of the valley, which indicated the existence of a powerful stream discharging towards Lake Champlain through what is now called Hollow Brook in Hinesburg. The delta lower down was said to be 570 feet, and the higher terraces 702 feet above Lake Champlain. In the light of our latest conclusions it appears that there was a water body from the Winooski combined with the drainage from the west slope of Camel's Hump which flowed through this col and deposited the large delta at South Hinesburg. Its altitude is 560–70 feet where it finally rested beneath the glacial lake and it is 100 feet thick. The terraces at the col (665 feet) do not seem to us to be a part of the delta.

The highest terraces on both sides of Richmond rise to

565–70 feet. In Jericho and Essex the bulk of the sediment increases, as the area washed on the large mountains is very great. The meeting point of Lee River and Brown's river lies in the midst of sands attaining the 550–60 feet elevation, and originally both of them joined the Winooski, by way of Alder Brook. Because the valley was filled too deep for the water to continue to follow Alder Brook, Brown's river was deflected northerly to meet the Lamoille at Fairfax, a valley devoid of terraces. The sand is seen also on the southwest side of the Winooski in Williston having been pushed across. The proper shore limit of the delta is seen in a line of bluffs running north and south a mile east of Essex Junction descending to 350–60 feet, or to about the marine limit. Thus the delta of this earlier and higher part of the Glacial Lake Champlain has fallen from 560 to 360 feet. There are well defined beaches on both sides of the railroad in Essex nearly two miles north of the Junction, at the height of land, which reach 380 feet.

The delta still continued to form after the water flowed into the Champlain estuary, and the next phase of it is conceived to extend from about 340 feet at the Junction to the bluffs extending northerly from the Twin Gorges east of Winooski village where the abrupt descent is clear for sixty feet, and on the south side to the athletic grounds of the University of Vermont where the steep slope is 160 feet, the summit upon both sides being 320 feet.

The lower marine shelf is very prominent in Burlington, just to the northeast of the railroad station, at 220 feet. A tunnel has been cut through it for the railroad. This level continues with slight variation to the Ethan Allen Park, where it shows marine shells.

In the Fifth Report I mentioned several basins in this sand plain with the theory of their erosion by the river current. It will be more in accordance with the latest suggestions that these basins represent masses of stagnant ice around which the water brought the sand and clay. One might have lain between Winooski and the Twin Gorges, a second above the lime quarries to Hubbell's Falls and Essex Junction, a third between the Junction and the high railroad bridge over the Winooski River. And if these be accepted there may have been others still higher up in Williston and Richmond.

Our re-examination of these deltas confirms the early opinion of the existence of two spillways from the ancient river, the first from Fort Ethan Allen to and down Sunderland Brook; the second from the mouth of Muddy Brook and the neighborhood of the Limekilns to Potash Brook, to Shelburne Bay at Queen City Park; 326 feet is the highest figure for the plain. It is likely that the Potash Brook was originally filled up to the height of 380 feet, for sand occurs

PLATE XXIX.

Cobble Hill, Milton. Showing at the right end remains of old Beaches.

at that elevation upon Mr. Henry Holt's grounds in Burlington and upon the opposite edge of the excavation more than a mile distant. This last represents a flat topped hill extending as far as to the east of Shelburne village. There is also a strongly marked level at 290 feet on both sides of Potash Brook. The clay in Potash Brook, in Sunderland Brook, at the Winooski brick yards and elsewhere may be conceived as having been deposited in the still water in holes about various bunches of stagnant ice.

The hill upon which the University of Vermont is situated, from the athletic grounds on the north to the southern end of Prospect street, consists of till or boulder clay and ledges surrounded by the sand, with an occasional wave cut cliff, as north of the Fletcher Hospital, east of Willard street and south of Main street, 360 to 380 feet. Doubtless there are pockets of pebbles and patches of sand over some portions of it of local derivation.

The 220 feet marine delta must have extended to the Red Rocks Park, from the north side of the higher Potash Brook delta.

LIMITS OF MARINE EXTENSION.

The clearest evidence of the former presence of the sea is the existence of the remains of marine animals—chiefly mollusca. These have been found to extend upwards to nearly 200 feet at Vergennes, nearly 300 feet at Burlington, 270 feet in Milton, nearly 400 at St. Albans, 305 feet at Highgate, 560 feet at Montreal. Following the differential line partly indicated, it is not likely that these fossils will be found farther south than the level of the lake at Ticonderoga, and south from Vergennes they will be in the low grounds in the west part of Panton and Addison, if at all. Assuming the correctness of the induction that the sea once supported organisms to these altitudes, it follows that the salt water must have extended at least 100 feet higher. The banks of earth seemingly accumu ated in this way are scattered from about 180 to 200 feet at West Haven, near Whitehall, N. Y. to 625 feet at Montreal upon Mt. Royal. If this inclined plain properly represents theformer sea level, it will be easy to say how much tipping has taken place. The total amount would be 448 feet, or from 3.2 to 3.3 feet per mile. Prof. Woodworth obtained the higher figure of 3.65 feet per mile from measurements upon the New York side of the lake. Supposing the rate of tipping to have been uniform, it will be possible to calculate what the highest marine limit shall have been at any point between West Haven and Montreal, and the figures thus obtained may be used to correct field observations to some extent. These must be modified by the fact that the inclination of this plane is greater north than south of Burlington. And the impression one gets from observation of the place of this higher marine limit does not always coincide with the calculated place.

BEACHES, AND WAVE CUT BEACHES IN MILTON.

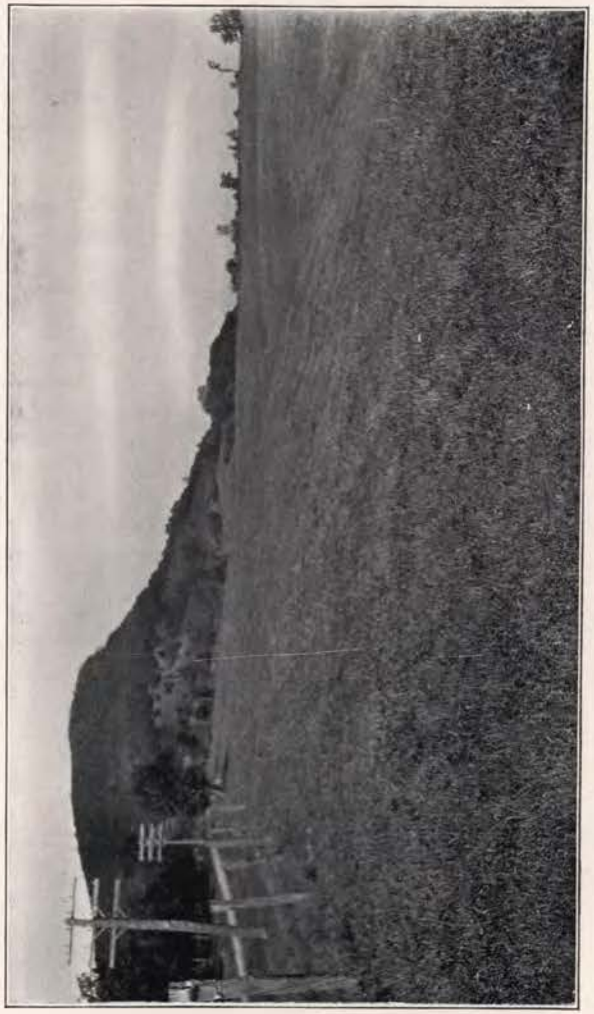
At Georgia station there are high banks of sand higher than the delta, which begins here and makes a conspicuous feature to the northwest of the station. The course of the river leads towards Georgia Plain, which belongs to a series below the delta, and at West Georgia ledges rise above the sands, causing the Lamoille to bend to the south into Milton. The middle part of Milton is occupied by immense sand plains upon both sides of the river, the one upon the north being 20 feet higher than the other, which measures 380 feet. Arrowhead Mountain rises above the northern flat and shows cut shelves upon both sides of it. Cobble Hill projects above the southern sand, and has a cut terrace upon the west side, 450, and four others high up upon the southeast side. These levels were given in the earlier report as 446, 463, 566 and 586 feet. A view of them is given herewith. Plates XXIX, XXX.

The proper delta reaches the height of 380 feet, and extends from the north base of Cobble Hill to beyond Checkerberry village. A ridge extends from this village to Cobble Hill, which holds the sand in place, otherwise it would all have been washed to the extensive lower regions in the south part of the town. At the level of 270 feet west of Checkerberry is a very marked flat in which marine shells are abundant.

Coming up Mallett's Creek from Colchester the marine clays reach the town line and above them is the beach of coarse gravel 40 feet thick, 340 to 380 feet level, shown in photograph. Plate XXXI. It is more sandy towards Mr. Lamb's. And the same strand appears on the east side of the railroad near the town line. A higher equally well marked sand beach 430 feet, appears at a fork in the road at the northeast base of Cobble Hill. The same beach is well developed in this first mile away from the north and south road, and points toward Checkerberry village. Other remnants skirt the delta farther on. The great sand plain is lower, 380 feet, and ten feet lower at the village corresponding to the descent of the river.

At Milton Falls four different levels are observable upon the west side near Skeel's Hotel, the highest slightly exceeding the delta. A mile north a large ledge at the fork in the road has the appearance of a cliff washed by the waves when the sea was here. Wave cut cliffs appear considerably higher up upon both sides of Arrowhead Mountain.

PLATE XXX.



Cobble Hill, Milton. Showing at the right end remains of old Beaches.

Of these approximate levels 380 is regarded as the highest delta mark and 430 as the highest marine level.

On the road to Westford, more than a mile east of the R. R. station, is a beach at 545 feet.

At Hardscrabble, a mile farther south, the same beach was rated at 555 feet.

Near the railroad and a mile south of the station is a second hill merging into a dune, 388 feet. Then 358 feet.

A sea cliff opposite Cobble Hill, 495.

A shelf farther south, 410.

Near the north line of Milton, a wave cut cliff, 369.

ST. ALBANS.

The discovery of the single valve of *Yoldia obesa*, near S. H., No. 1, upon Stevens Brook, at the height of 525 feet, does not make it incumbent upon us to accept that as the upper marine limit. It is an exceptional occurence and will be disregarded in forming conclusions, though it should not be forgotten should some future discovery bring confirmation to it.

With slight revisions of measurement the best illustration of the highest marine level may be found at the intersection of South Main Street and Parsons Avenue 458 feet, which is 115 feet higher than the locality of marine shells about a mile south of the railroad station. 200 feet more will accord with marks of wave action upon Prospect Hill, near by. As this agrees with the level reported by Baron DeGeer, 658 feet, it may be regarded as equivalent to the beach measured by that gentleman. We cannot regard it as marine, but it corresponds very well to one of the levels of the Glacial Lake Champlain. The exact figure may be a few feet lower than this. Several other shelves are the following: at P. O'Neil's 758; H. Revoir's, J. H. Brainerd's and J. G. Smith's, 740. These are in a cove rising gradually from the neighborhood of Prospect Hill.

Between the railroad and the lake there is a broad plain at 279 feet, outside of which is a sea cliff where the water dashed against the red Cambrian dolomite. This was part of the very distinct marine plain with shells marking 200 feet in Shelburne, 220 feet near the railroad station in Burlington and possibly Highgate Center, 306 feet.

GEORGIA.

Georgia station, 358.

Two levels of sand near by, 421, 471.

Near railroad about one mile north, 510, 518, 526.

Near railroad crossing halfway between Georgia and Oakland, 405.

Washed bar one mile north of Georgia P. O., 518.
Same at cross road not far away, 540.
Also at S. H. No. 7.

Near north line of town, west flank of Prospect Hill is a fine beach and sea cliff, near those described in St. Albans.

SECTION FROM CHESTERFIELD, N. Y., TO JERICHO, VT., THROUGH BURLINGTON.

It will be interesting to compare the results obtained respecting the various levels along an east and west line in New York and Vermont. The data from New York are given by Professor J. B. Woodworth.

NEW YORK.*

580–90	Highest beachlines, Chesterfield
500	Delta Port Kent, one of the strongest wave lines
350	Marked wave action
340	Upper marine limits 340
300	Highest shells S. of Trembleau Mountain
200–260	Shore lines, Port Kent

VERMONT.

633	Highest silt in Jericho
560–350	Delta Glacial L. C.
350–320	Delta deposits
295	Burlington
220	Lower marine terrace, very marked

MOORE'S QUADRANGLE COMPARED WITH ST. ALBANS AND MILTON.

750 to 640 Upper beach and water lines	St. Albans, 758, 740, 658 Milton, 586, 566, 560
450 Highest marine limit	St. Albans, 458 Milton, 430
346 Marine shells, St. Albans, 373	
280 Delta at Moore's	St. Albans, 279 lower marine flat Milton, 270

WAS THE TERTIARY OF VERMONT A DELTA DEPOSIT?

The existence of Miocene Tertiary deposits has been established by the occurrence of the fossil seeds and nuts at Brandon. In the 1861 Report it was claimed that the

*Pleistocene Geology of Moore's Quadrangle, by Jay Backens Woodworth. Bulletin 83, New York State Education Department. June 1905.

PLATE XXXI.

Gravel Bed near Mr. Lambs, Colchester, Ancient Beach.

kaolin clays, the iron and manganese ores being associated with the fossils, were deposited with them and were, therefore, of the same age. The other view that has been more or less insisted upon represents the ores as the weathered outcrop of the Silurian and other ancient rocks and, consequently, older than the Tertiary.

In placing upon the geological map of 1861 a narrow strip of color to represent the Tertiary, we had in mind the existence of a broad terrace at the base of the Quartzite hills, which was regarded as the formation in question. It was said to be overlain by the drift at Bennington.

With these premises before us, it is legitimate to surmise that a line must be drawn between the Tertiary and the till, and to ask geologists in the future to search for it. The question forced itself upon us in an examination of the beautiful deltas at Bristol, having the altitudes of the highest stages of Glacial Lake Champlain, 600 and 490 feet. The terrace is allied to the Tertiary deposits, and the kaolin and iron ores are associated with similar beds farther north in Monkton. May it not be possible that the substratum of this delta is a deposit of Tertiary age? If so, some one may find the line of union between the Tertiary and the Quaternary in Vermont. And it may also be determined whether, while sedentary, it might not also possess some features of a delta or beach deposit.

THE GLACIATION OF MT. MANSFIELD.

A little may be added to what has been published upon the glaciation of this elevation, as seen about the first of August, 1909. The ridge has been so thoroughly exposed to the weather that the striation, which was nearly universal at first, has mostly been obliterated. The most durable mineral is the quartz in white veins. Upon the very highest part of the Chin, lines upon the quartz had the direction of S. 50° E. At what might be called the south base of the Chin, in a col, the striation is very pronounced, there being deep scratches upon the schists crossing the ridge transversely. A little farther along is the "Drift Rock", first noticed by A. D. Hager and figured in his report. A rough estimate is that of a block twenty feet long, ten feet wide and thick, not taking into account the large pieces which have fallen from it upon the west side. The distance of its transportation may not have been large, but no other theory can explain its present position. Using the usual formula for calculation the larger block should weigh one hundred and seventy tons.

Excellent striæ are visible at the Summit House, both in front of the veranda and about fifty feet to the south. They show well because the earth has been removed from

REPORT

OF THE

STATE GEOLOGIST

ON THE

MINERAL INDUSTRIES AND GEOLOGY OF
CERTAIN AREAS

OF

VERMONT

1909-1910

SEVENTH OF THIS SERIES.

GEORGE H. PERKINS, Ph. D.
State Geologist and Professor of Geology, University of Vermont.

BELLOWS FALLS, VT.
THE P. H. GOBIE PRESS
1910

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the rock quite recently. On the summit of the nose other striæ are visible. The last two named tend to curve a little more easterly than the first. Besides striation, many boulders, up to 300 pounds weight, may be seen near the hotel. They consist of the grayish quartzites and schists extending for many miles to the northwest of the mountain in Franklin county. The east side of the ridge is everywhere very rough, often precipitous, and large blocks of rock have fallen down from these cliffs. Had the ice come from the northeast instead of the northwest these precipices would have been smoothed over like the present northwest slope. There is a very scant layer of till upon the road leading down from the summit.

The station used by the U. S. G. & C. S. for the measurement of angles was situated upon the Nose, which is not the highest elevation of the mountain. Those who make maps must bear this fact in mind, so as not to ascribe to the Chin the latitude, longitude and altitude belonging to the Nose. It is the nearly universal custom of engineers to place their instruments used for the measurement of angles upon the very highest points of the mountains and hills; and why there should have been a departure from the rule in this instance, is not easy to understand.

August, 1909.

Trilobites of the Chazy Formation in Vermont.

PERCY E. RAYMOND.

Assistant Curator in Charge of Invertebrate Paleontology, Carnegie Museum, Pittsburg, Penna.

INTRODUUCTION BY THE STATE GEOLOGIST.

More than twenty years ago the Geologist collected a considerable series of fossils from the Chazy beds on Isle La Motte.

Among the specimens found in what was locally known as "The Edmunds Layer", some portions of which were very rich in fossils, especially Cephalopods and Trilobites, were forms that could not be identified with any described species. For various reasons these remained unstudied until recently. Some of the more important Cephalopods are described and figured by Dr. R. Ruedemann in Bulletin 90, New York State Museum,

Cephalopods of the Champlain Basin, 1906.

The writer had commenced the study of some of the Trilobites when, finding that Dr. Percy E. Raymond had for some time been giving especial attention to Chazy Trilobites and had already published important contributions to the literature of this subject, he offered to send the Vermont specimens to Dr. Raymond for study and description.

The proposal being accepted the task was undertaken and its results are given in the following pages.

In Annals of the Carnegie Museum, Vol. III, No. 2, 1905, Dr. Raymond has published some of the material included in the present article, but it has all been reconstructed and important additions have been made.

Of all the fossils which are found in the Chazy, the trilobites are the most interesting, the most characteristic, and, in many places, the most numerous. At many places in the western part of Vermont the strata of the Chazy are well exposed, and in previous reports of this Survey, Professor Perkins has described these outcrops in detail. While doing this work he obtained many trilobites, which he has very kindly turned over to me for study. While the chapter is based primarily on a very fine collection obtained by Professor Perkins on Isle La Motte, all the species known from the Chazy have been described and figured, for all species known from the rocks on the western side of Lake Champlain will probably be found on the eastern side.

My thanks are due to Professor Perkins for the opportunity to study this collection, and for his great generosity in allowing me to describe several unique specimens which have added much to our knowledge of a number of the species.

Dr. W. J. Holland, Director of the Carnegie Museum, has very kindly allowed the use of the plates, which first appeared in the Annals of the Carnegie Museum. To him special thanks are due, for without these plates it would have been very difficult to have adequately illustrated this article.

ARTHROPODA.

Subclass TRILOBITA.
Order HYPOPARIA Beecher.
Family HARPEDIDÆ Barrande.
Genus *HARPES* Goldfuss.
Subgenus EOHARPES Raymond.
Eoharpes antiquatus (Billings).
Plate XXXII, fig. 1.

Harpes antiquatus Billings, 1859, Canadian Naturalist and Geologist, volume 4, page 469, figure 38.

Harpes antiquatus Billings, 1863, Geology Canada, page 133, figure 67.

The writer has shown in a previous article that the name *Harpina* was preoccupied when used by Novak, and the name *Eoharpes* was suggested to take its place. (American Journal of Science, series 4, vol. XIX, p. 377, 1905).

DESCRIPTION.

Cephalon nearly semicircular in front, border narrow, concave, the genal angles extending back a distance equal to about half the whole length of the specimen, slightly incurved at the posterior ends. Eyes small, simple, situated on the highest point of the cheeks and opposite the anterior fourth of the glabella. Eye lines sharp and prominent, running a little forward and inward to the front of the glabella. Outside the eyes are two raised lines running backward and outward down the steep slopes of the cheeks, nearly to the concave border. The cheeks are much steeper both at the sides and in front, than in *Eoharpes ottawaensis*, and the glabella is more convex and more distinctly outlined. On the front, below each eye, is a depression starting from the front of the glabella and running backward around the middle of the slope of the cheeks.

The whole surface of the cheeks and border is thickly pitted, as is the top of the glabella, while the sides of the glabella and its lobes are smooth.

The neck ring is narrow and shows a median pustule.

A small specimen, 3 mm. long and 3.65 mm. wide, differs from the adult in being proportionally wider and in having the anterior end of the glabella and the ocelli relatively further forward. The border is nearly flat instead of concave, and the glabella shows traces of a second pair of furrows.

The following measurements show the proportions of the various parts. An average adult. Cephalon: length 8 mm.; width 9 mm.; from front to posterior margin of neck ring, 5 mm.; length of glabella, 3.5 mm. Distance of eyes from glabella, 1.25 mm.; eyes 3.75 mm. apart.

Largest specimen. Cephalon; length 15.5 mm.; width 14.5 mm.

Locality.—This species is common in the lower limestones at Valcour, Valcour Island, and Chazy, New York, and occasionally occurs in the middle Chazy. It is also quite common on Isle La Motte, Vermont.

Eoharpes ottawaensis (Billings).
Plate XXXII, fig. 2.

Harpes ottawœnsis Billings, 1865, Paleozoic Fossils Canada, Volume I, page 183, figure 166.

Harpina, cf. *Harpes ottawensis* Clarke, 1897, Paleontology Minnesota, Volume 3, part 2, page 757, figure 79.

Harpina ottawensis Weller, 1902, Paleontology New Jersey, Volume III, page 191, plate XIV, figures 1, 2.

This species differs from the last chiefly in its larger size, the wider cephalic border, and the position of the ocelli.

DESCRIPTION.

Cephalon.—Glabella oblong, strongly convex, tapering toward the front. The first pair of glabellar furrows make distinct, rounded lobes, but reach only about half way to the median line. The second and third pairs of furrows are very faint, often not visible. Neck segment narrow and convex.

Cheeks strongly convex, highest at the eyes, sloping abruptly at the sides, but gently in front, where an angle of about 45° is made with the border. Eyes small, situated well forward and rather close to the glabella.

Border semi-circular in front, about five or six millimeters wide, becoming narrower back on the genal angles, which are prolonged about half the length of the cephalon behind the neck segment. The entire border and cheeks outside the glabella are thickly pitted, a single row of larger pits extending around the outside margin of the border and along the edge of the glabella. A double row of large pits marks the juncture of the convex cheeks with the concave border. Glabella and two small oval spaces outside the posterior glabellar lobes, smooth, with the exception of a narrow space along the crest of the glabella, which is faintly punctate.

Measurements.—An average cephalon: length, 25 mm.; width, 26 mm. Anterior margin to neck segment, 13 mm.; glabella, 7.5 mm. long; eyes, 7 mm. apart, 1.5 mm. from side of glabella.

Another specimen is 30 mm. long, 27 mm. wide.

Locality.—Most abundant in the lower Chazy limestone in the rocks along the lake shore about a mile north of Valcour, New York.

Family TRINUCLEIDÆ Barrande.
Genus *AMPYX* Dalman.
Subgenus LONCHODOMAS Angelin.
Lonchodomas halli (Billings).
Plate XXXII, figs. 3–6.

Ampyx halli Billings, 1861. On some new or little known species of Lower Silurian Fossils from the Potsdam Group. Geological Survey of Canada. Reprinted in Volume I, Paleozoic Fossils of Canada, 1865, page 24, figure 25, *a-c*.
Ampyx halli Billings, 1861, Geological Survey of Vermont, Volume II, page 959, figure 365.
Ampyx halli Vodges, 1893, American Geologist, Volume XI, page 106, figure 5.

One of the common trilobites of the Chazy limestone is the little *Ampyx* which Billings described from Highgate Springs, Vermont. In spite of the frequency with which it is met, no complete specimens have yet been found. Pygidia, although small, are frequently obtained, but of the thorax only the last two segments have been found.

An examination of the type at Ottawa shows that the pygidium of that specimen has attached to it the last two thoracic segments, which explains the surprising length of the pygidium figured in the Paleozoic Fossils of Canada, page 24. A similar specimen was found by the writer on Valcour Island.

DESCRIPTION.

Cephalon.—Cranidium triangular, the greatest width at the neck segment. The glabella extends about half its own length beyond the anterior angles of the fixed cheeks, and is then prolonged into a long, fluted spine, which curves gently upward. This spine is prismatic, with a deep furrow on each of its four sides. The furrow on the upper side extends back to about the region of the fixed cheeks. Glabella widest at the anterior angles of the fixed cheeks and contracting posteriorly so that it forms about one-fifth of the whole width at the neck segment. On the cast there are two small nodes on each side of the glabella near its posterior end, one pair a little in front of the other. A distinct carina extends along the top of the glabella to the posterior end of the dorsal furrow on the rostrum.

Thorax.—A specimen from Valcour Island retains the last two segments of the thorax. They are narrow, extend horizontally, and on the pleura are deeply grooved. The fourth segment is 5 mm. wide, .3 mm. long and the axis is 1.6 mm. wide. The pygidium of the same specimen is 1.25 mm. long, 4.3 mm. wide, and the axis is 1.3 mm. wide at the anterior end.

Pygidium.—The pygidium is about three times as wide as long, usually regularly rounded posteriorly, sometimes somewhat triangular. Axis wide, prominent, extending to the posterior end of the pygidium. The exfoliated axis shows seven to ten pairs of nodes very similar to those noticed by Ruedemann on specimens of *Lonchodomus hastatus* from Rysedorph Hill. The pleura show three or four pairs of rather indistinct ribs. The margin is abruptly deflected all around.

Locality.—The figured specimen is from Valcour Island. The species seems to occur in only a limited area in the region of the typical Chazy deposits. It has not been reported south of Valcour, New York, nor north of St. Dominique, Quebec. At Chazy the specimens are all found in one horizon, about the middle of the group. At Valcour it is common in the lower portion, and on Valcour Island it occurs from a horizon about three hundred feet above the base to within about one hundred feet of the top.

Beside the original locality at Highgate Springs this species has also been found in Vermont at Isle La Motte and at South Hero. This species was named for Dr. G. M. Hall, of Swanton, Vermont.

Order OPISTHOPARIA Beecher.
Family OLENIDÆ Salter.
Genus *REMOPLEURIDES* Portlock.
Remopleurides canadensis (Billings.)
Plate XXXII, figures 8–10.

Remopleurides canadensis Billings, 1865, Paleozoic Fossils of Canada, Volume I, p. 182, fig. 164.

DESCRIPTION.

Cephalon.—Glabella high, nearly flat on top, but with steep sides and front. It occupies nearly three-fourths of the whole width of the cephalon. Glabellar furrows very faint, three pairs showing on the cast, while the outer shell sometimes shows two pairs, but generally none. Surface finely granulose.

Neck furrow wide and deep, extending to the genal angles. Neck segment wide and convex, with a small tubercle close to the furrow.

Free cheeks small, extending only to the front of the eyes, strongly striated. Genal angles extended into small short spines. Eyes very large, extending from the neck furrow around almost to the front of the glabella. Lenses very fine and very numerous.

Thorax.—No specimen in the collection shows the total number of thoracic segments, and the largest number on any fragment is eight. The median lobe is very wide toward the front, but tapers rapidly. The segments are beautifully adapted for rolling up, having a very neat interlocking device. At the sides of each segment are fulcral nodes, and processes which fit over the segment ahead and against its fulcral projection. The side lobes of the segments are short, obliquely furrowed, and turn back at angles from 30° to 45°, the posterior ones turning back most sharply. The pygidium is small, and divided into four lobes which extend back as spines. On the anterior edge are two nodes similar to those on the thoracic segments. There are two large projections on the surface of the pygidium, and each is divided by a diagonal impressed line.

The following are the measurements of a couple of heads. An average cephalon: length, 9.5 mm.; width, 11 mm.; width of glabella at widest part, 8 mm.; at interior ends of eyes 5 mm. A larger cephalon is 12.5 mm. long, 16 mm. wide, and the greatest width of the glabella is 11 mm.

The thorax and pygidium of this species are very much like those of *Remopleurides salteri* var. *girvanensis* Reed from the Llandeilo of the Girvan District. (The Lower Paleozoic Trilobites of the Girvan District, Ayrshire, 1903, pt. I, p. 39, pl. VI, figs. 11-14). The whole structure of the free cheeks, thorax and pygidium is very different from that of *Remopleurides* (*Caphyra*) *radians* Barrande and *R. striatulus* Walcott.

Locality.—Found in the middle Chazy on the east side of Valcour Island, New York, and also at Chazy. The figured specimens are from Smuggler's Bay, Valcour Island.

Family BATHYURIDÆ Miller.
Genus *BATHYURELLUS* Billings.
Bathyurellus brevispinus Raymond.
Plate XXXII, figs. 13-15.

Bathyurellus brevispinus Raymond, 1905. Annals Carnegie Museum, Volume, III, p. 337, pl. 10, figs. 13-15.

Description.

Cephalon very strongly convex, the highest point at the neck segment. Glabella moderately convex and smooth. Its greatest width is between the eyes and it tapers a little both backward and forward. In front it becomes gradually less convex, sloping easily down to the cheeks. Glabella entirely smooth, without furrows. Neck segment wide at glabella, but narrower at the sides. Eyes broken, but the eye lobes show them to be large, lunate, and *Asaphus*-like. In front of each is a shallow groove extending to the glabella.

Free cheeks large, extended into short, blunt spines posteriorly. Around the whole margin of the cephalon is a narrow, concave border. The following measurements are taken from the two specimens. The cephalon: length, 15.5 mm.; width, 14.5 mm.; length glabella, 8 mm.; width, glabella, 4.5 mm. The cranidium: length, 8 mm.; length glabella, 5.5 mm.; width glabella, 3 mm.

The nearest relative of this species is *Bathyurellus formosus* Billings, which was described from Division P, Cow Head, Newfoundland. *Bathyurellus brevispinus* differs from that species principally in the length of the genal spines and in the convexity of the glabella. In our species the glabella is depressed in front, but in the Newfoundland form it is strongly convex.

Locality.—Found in the pure dolomite layers in the reef three miles southeast of Chazy, New York, near the Lake Champlain shore.

Bathyurellus minor Raymond.
Plate XXXII, fig. 16.

Bathyurellus minor Raymond, 1905. Annals Carnegie Museum, Volume III, p. 338, pl. 10, fig. 16.
Bathyurellus validus Raymond, Bulletin American Paleontology, Volume III, No. 14, faunal list, page 301.

Description.

Cephalon and thorax unknown.

Pygidium.—Outline almost semicircular. Axis convex, showing from two to five annulations. It extends two thirds the length of the pygidium. Sides of the axis nearly parallel and the posterior end abruptly rounded. Entire surface outside the axis concave and smooth.

Measurements.—One specimen is 16 mm. wide, 3 mm. long, axis, 2 mm. long, 2 mm. wide on anterior margin.

Another pygidium: width, 4 mm.; length, 2.5 mm.; axis, 1.5 mm. long, 1.25 mm. wide on anterior margin.

Locality.—The specimen figured is from B13, near the middle of the Chazy at Crown Point, New York. The species occurs at several localities on Valcour Island.

Family ASAPHIDÆ Emmrich.
Genus *BASILICUS* Salter.
Basilicus marginalis (Hall).
Plate XXXII, figs. 17–20.

Asaphus marginalis Hall, 1847, Paleontology of New York, Volume I, page 247 plate 4 bis, figure 15.

Asaphus marginalis Emmons, 1855, American Geology, Volume I, part 2, page 235, plate 3, figure 16.

DESCRIPTION.

Cephalon broad, not very convex, with a broad concave border all around. Cranidium wide in front, the fixed cheeks small and the eyes close to the glabella. Glabella elongate oval, gently convex, distinctly outlined. There are four pairs of shallow glabellar furrows. The first two pairs are rather indistinct, broad, and are nearly perpendicular to the axis. The third and fourth pairs are deeper, with a diagonal course, and the last pair curve round at the ends, forming two almost isolated lobes near the posterior edge of the glabella. The neck furrow is deep and prominent on the cheeks, but is hardly visible on the glabella. On the median line, opposite the anterior ends of the last pair of glabellar furrows, there is a small spine. From the front of the glabella a ridge runs forward across the concave border, and forms a small triangular projection of the margin. It sends off a lateral ridge along the front for a short distance on each side. In front of each eye is a smooth ridge which runs obliquely forward to the glabella, meeting it at about the place of origin of the second pair of glabellar furrows.

The eyes are relatively small, situated far back and close to the glabella. The free cheeks are large, the genal angles extended as broad, smooth spines. A concentric furrow and ridge start just outside the fixed cheeks and run forward, a little outside the base of the eye, meeting the glabella ahead of the first pair of glabellar furrows.

Surface finely granulose.

A small cranidium, 4 mm. long, from Chazy, New York, shows that in the young stages the glabella is very strongly outlined. The four pairs of glabellar furrows are very distinct, and the neck segment shows on the glabella although the posterior pair of glabellar furrows are so close to it as to obscure it somewhat.

Thorax unknown.

Pygidium strongly ribbed, moderately convex, with wide, almost smooth, depressed border. The posterior end of one perfect pygidium is prolonged into two short flat lobes. Whether this is due to accidental causes, a pathologic condition of the individual, or whether it is the normal form, the material at hand is not sufficient to indicate. Axis very narrow and convex, ending abruptly at the border. It shows ten or twelve distinct annulations and sometimes more faint ones can be made out. The pleura show about the same number of narrow, distinct ribs, which are very strongly outlined on the convex portion of the pygidium, but become faint on the border.

Surface minutely granulose.

Measurements.—A cranidum: length, 22.5 mm.; width at ends of fixed cheeks, 28 mm.; length, glabella, 16 mm. A small cranidium: length, 4 mm.; width at ends of fixed cheeks, 3.5 mm. Glabella, 3 mm. long. A large cranidium: length, 100 mm.; width of front, 130 mm.; length of glabella, 68 mm. A large pygidium: length, 78 mm.; width, 58 mm.; axis, 40 mm. long, 10 mm. wide at the front.

This fine species should be compared very carefully with *Asaphus tyrannus* Murchison, as it agrees with it in many particulars of both cephalon and pygidium. The glabella, glabellar furrows, shape of cranidium and presence of a glabellar spine are the same in both species. *Asaphus tyrannus* is one of the typical Llandeilo species, and does not seem to occur outside the typical region in South Wales.

Locality.—Most of the specimens are from the trilobite layers on the east side of Valcour Island, but one cranidium was found in the reef at Smuggler's Bay, and another at McCullough's Sugar Bush, Chazy, New York. The specimen figured on plate XXXII, figure 20, was loaned by Erastus M. Hudson, who found it on the east side of Valcour Island.

Genus *ISOTELUS* Dekay.
Isotelus harrisi Raymond.
Plate XXXIV, figs. 3, 5–7; plate XXXVII, fig. 1.

Isotelus harrisi Raymond, 1905. Annals Carnegie Museum, Vol. III, p. 343, Pl. 12, figs. 3 to 7.

DESCRIPTION.

Cephalon large, smooth, depressed, with a nearly flat border around the front. Eyes large, situated rather far apart and about one quarter the length of the cephalon from the posterior margin. Cranidium shows no trace of glabellar furrows. Free cheeks large, bearing a genal spine of varying length, usually not over an inch long on a cephalon three inches in length—measured along the axis of the cranidium.

Thorax of eight rather flat, grooved segments. The axial lobe wide, gently convex, and rather strongly outlined by the dorsal furrows.

Pygidium rounded in outline, regularly convex, with a somewhat depressed border. Axis barely outlined except at the front. Ribs obscure, visible only in oblique light and best seen on the cast.

Length of cranidium 66 mm., width between eyes 60 mm., back of eye 18 mm. from the posterior margin. A pygidium is 79 mm. long, 86 mm. wide, axis 40 mm. wide at the anterior margin.

Locality.—The species is found at Crown Point, Valcour Island, Chazy and Cooperville, New York.

In the collection obtained by Professor Perkins on Isle La Motte this species is very abundant.

Genus *ASAPHUS* Brongniart.

Subgenus ONCHOMETOPUS Schmidt.

Onchometopus obtusus (Hall).

Plate XXXIV, figures 1, 2; plate XXXVIII, figures 2–4.

Asaphus ? obtusus Hall, 1847. Paleontology New York, Volume I, p. 24, Plate 4 bis, fig. 14.

Isotelus obtusus Raymond, 1905. Annals Carnegie Museum, Volume III, p. 344, Plate 12, figs. 1, 2.

This species, which can now be described from a nearly complete specimen sent by Professor Perkins, should be removed to the genus *Onchometopus*, the most striking generic character being the absence of the channeled border on the pygidium.

DESCRIPTION.

Entire animal oval in outline, rather broad and only slightly convex. The entire test is covered with large punctæ, making the identification of the species very easy.

Cephalon nearly semicircular in outline, being about one-half as long as wide. It is gently and regularly convex, and lacks the depressed or concave border seen in *Isotelus* and *Isoteloides angusticaudus.* The glabella is very faintly defined, nearly smooth, three pairs of very faint furrows being visible on the cast. The neck furrow is shallow, and hardly visible on the free cheeks. Just in front of it is a small median tubercle. The eyes are small, and are situated about their own length ahead of the posterior margin. Free cheeks without spines at the genal angles.

The thorax has eight rather broad, flat segments which are abruptly deflected at their outer ends. The median lobe is about one-third the total width, being wider than in *Asaphus* and less wide than in *Isotelus.* In the figure on plate XXXIV, figure 1, the axial lobe is represented as being much wider than it really is.

Pygidium two-thirds as long as wide, uniformly convex, without depressed border. Axial lobe broad at the anterior end, tapering rapidly, and becoming obscure on the middle of the pygidium. On the cast it is more prominent. There are no traces of segments on the axial lobe or on the pleura.

The following measurements give the proportions of the various parts:

The specimen figured on plate XXXIV, fig. 1. Length 57 mm., width at genal angles, 31 mm. Length of cephalon, 16 mm. Length of thorax 20.5 mm., width of axial lobe, 12 mm.

The specimen with thorax and pygidium, figure 2 of same plate. Width of thorax at posterior end, 26 mm.; width of axial lobe, 12 mm.; length of pygidium 17 mm.; width, 25 mm.

Three pygidia have the following dimensions: length, 26 mm.; width 40 mm.; length 19 mm.; width 28 mm.; length 5.5 mm.; width 8.5 mm.

Locality.—This species is most common in the upper part of the Chazy and has been found at Crown Point, Valcour Island, and Chazy, New York, and on Isle La Motte, Vermont.

Genus *ISOTELOIDES* nov.

Similar to *Isotelus*, but with narrow axial lobe, a definite glabella, and an *Asaphus*-like hypostoma. Type, *Asaphus canalis* as described by Whitfield.

Isoteloides angusticaudus Raymond.

Plate XXXV, figs. 3, 4; plate XXXVII, fig. 7.

Isotelus angusticaudum Raymond, 1905. Annals Carnegie Museum, Volume III, p. 345, pl. 13, figs. 3, 4.

DESCRIPTION.

Entire test oval, somewhat pointed at the extremities; about twice as long as wide. Body compressed, strongly convex; shell finely punctate.

Cephalon about seven-tenths as long as wide, strongly convex, depressed and rather pointed at the anteriot margin. Eyes large, about their own width from the posterior margin. Glabella nearly smooth, the cast showing two pairs of very faint furrows. Genal angles rounded, without spines. The neck furrow is slightly impressed, and in front of it is a small median pustule.

Thorax of eight segments. Median lobe rather broad, pleura abruptly deflected.

Pygidium narrow, strongly and uniformly convex, tapering rapidly. Sides nearly straight, the margin slightly concave and very steep; axis not strongly marked, wide at the anterior end, but tapering rapidly. In the cast there are traces of annulations on the axis and faint indications of ribs on the pleura.

The entire specimen is 58 mm. long and 27 mm. wide. One pygidium is 18 mm. long and 19 mm. wide, while a large one is 35 mm. long and 36 mm. wide. A large cephalon is 35 mm. long and 50 mm. wide.

This species differs from *Onchometopus obtusus* in its much narrower and more convex form, and in having a concave border in front of the glabella.

Locality.—A very rare fossil on Valcour Island, N. Y., but common on Isle La Motte, Vermont.

Genus *NILEUS* Dalman.

Nileus perkinsi sp. nov.

Plate XXXVIII, figs. 7, 8.

This species is so far known from two specimens, one obtained by Professor Perkins at Isle La Motte, and one in the U. S. National Museum from the same locality.

Description.

Cephalon about three-fourths as long as wide, strongly and evenly convex, sloping gently to the margins without any depressed border. Eyes very large, situated far apart and close to the posterior border of the cephalon. The glabella is not differentiated from the remainder of the cephalon and is smooth except for a very small median tubercle. The genal angles are not well preserved on either of the specimens at hand but appear to be regularly rounded and aspinose. The surface of the test is marked by very minute punctæ.

Of the thorax only five segments are preserved. It is strongly convex and dorsal furrows appear to be absent.

This species differs from *Nileus vigilans* (Meek and Worthen) as described by Clarke from Minnesota in several particulars, but principally in respect to the eyes which are much larger and further back on the cephalon in our species. This species from the Chazy is more closely related to *Nileus scrutator* Billings, but differs from that species in having the cephalon longer in proportion to the width. One specimen of *Nileus perkinsi* is 25 mm. long and 35 mm. wide, while Billings gives the measurements of one of his specimens as 9 lines long and 17 lines wide. According to Billings' figure the anterior portion of the cephalon of *N. scrutator* is abruptly incurved, while the axial portion of the cephalon of the species here described is almost flat. Both *Nileus macrops* Billings and *N. affinis*

Billings have the eyes much larger and placed further forward than in our species. (See Paleozoic Fossils of Canada, Vol. 1, pp. 273–275, figs. 259–261, and Paleontology of Minnesota, Vol. III, pt. II, p. 712, figs. 17–19.)

Locality.— Both specimens are from the buff dolomite at Isle La Motte, Vermont. The species is named for Professor George H. Perkins, the eminent Geologist of the State.

Isotelus platymarginatus sp. nov.

Plate XXXIV, fig. 4; plate XXXVII, figs. 2–5; plate XXXIX, fig. 3.

This species differs from *Isotelus harrisi* in having a very wide concave border on the pygidium, and a narrower cranidium. The type is a small specimen collected by Prof. Perkins in the "buff" material at Isle La Motte, Vermont, and is in the Vermont University Museum.

Genus *VOGDESIA* nov.

Similar to *Nileus*, but with smaller eyes, more definite dorsal furrows, and the median pustule behind the eyes. Type, *Isotelus? bearsi* Raymond.

Vogdesia bearsi Raymond.

Plate XXXII, figs. 21–24; plate XXXIX, figs. 10–12.

Isotelus bearsi Raymond, 1905. Annals Carnegie Museum, Volume III, p. 345, pl. 10, figs. 21–25.

When first described this species was referred with doubt to the genus *Isotelus*, but the species is so different from the typical forms of that genus that a new genus has been created for it. The characters on which the genus is based are the dorsal furrows, the incurved frontal margin, and the stalked eyes of the cephalon.

Description.

Cephalon broad, smooth, flattened on top, with abruptly rounded slopes. Cranidium smooth, flattened, marked by two deep dorsal furrows as in *Illænus*. These furrows start back of the eyes, run inward and around close to the base of the eye stalks, then outward again to the margin. Indistinct glabellar furrows can sometimes be seen, and on casts of young individuals are four pairs of faint depressions.

Eyes large, raised high above the surface of the head on stalks. Free cheeks relatively small, nearly reaching each other around the front of the head by long spiniform projections. Genal angles rounded. Around the margin of the free cheeks is an extremely narrow striate border.

Thorax unknown.

Pygidium almost semicircular, very evenly convex, with the axis only faintly indicated. There are slight traces of ribs on the pleura and a flattened border extends all around. This pygidium somewhat resembles that of *Onchometopus obtusus* (Hall), but it may be distingiushed from that species by the absence of punctæ, the presence of a depressed border, and by the entire frontal margin.

Measurements.—A cranidium: length 15 mm.; width between tips of free cheeks 22 mm.; between bases of eyes 8.5 mm. Another cranidium is 21 mm. long. The eyes stand 5 mm. above the surface of the cranidium or a total height of 12 mm. above the lateral margin of the cephalon. One pygidium is 11 mm. long and 16 mm. wide, while another is 21 x 27 mm.

Locality.—Found only in the trilobite layers in Sloop Bay, Valcour Island, New York, in the middle of the Chazy.

Family ILLÆNIDÆ.

Genus *ILLAENUS* Dalman.

Illænus punctatus Raymond.

Plate XXXV, fig. 10.

Illaenus punctatus Raymond, 1905. Annals Carnegie Museum, Volume, III, p. 347, pl. 13, fig. 10.

A rare trilobite in the Chazy is a small *Illænus* with an extremely punctate and wrinkled surface. Of this species the collections afford one whole specimen, four cranidia and one pygidium, but the surface is so characteristic that no confusion should arise from a description of this small amount of material.

Description.

Cephalon.—Cranidium small, regularly rounded and abrupt in front. Dorsal furrows short and faint, turning out slightly at the anterior end. Eyes small, situated well back and far apart. Surface very punctate with the exception of two small spots between the anterior ends of the dorsal furrows of the eyes. These are smooth. The front slope is covered with fine concentric wrinkles, between which are rows of punctæ.

Thorax of nine segments which are very narrow and turn down and a little backward at the sides, but are straight and flat on the dorsal region of the pleura. Axis strongly convex and about one-third the width of the thorax. It

tapers very gradually, and in our specimen is 4.5 mm. wide at the end of the thorax, and 4 mm. wide at the pygidium, thus losing only .5 mm. in a length of 6.75 mm. Surface punctate.

Pygidium almost semicircular, gently convex. Axis is defined for a short distance, but is not prominent. Surface covered with very numerous shallow punctæ.

In the complete specimen the pygidium is drawn up at right angles to the axis of the body so that it is hardly visible from the dorsal aspect. It can not be determined from our material whether this is the natural position, or whether it may be due to crushing. The cephalon is distorted, making one eye appear much more prominent than it should, while the other is removed. The entire specimen is 14 mm. long and 12 mm. wide at the genal angles. The cephalon is 7.5 mm. long and the thorax and pygidium, if flat instead of being drawn up, would make the total length 19 mm.

Locality.—This species has been found only in the middle Chazy at Crown Point and Valcour Island, New York.

Subgenus Thaleops Conrad.

Thaleops arctura (Hall).

Plate XXXV, fig. 5.

Illænus arcturus Hall, 1847, Paleontology of New York, Volume I, page 23, plate 4 bis, figure 12.

Illænus arcturus Emmons, 1855, American Geology, Volume I, part 2, page 235, plate 3, figure 12.

Illænus arcturus Billings, 1859, Canadian Naturalist and Geologist, Volume IV, page 379.

Illænus ovatus Raymond, 1902, Bulletin American Paleontology, Volume III, number 14, plate 18, figure 9.

Thaleops ovata Raymond, 1905. Annals Carnegie Museum, Volume III, p. 352, pl. 13, fig. 5.

Thaleops arctura Raymond and Narraway, 1908. Annals Carnegie Museum, Vol. IV, p. 248, pl. LXI, fig. 8.

Description.

Whole animal short and wide. Both cephalon and pygidium very broadly rounded.

Cephalon very broad, abruptly deflected in front with the free cheeks produced into long lateral spines.

Glabella outlined by broad deep furrows which run about parallel from the posterior margin half way to the front, then turn outward and downward over the front of the cephalon. These dorsal furrows are especially deep and strong on the cast. On the front of the horizontal part of the glabella are two slight elevations outlined by indistinct furrows, indicating the position of the first pair of glabellar furrows. Neck furrow visible on the cast, but only seldom seen on the test. Fixed cheeks moderately convex. Eyes rather small, situated high on stalks which extend outward and upward at an angle of about 45°. Free cheeks drawn out into long narrow spines. All around the front is a very narrow striate margin. Surface punctate.

Thorax of ten narrow segments which run nearly straight across the body, turning downward and backward on the sides. Axis about one-third the width of the dorsal surface and only moderately convex, while the pleura are nearly flat. Segments sparsely marked with punctæ which are arranged in straight lines across the thorax, one or two rows to a segment. They are more noticeable on the first two or three segments than on the ones further back.

Pygidium.—Pygidium short and wide, gently rounded posteriorly. Axis high, extending about half way to the posterior end and outlined all around by a deep furrow. On the cast the posterior end of the axis is faintly bilobed, and back of it is a shallow groove extending over the posterior slope to the margin. On one specimen the cast shows a ridge in place of this groove. Surface covered with shallow punctæ.

Measurements.—Whole specimen: length, 30 mm.; greatest width at outside of tip of free cheek spines, 41 mm. Width front end of thorax, 26 mm. Width of front of glabella, 12 mm. Glabella, at neck ring, 7 mm. wide. Width between eyes, 29 mm. Between bases of eye stalks, 19 mm. Height of front glabella, 10 mm. Length of thorax, 9 mm. Length of cephalon, 11 mm. Pygidium, 10 mm. long. Width of axis at cephalon, 10 mm. Axis at pygidium, 8 mm. wide. Length of axis on pygidium, 5 mm.

A large cranidium: width between bases of eyes, 31 mm.; length, 21 mm. Width of glabella: 12 mm. at neck ring; 17 mm. in front.

Another pygidium: width at front, 23 mm.; greatest width, 27 mm.; length, 16.5 mm.; axis, 8 mm. long.

In the last paper cited above it was shown that *Thaleops arctura* differed from *T. ovata* in having longer and more angular genal spines, and more elevated eye-stalks.

Locality.—The species is very common at Crown Point, Valcour, Valcour Island, Chazy, New York, and Isle La Motte, Vermont.

Subgenus Bumastus Murchison.

Bumastus globosus (Billings).

Plate XXXV, figs. 6, 7.

Illænus globosus Billings, 1859, Canadian Naturalist and Geologist, Volume IV, page 367, figures 1–3.
Illænus globosus Billings, 1863. Geology of Canada, p. 133, figs. 64 a–c.

This little species is very common in the Chazy of the northern part of the Champlain Valley, especially in the reef material where there are pockets which consist almost entirely of the separated head and abdomen shields of this one trilobite. The axis of the thorax is very wide and the pygidium smooth and undifferentiated like *Bumastus*. The head, however, shows fairly strong, though short dorsal furrows, and the furrows on the thorax, while very far apart, are deeply impressed.

Description.

Cephalon short, broadly rounded, and steeply convex toward the front and at the sides. Frontal margins striate and incurved. Dorsal furrows short, directed obliquely inward, with a slight outward curve at the anterior end. Eyes small, far back, and very far apart. Free cheeks also small, steeply sloping. Genal angles rounded, extending a little back of the posterior margin of the cranidium. Shell smooth, not punctate. Thorax of ten segments. Axis very wide, dorsal furrows deep, and paralleled by ridges, in passing over which the segments turn forward and then backward.

Sides steep and the ends of the segments directed backward. Pygidium regularly rounded, very convex, without any trace of the axis except at the anterior margin. The whole trilobite is oblong, tapering only a little.

Measurements.—A thorax and pygidium: length of thorax, 12 mm.; pygidium, 13 mm. Width of thorax at anterior end, 21 mm. Width of axis, 15 mm. Width of pygidium 19 mm.

A cephalon: length, 10 mm.; width, 14 mm. Width between eyes, 11.5 mm. Distance of back of eyes from posterior margin, 1 mm.

Another cephalon: length, 30 mm.; width of cranidium, 44 mm.

Another is 18 mm. long, cranidium, 22 mm. wide.

Locality.—Very common at Chazy, Valcour Island, Plattsburgh, and Crown Point, New York, and on Isle La Motte, Vermont.

Bumastus erastusi Raymond.

Plate XXXV, figs. 8, 9.

Illænus crassicauda? Hall, 1847, Paleontology of New York, Volume I, page 24, plate 4 bis, figure 13. Not *Illænus crassicauda* Hall, 1847, Paleontology of New York, Volume I, page 229, plate 60, figures 4 *a-d*.
Illænus erastusi Raymond, 1905. Annals Carnegie Museum, Volume III, p. 351, pl. 13, figs. 8, 9.

All the specimens in our collection are of separated head and abdomen shields. No complete specimens have, as yet, been found.

DESCRIPTION.

Cephalon large, nearly semicircular, the genal angles obtusely rounded but extending somewhat behind the posterior margin of the glabella. Glabella smooth, not differentiated. Dorsal furrows far apart, joining the neck furrows, which are visible only back of the eyes. The dorsal furrows run forward and approximately parallel, for a short distance, then turn outward and fade out after reaching three-quarters of the distance to the anterior margin. In the course of each, about half way between its anterior end and the margin, is a small pit, and to this pit the dorsal furrow is connected by an almost imperceptible depression in the surface.

The eyes are large, situated well to the sides and far back. Free cheeks large, extending a little back of the posterior margin of the cranidium, bearing no spines, but having a very narrow convex border. The anterior border of the cephalon is striate or wrinkled for some distance back from the anterior margin and thickly sprinkled with fine punctæ.

Thorax unknown

Pygidium.—Pygidium larger than the cephalon, uniformly convex, the only trace of the axis being on the anterior margin. Surface covered by very fine punctæ.

Measurements.—A cephalon; length, 21 mm.; width, 40 mm. Length of furrows, 14 mm., width between posterior ends of furrows, 18 mm. Width between eyes, 24 mm.

Cranidium: length, 29 mm.; width, 36 mm.; furrows, 18 mm. long.

A pygidium: length, 29 mm.; width, 30 mm. Another: length, 34 mm., width, 37 mm.

Locality.—This species is quite common at Smuggler's Bay, Valcour Island, and at Chazy, New York. It is also very abundant in the collection made by Professor Perkins on Isle La Motte, Vt.

Bumastus limbatus sp. nov.

Plate XXXV, figs. 1, 2.

Illænus indeterminatus Raymond, non Walcott, 1905. Annals Carnegie Museum Volume III, p. 347, pl. 13, figs. 1, 2.

This species was first identified as *Illænus indeterminatus*, a species which had never been adequately figured, but when Mr. Narraway found specimens of the real *I. indeterminatus* in the Black River, it was at once seen that there were important differences between the two species. The dorsal furrows of *B. limbatus* are much less arcuate than those of *B. indeterminatus*, and the free cheeks in the former species are drawn out into broad spines, while in the latter species the genal angles are rounded.

DESCRIPTION.

Cephalon more than twice as wide as long, the free cheeks extended as broad genal spines. Surface only moderately convex, sloping gradually to the front. The dorsal furrows start back of the eyes on the fixed cheeks, run inward and almost parallel to the posterior margin for a short distance, then turn forward, and, after passing the middle of the length of the cranidium, turn outward, reaching to the striate portion of the convex margin. Eyes very large and depressed, situated far apart and some distance from the margin. Free cheeks large, extending back of the posterior margin of the cranidium as broad genal spines. The whole border is marked by four or five deep furrows which start at the sides and extend around the front.

Thorax and pygidium unknown.

Measurements.—A cranidium: length 53 mm.; width 78 mm.; width between eyes 74 mm. A smaller cranidium: length 36 mm.; width 52 mm.

Locality.—This species is rare, and has been found only in the buff dolomite of the reef at Smuggler's Bay, Valcour Island and at the same horizon on Isle La Motte, Vermont.

Family PROETIDÆ Barrande.

Genus *PROETUS* Steininger.

Proetus clelandi Raymond.

Plate XXXV figs. 13, 14.

Proetus clelandi Raymond, 1905. Annals Carnegie Museum, Volume III, p. 354, pl. 13, figs. 13, 14.

DESCRIPTION.

Cephalon.—Glabella strongly convex, abrupt in front and at the sides. There are two pairs of very faint glabellar furrows, the posterior pair a little longer and deeper than the anterior pair. Margin in front of the glabella narrow and concave. Neck segment narrow and convex, with a deep furrow separating it from the glabella. There is a small tubercle on the middle of the ring. Eye lobes small, and far back. Free cheeks missing.

The following are the measurements of the best specimen. Cranidium: length, 10.5 mm.; width between eyes, 8 mm.; length of glabella, 8 mm.; width of concave border, 2 mm.

This species differs from *Proetus parviusculus* Hall by showing glabellar furrows and in the presence of a tubercle in the neck ring. The general shape of the glabella is about the same. It somewhat resembles *Proetus latimarginatus* Weller from the Trenton of New Jersey, but the glabellar furrows are not so deep and it has only two instead of three pairs.

Locality.—In a coarse reddish limestone at Chazy, New York.

Family LICHADIDÆ Barrande.

Genus *LICHAS* Dalman.

Subgenus AMPHILICHAS Raymond.

Amphilichas minganensis (Billings).

Plate XXXVI, figs. 1–3; plate XXXIX, fig. 14.

Lichas minganensis Billings, 1865, Palæozoic Fossils Canada, Volume I, page 181, figure 163 *a-b*.
Lichas champlainensis Whitfield, 1881, Bulletin American Museum Natural History, volume I, number 8, page 342, plate 33, figures 6–8.

In the absence of a complete specimen of either of the above species, it may seem unwarranted to put the two together, but there seems to be sufficient evidence that there is but one species commonly met with in the Chazy, and as all the cephalons belong to Billings' species and all the pygidia to Whitfield's *Lichas champlainensis*, there seems to be a strong probability that the two are one species.

Billings, in 1865, described the glabella of a *Lichas* from the Chazy or Black River limestone of Large Island in the Mingan Islands. Whitfield, in 1881, described a pygidium from the Birdseye limestone (now known to be dolomite layers of the Chazy) at Isle La Motte, Vermont. The glabellæ are very commonly met with at Valcour Island, Chazy and elsewhere, and, although there is some variation, due to the state of preservation, all can be readily referred to *L. minganensis*. Pygidia are not so common and there is more variation, but there are specimens from the buff-colored layers, at Chazy, which correspond exactly to Whitfield's figures, and, in this locality, they are associated with glabellæ which correspond with Billings' description of *L. minganensis*.

The name *Platymetopus* Angelin being preoccupied, Professor Reed proposed *Paralichas* to replace it. That name also having been previously used, the writer has suggested *Amphilichas*. (American Journal of Science, Vol. XIX, p. 377, 1905.)

DESCRIPTION.

Cephalon.—Only the glabella and fixed cheeks are known, the free cheeks and eyes not having, as yet, been found. Whole head quite convex, sharply deflected in front. Median lobe nearly rectangular posteriorly, but expanding rapidly in front. Neck ring nearly flat, quite broad back of the middle lobe, but becoming narrower at the sides. Along the anterior edge is a flat border which is very narrow in front of the middle lobe but becomes wider in front of the side lobes. The entire surface is covered with variously sized pustules.

Thorax.—Unknown.

Pygidium broad and flat, with strongly elevated axial lobe, which is broad at the anterior end, tapers slightly for a short distance, and is then reduced rapidly to a point. The axis always shows two strong annulations and sometimes two faint ones. There are three broad lobes on each side of the axis. They are directed backward and have free terminations. Each lobe has a deeply impressed line which extends back about half its length. These lines are not very conspicuous on the two posterior lobes. Surface entirely covered with small pustules.

The principal variations in the cephalons of this species lie in the width of the middle lobe, which is narrow on some forms and wide on others, and in the size of the pustules on the surface. On some specimens the pustules are fine, even, and inconspicuous, while on others there are large and small ones, making a pretty and showy ornamentation.

The pygidia vary in the number of annulations on the axis, and in the width and convexity of the axis, relative to the rest of the pygidium. In some, the cross section of the axis would be about semicircular. Others are more flattened and diminish more abruptly posteriorly.

Hypostoma.—The hypostoma found constantly associated with this species is shown on plate XXXVI, figure 3.

Measurements.—A cranidium: 20 mm. long; 26 mm. wide.

Middle lobe 7 mm. wide behind; 15.5 mm. wide in front. Second lobes, 7 mm. wide.

Another cranidium: length 15.5 mm.; width 24 mm.; middle lobe 5 mm. wide behind; 13.5 mm. wide in front.

A pygidium: length 8 mm.; width 11.5 mm.; axis 5 mm. long.

Another pygidium: length 16 mm.; width 22 mm.; axis 9 mm. long.

Locality.—Occurs in middle and upper Chazy on Valcour Island, also at Chazy and Cooperville, New York; Isle La Motte, Vermont; Montreal and Mingan Islands, Canada.

Family ACIDASPIDÆ Barrande.

Genus *CERATOCEPHALA* Warder.

Ceratocephala narrawayi sp. nov.

Plate XXXIX, fig. 15.

In a fragment of limestone from the middle Chazy at Chazy, New York, was found a minute glabella of a species of *Ceratocephala*. This is of particular interest as it is the only representative of this genus as yet definitely known to have been found in the American Ordovician. This little specimen belongs to a species very closely related to *Ceratocephala coalescens* van Ingen, a species found in the Silurian limestone at St. Clair Spring, near Batesville, Arkansas. (See School of Mines Quarterly vol. XXIII, 1901, p. 48, fig. 11.) The glabella here described differs from that of *C. coalescens* in being slightly shorter and wider and in having the surface covered with minute granules instead of being smooth. The side lobes are not so completely isolated from the median lobe as in that species, and the neck-ring shows a median pustule and two small lateral ones instead of being smooth.

DESCRIPTION.

Cranidium, disregarding the spines, nearly circular in outline, slightly and regularly convex, surface granulose. The second pair of glabellar furrows turn backward parallel to the axis of the glabella and divide it into three longitudinal ridges, the central one large, expanding toward the front, and reaching nearly to the anterior margin of the cranidium. The side lobes are small, reniform, the third pair of furrows being represented only by pits so that lobes two and three are coalescent. The fixed cheeks are small and convex, the suture cutting close to the glabella. The neck furrow is narrow and deep, and the neck-ring rather wide. It bears two long widely divergent spines whose bases are separated. There are also two lateral pustules and a median pustule on the dorsal surface of the ring.

The crandium, without the spines, is 1.5 millimeters long and the most perfect spine is of about the same length.

Locality.—McCullough's sugar-bush, Chazy, New York.

Genus *GLAPHURUS* Raymond.

Glaphurus pustulatus (Walcott).

Plate XXXVI figs. 4–6; plate XXXIII, fig. 9-11.

Arionellus pustulatus Walcott, 1877, Advance Sheets Thirty-first Annual Report New York State Museum Natural History, page 15.

Arionellus pustulatus Walcott, 1879, Thirty-first Annual Report New York State Museum Natural History, page 68.

Sao (?) Lamottensis Whitfield, 1881, Bulletin American Museum Natural History, volume I, page 334, plate 33, figures 9–11.

Agraulos (Arionellus) pustulatus Vodges, 1890, Bibliography of Paleozoic Crustacea from 1698 to 1839. Bulletin United States Geological Survey, number 63.

Glaphurus pustulatus Raymond, 1905. Annals Carnegie Museum, volume III, p. 357, pl. 14, figs. 4–6.

DESCRIPTION.

Cephalon broad, roughly semicircular, spinose; cranidium large, extending nearly the whole width of the cephalon and terminating anteriorly in a sort of ring-shaped projection on which are five long slim spines which point forward and upward at an angle of about forty-five degrees. Fixed cheeks prominent, convex, sloping rapidly to the sides. Glabella very convex, separated from the fixed cheeks by a deep furrow which extends around the front and makes a little more than half a circle. The anterior pair of glabellar furrows are short and directed a little backward, making only a sort of a dent in the side of the glabella near the front. Back of these furrows there is, on each side, a pit parallel to the axis of the glabella, making two small convex side lobes. Over the fixed cheeks and glabella are scattered spines of different sizes. On the top of the glabella and close to the axis are two rows of large spines, three in each row. On each fixed cheek is a row of large spines parallel to the furrow outlining the glabella. There are three or four spines on each side. Interspersed with these are a large number of smaller spines, all pointing upward and forward.

The neck furrow extends all across the cranidium and the neck segment is narrow and convex. At each lateral angle is a long thin spine which extends out horizontally and turns a little backward.

Free cheeks large, with a narrow, convex border, which bears numerous small spines. At the genal angle the cheek bears a short, robust backward-directed spine. The whole surface of the free cheek is covered with small spines or pustules and between them are minute pits. The eyes are small, situated some distance from the glabella and about opposite the anterior pair of glabellar furrows.

Thorax.—The best specimens in the collection have only eleven segments in the thorax, but all are small, and it is possible that larger individuals would show more segments. Axis very convex, prominent, occupying more than one-third of the width. Each segment bears, on each side of the axis, near the dorsal furrows, a node with three small spines, and along the top of the axial lobe are numerous small spines. In removing the matrix from the specimen, the shell is almost always broken from the axis of the thorax and only one specimen shows any other than a smooth condition of the segments along the axial lobe.

The pleura are narrow and flat. The first segment ends in sharp spines which are directed backward, but the succeeding ones seem to be rather rounded on the ends and each bears three nearly horizontal spines, two of them short and one very long.

Along the front of each segment on the pleura is a narrow raised border which becomes stronger toward the sides. On it are upward pointing spines, and at the side of the pleuron it supports two small, nearly horizontal spines. Back of this ridge is a narrow groove, behind which is another ridge which bears numerous large spines which point upward but ends in a large horizontal spine at the side which points a little backward.

Pygidium very small, semicircular; axis prominent, extending to the posterior border. Margin entire, a narrow convex border ornamented with small spines running all around. The axis shows two or three annulations, and behind the last annulation are rows of very small spines which run over the axis parallel to the annulations. Side lobes covered with small spines, and show two to four pairs of faint ribs.

Measurements.—A cranidium and six segments: length 19 mm.; length crandium 10 mm.; width 17 mm.; length of glabella 7 mm.; width glabella 7 mm.; eye 5 mm. from posterior margin; 3 mm. from glabella. Length of the horizontal spine on 5th segment 4 mm.; spine from neck segment 3.5 mm.; a spine on middle of front of cranidium 2.5 mm.; a spine on side of cranidium 3 mm.

This species became so well known under its very appropriate name of *lamottensis* that it is with great reluctance that we change it back to the less known but earlier specific name, *pustulatus*.

On plate, XXXVIII, figure 10, is depicted the largest and finest specimen of this species that the writer has yet seen. It was found by Professor Perkins on Isle La Motte, and is of especial importance as it is the only specimen which has so far come under my observation which retains the free cheeks. The course of the suture as shown by this specimen indicates that the species belongs to the *Acidaspidæ*, but the remainder of the animal is so unlike the other members of this family that it seems best to elevate *Glaphurus* to generic rank, rather than to consider it as a subgenus as was done in my previous paper.

Locality.—The species occurs both in the reef material and in the coarsely crystalline limestone which accompanies it at Valcour Island, Sloop Island, Chazy, Cooperville, N. Y., and Isle La Motte, Vt.

Order PROPARIA Beecher.

Family *ENCRINURIDÆ* Linnasson.

Genus CYBELE Loven.

Cybele prima Raymond.

Plate XXXVI, figs. 7–9.

Glaphurus primus Raymond, 1905. Annals Carnegie Museum, Volume III, p 362, pl. 14, figs. 6, 7.
Cybele valcourensis Raymond, 1905. Annals Carnegie Museum, Volume III, p. 362, pl. 14, fig. 9.
Cybele prima Narraway and Raymond, 1906. Annals Carnegie Museum, Volume, III, p. 601.

The writer has already explained how he was led to describe the cranidia and free cheeks of this species as a species of *Glaphurus*, and how the fortunate discovery of a nearly complete specimen of a *Cybele* by Mr. Narraway gave us our first knowledge of the glabella of the American species of that genus.

DESCRIPTION.

Cephalon.—Cephalon short, broad, with glabella outlined by a narrow but deep furrow. Glabella moderately convex, having on a general view a central lobe which expands toward the front, and two small side lobes. This appearance is caused by three pairs of glabellar furrows, all of which are short and turn backward. The second pair run back into the third pair, and the third pair join the neck furrow. The surface is spinose but has fewer spines than *Glaphurus pustulatus*. The fixed cheeks are very convex. Free cheeks convex, the eye small but prominent. There is a convex spinose border which is separated from the cheek by a narrow furrow and at the genal angle is a large spine. The surface of the cheek is pitted all over except just below and a little in front of the eye where there is a group of small spines.

Pygidium narrow, tapering almost to a point. Axis narrow, but very prominent, not extending to the posterior end. The first annulation of the axis extends clear across, and behind it are fifteen to eighteen which show only on the sides. Along the top of the axis are four or five pairs of nodes which are located at equal intervals along its length. There is a single median protuberance at the posterior end of the axis. On the pleura are four pairs of double ribs which turn back nearly parallel to the axis. Each double rib consists of a smaller anterior and larger posterior portion. The ribs end in short rounded spines which extend only a very short distance behind the border and, when the spines are broken, as is often the case, the margin appears as if entire. Up near the axis each rib bears a small node.

Measurements.—Three pygidia:

1. Length 4.5 mm.; width 3.75 mm.; length of axis 3.5 mm.
2. Length 3.75 mm.; width 3 mm.; axis 3 mm. long.
3. Length 6 mm.; width 5 mm; axis 4.75 mm. long.

From *Cybele mirus* (Billings,) this species differs in being more slender and in having only one annulation, instead of fourteen, extending across the axis.

To *Cybele winchelli* Clarke, our species is very closely related, but it has evidences of a great many more annulations on the axis than are shown by that species.

Locality.—This species has been found only in the lower Chazy at Valcour Island, N. Y. It should also be found on the southern end of Isle La Motte.

Family CHEIRURUIDÆ Salter.

Genus *PLIOMERA* Angelin.

Subgenus PLIOMEROPS Raymond.

Pliomerops canadensis (Billings).

Plate XXXVI, figs. 10–13; plate XXXVIII, fig. 14.

Cf. *Calymene multicosta* Hall, 1847, Paleontology of New York, Volume I, page 228, plate 60, figure 3.
Amphion canadensis Billings, 1859, Canadian Naturalist and Geologist, volume IV, page 381, figure 12, *a*, *b*.
Amphion canadensis Billings, 1863, Geology of Canada, page 133, figure 69.
Amphion canadensis Billings, 1865, Paleozoic Fossils Canada, Volume I, page 288, figure 278.
Pliomerops canadensis Raymond, 1905. American Journal of Science, volume, XIX, p. 377.

Pliomera fischeri, the type of the genus *Pliomera*, differs from nearly all of the other species usually referred to the genus *Amphion* in having a median indentation or furrow in the front of the glabella. The cephalon of that species also has a denticulate frontal border, while the other species have smooth borders. For these reasons the writer has in the paper cited above, erected a new subgenus with *Amphion canadensis* as the type.

Pliomerops canadensis is probably another trilobite that was first described from Vermont. Hall described as *Calymene multicosta* a specimen obtained from Isle La Motte. The specimen was unfortunately so poorly preserved that it is not safe to say that it was this species, but no other has yet been found in the Chazy with as many thoracic segments as are depicted in Hall's figure.

DESCRIPTION.

Cephalon wide, short, rather uniformly convex. Glabella gently convex, broadly rounded in front. There are three pairs of glabellar furrows, the first pair being very close to the anterior margin and not very deeply impressed. They vary in direction on different specimens, sometimes running somewhat forward, while, in other specimens, they are curved backward. The second and third pairs run very nearly perpendicular to the axis and about half way to the center of the glabella. Fixed cheeks large, including the genal angles which are rounded and without spines. Free cheeks small. Eyes prominent, opposite the second glabellar lobes and situated at a distance from the glabella equal to about their own width. The entire cephalon is surrounded by a wide, convex border which is outlined by a deep furrow. Surface granular.

Thorax.—There are nineteen thoraic segments. The axis occupies about one-third the width of the thorax and tapers very gradually toward the pygidium. The trilobite is widest at the posterior angles of the cephalon, but tapers only a little posteriorly. The pygidium forms almost a semicircle. On the axis the segments bend forward very considerably, while on the side lobes their course is almost perpendicular to the axis; at the sides they turn backward and curve sharply downward.

Pygidium.—The pygidium is nearly semicircular, convex, steep at the sides and back. Axis of medium width, with six annulations, the last triangular. There are five ribs on each side, extending, as spines, beyond the margin. These spinose terminations are quite close together, the spaces being of less width than the spines.

Measurements.—Largest specimen: length, 78 mm.; width back of cephalon, 40 mm.; length of cephalon, 18 mm. Eyes 25 mm. apart; 5 mm. from back of cephalon, 4 mm. from glabella. Thorax 48 mm. long. Axis 14 mm. wide at cephalon; 11 mm. at pygidium. Thorax 29 mm. wide at pygidium.

Second in size: length 38 mm.; width back of cephalon 21 mm. Cephalon 9 mm. long. Thorax 25 mm. long. Axis 8 mm. wide at front; 5 mm. at pygidium. Thorax 15 mm. wide at pygidium. Distance between eyes 13 mm. They are situated 2 mm. from the glabella and 2.5 mm. from the posterior margin.

A small specimen: length 31 mm.; width back of cephalon 18 mm. Eyes 12 mm. apart; 2 mm. from glabella; 1.5 mm. from the posterior edge. Thorax 18.5 mm. long. Axis 6.5 mm. wide at cephalon; 4 mm. wide at pygidium. Length of cephalon, 7 mm. Width at front of pygidium, 6 mm.

Localily.—Valcour, Valcour Island, Chazy and Cooperville, New York; Isle La Motte, Vermont; Montreal and Mingan Islands, Canada.

Genus *CERAURUS* Green.

Ceraurus pompilius (Billings).

Plate XXXVI, fig. 14.

Cheirurus pompilius Billings, 1865, Paleozoic Fossils of Canada, Volume I, page 181, figure 162.

The specimen on which this species was founded is so small a fragment that it is with some doubt that we assign our specimens to Billings' species. This is, however, the only species of *Ceraurus* in our collections with a subrectangular glabella and isolated posterior glabellar lobes. Glabellæ of this sort are quite common in the trilobite layers at Sloop Bay, where they accompany the following species, but can always be easily distinguished from it.

Description.

Glabella subrectangular, broadly rounded in front; moderately convex. Three pairs of glabellar furrows; the first two pairs nearly parallel to the neck furrow, while the last pair turn abruptly back, joining the neck furrow. Neck segment wide, separated from the glabella by a deep furrow. Fixed cheeks wide, triangular and bearing the genal spine, which is very long and slightly bowed. Eye small, situated opposite the third glabellar lobe and about 2 mm. from it. Free cheeks small. Whole surface papillose, the pustules being small and thickly scattered over the glabella and cheeks but rather sparingly on the margins and spines, where there are large, smooth intervals.

Measurements.—A cephalon: length 6 mm.; width 19 mm.; length of genal spine, 13 mm.; width of glabella, 5 mm. This is about the average size.

This species is very closely allied to *Ceraurus polydorus* Billings, from Table Head, Portland Creek, Newfoundland, which may account for the fact that the latter species has been listed from Valcour Island, by Brainerd and Seely.

Locality.—Trilobite layers, Sloop Bay, Valcour Island. A single specimen was found on the north end of Sloop Island. It occurs also in the Mingan Islands, Canada.

Ceraurus hudsoni Raymond.

Plate XXXVI, fig. 15.

Ceraurus hudsoni Raymond, 1905. Annals Carnegie Museum, Volume III, p. 367, pl. 14, fig. 15.

Description.

Cephalon.—Glabella broad, prominent, gently convex, expanding considerably toward the front. Glabellar furrows, three pairs, parallel to the neck furrow, the posterior pair turning back to join the neck furrow. Neck segment wide, convex, highest posteriorly. Fixed cheeks large, convex, extended at the genal angles into long spines which appear to be somewhat more divergent than in *Ceraurus pompilius*. Free cheek small. Eyes small, situated opposite the second glabellar lobe and some distance from the glabella. Glabella and cheeks covered with strong pustules of various sizes, many quite large. The genal spines and borders are ornamented with small, distant papillæ.

Thorax and pygidium unknown.

Measurements.—A cephalon: length 8 mm.; width 19 mm.; width of glabella in front, 7.5 mm., behind, 5 mm. Another: length 11 mm.; width 24 mm.; width of glabella in front, 10 mm., behind, 7.5 mm. A third: length 9.5 mm., width 27 mm.

This species is closely related, on one side, to *Ceraurus pompilius* and, on the other, to *Ceraurus pleurexanthemus*. From C. *pompilius* it differs in having the glabella expanded toward the front and in the much larger and more prominent pustules on the surface. From C. *pleurexanthemus* it differs in having the cheeks smaller and more convex, and in having the eye further forward.

Locality.—Trilobite layers, Sloop Bay, Valcour Island.

Subgenus Pseudosphærexochus Schmidt.

Pseudosphærexochus vulcanus (Billings).

Plate XXXVI, fig. 16.

Cheirurus vulcanus Billings, 1865, Paleozoic Fossils Canada, Volume I, page 284, figures 271, *a, b, c*.

Cheirurus prolificus Billings, 1865, Paleozoic Fossils Canada, Volume I, page 285, figure 273; page 325, figures 311, 312.

Description.

Cephalon wide, the glabella very large and convex, the cheeks drooping. Glabella wide, convex, tapering very rapidly toward the front. There are three pairs of glabellar furrows, the first pair short, running a little forward, at first, and then backward; the second pair longer, running in almost perpendicular to the axis a short distance, then turning backward, and then forward again, in a sigmoid curve. The last pair run backward and upward and when nearly to the summit of the glabella, turn backward, and, by a very slight depression, connect with the neck furrow. Fixed cheeks small; free cheeks relatively large. Eyes small, very close to the glabella, and opposite the ends of the posterior pair of glabellar furrows. Entire cephalon bounded by a rather wide convex border. Surface sparsely covered with small tubercles.

Measurements.—Length of cephalon 13 mm.; width 26 mm. Width of glabella behind 13.5 mm. Width of glabella at the first pair of furrows 8 mm. Width between eyes 13.5 mm.

Locality.—The specimen figured was collected by Mrs. Eleanor M. Hudson, who has very kindly allowed me to use the specimen for description. Acidaspis layers, Smuggler's Bay, Valcour Island.

Pseudosphærexochus vulcanus billings, Raymond.

Plate XXXVI, fig. 17.

Cheirurus vulcanus Billings, 1865, Paleozoic Fossils Canada, Volume I, page 324, figure 310 *a*, *b*, *c*. Not *Cheirurus vulcanus* Billings, 1865, Paleozoic Fossils Canada, volume I, page 284, figures 271 *a*, *b*, *c*.
Pseudosphaerexochus vulcanus var. billingsi Raymoud, 1905. Annals Carnegie Museum, Volume III, p. 369, pl. 14, fig. 17.

At Standbridge, where *Cheirurus vulcanus* has been found in the Quebec group, it is accompanied by a variety which Billings figures in the paper cited above. This variety differs from the form just described, in having a narrower and much more elevated glabella, which does not taper so rapidly in front, while the posterior part of the glabella, instead of sloping down to the neck ring, is very high and abrupt, sometimes almost spiniform.

This variety occurs also at Valcour Island, where two specimens have been found by Professor Hudson in the Trilobite layers at Sloop Bay. The whole aspect of the cephalon is so different from the typical form of the species that it will be found convenient to distinguish it by the varietal name, *billingsi.*

Pseudosphærexochus approximus Raymond.

Plate XXXVI, fig. 18.

Pseudosphærexochus approximus Raymond, 1905. Annals Carnegie Museum, Volume III, p. 369, pl. 14, fig. 18.
Cf. *Cheirurus prolificus* Billings, Paleozoic Fossils, Canada, Volume I, plate 285, figure 273.

DESCRIPTION.

Glabella convex, the highest part along the median line. Sides nearly parallel, expanding a trifle toward the front. Broadly rounded in front. There are three pairs of glabellar furrows which are not deeply indented. The posterior pair turn back and run nearly to the neck ring. Neck segment narrow, the furrow in front of it sharp and not deeply impressed. Eye lobe small, situated beside the posterior half of the second glabellar lobe and the anterior half of the third lobe. Fixed cheek small, triangular, and extending to the genal angle. Surface finely papillose.

Measurements.—A cranidium: length 7 mm.; width 13 mm.; width of glabella, 6 mm.

This species differs from *Cheirurus prolificus* Billings, in only two particulars. The glabella of that species tapers toward the front, while, in our species, it is as wide or wider at the front than at the neck segment. The posterior pair of glabellar furrows in C. *prolificus* make a sigmoid curvature, while, in our species, they turn back sharply at their posterior ends.

Locality.—Sloop Bay, Valcour Island.

Pseudosphærexochus chazyensis Raymond.

Plate XXXVI, figs. 19, 20.

Pseudosphærexochus chazyensis Raymond, 1905. Annals Carnegie Museum, Volume III, p. 370, pl. 14, fig. 19, 20.

In certain layers are occasionally found small glabellæ which may, at first glance, be taken for *Sphærexochus parvus,* but a closer examination shows them to belong to the subgenus *Pseudosphærexochus.* All the specimens, so far found, are glabellæ, and all are of small size. They occur mostly in the lower layers of the Chazy, nearly always associated with *Eoharpes antiquatus.*

DESCRIPTION.

Glabella small, very convex, tapering rapidly toward the front. There are three pairs of glabellar furrows, the first two pairs, short, and almost parallel to the neck furrow; the posterior pair slant backward, little at first, but, as they get higher on the glabella, turn abruptly backward and reach nearly to the neck furrow. Surface covered with small papillæ. Neck ring narrow and convex. The largest specimen in the collection differs from the others in having only two pairs of glabellar furrows.

Measurements.—Largest glabella: 6 mm. long, 5 mm. wide. Another is 3 mm. long, 2.5 mm. wide.

This species differs from *Pseudosphærexochus vulcanus* in having a much narrower and convex glabella, and from *P. vulcanus billingsi* by being much more tapering and in having the posterior part of the glabella much less elevated above the neck segment.

Locality.—Rather common in the upper part of the Chazy at Valcour Island and in the lower part at Chazy, New York.

Subgenus NIESZKOWSKIA Schmidt.

Nieszkowski satyrus (Billings).

Plate XXXVI, figure 21.

Cheirurus satyrus Billings, 1865, Paleozoic Fossils Canada, Volume I, page 324 figure 309.

Unfortunately we are in a position to add little to Mr. Billings' description of this species, as it is represented in our collection by only a single individual. The specimen consists of the glabella and a portion of one fixed cheek.

DESCRIPTION.

Glabella very strongly convex, almost conical, and extending into a stout spine which projects vertically a little in front of the neck segment. There are three pairs of glabellar furrows. The posterior pair extends upward to the back of the spine, while the other pairs are shorter and do not turn back so far. Unfortunately the spine was broken off and lost. The neck segment is wide, almost flat, and has a small tubercle on the median line. The fixed cheek is large and coarsely pitted, while the glabella appears to be smooth.

Measurements.—The cephalon of our specimen is 20 mm. long and 38 mm. wide, while Billings' specimen, from Montreal, is only 5 mm. in length.

Locality.—In the coarse, gray limestone on the north end of Sloop Island, east of Valcour Island, New York.

Nieszkowskia mars (Hudson).

Cheirusus mars Hudson, 1905. Bulletin New York State Museum, No. 80, p, 295, pl. 5, figs. 1-2.

DESCRIPTION.

The glabella, the only portion known, is regularly convex, the posterior portion drawn out into a short conical spine which overhangs the neck-ring. The glabellar furrows are convex toward the front throughout their length; the two anterior pairs reach to a little less than one-fourth the distance across the glabella; the middle one is most convex toward the front; the posterior furrow is less bent than the first, reaches about halfway to the apex of the cone and is bent so as to meet its axis at an angle of about 70 degrees. Marginal furrow rounded in front, distinctly angled as it turns to pass along the sides.

This species differs from *Pseudosphærexochus vulcanus billingsi* in the pronounced character of the conical spur, while the spur and the glabellar furrows are very different from those of *Nieszkowskia satyrus.*

Locality.—This species has so far been found only on the eastern side of Valcour Island, New York.

Subgenus HELIOMERA Raymond.

Heliomera sol (Billings).

Plate XXXVIII, figure 12.

Cheirurus sol Billings, 1865. Paleozoic Fossils Canada, Volume 1, p. 288, fig. 276
Heliomera sol Ramond, 1905. American Journal of Science, Volume XX, p. 381,

Cephalon short, wide, the glabella very large and flattened, the cheeks small. Glabella almost semi-circular, with 3 pairs of long narrow glabellar furrows, all of which turn backward on their inner ends, each joining the one back of it, and the third pair joining the neck furrow, thus producing a central lobe like that of *Amphilichas.* This central lobe is of uniform width up to the inner ends of the first pair of glabellar furrows, but turns outward in front of that point. Toward the front of this median lobe there is a slight depression, somewhat similar to that sometimes seen in *Pliomera.* The first pair of glabellar furrows run backward at an angle of about 45°, the second pair at a smaller angle, while the third pair are nearly parallel to the neck furrow. The glabellar lobes are narrow and club-shaped. This radiating arrangement of the glabellar furrows and lobes probably suggested the specific name. The neck ring is wide, flat, and separated from the glabella by a deep furrow, which extends the whole width of the cephalon. The cheeks are not sufficiently well preserved to be described, but enough of the test remains to show that the outline of the cephalon was the same as in *Pseudosphærexochus vulcanus.* There is a narrow, smooth border all around the front of the cephalon, and the surface is covered with fine tubercles. The relations of this species are rather doubtful. From the form of the cephalon it evidently belongs close to *Pseudosphærexochus,* but there has not been seen in species of that genus any tendency to vary in the direction of an isolated central lobe and long isolated glabellar furrows. The glabellar furrows in the various species of *Pseudosphærexochus* are usually faint, never deeply impressed as in this species. In this last character and in the presence of the median depression of the glabella, it recalls *Pliomera.* The glabella is much larger in proportion to the size of the cephalon in *Heliomera sol,* however, and it is probable that this form must be regarded as intermediate between the two genera. For trilobites with this type of glabellar structure the subgeneric name *Heliomera* was suggested.

Locality.—From the Raphistoma layers in the upper part of the Lower Chazy, at Chazy, New York.

Subgenus SPHÆROCORYPHE Angelin.

Spœrocoryphe goodnovi Raymond.

Plate XXXVI, fig. 23; plate XXXIX, figs. 16–18.

Sphœrocoryphe goodnovi Raymond, 1905. Annals Carnegie Museum, Volume III, p. 371, pl. 14, fig. 23.

DESCRIPTION.

Glabella small, the bulbous frontal lobe occupying fully two-thirds of the length. Back of the frontal lobe the two glabellar furrows meet on top, making a complete furrow over the glabella. Behind this are two small glabellar lobes and then the neck furrow, behind which is a narrow neck ring. Fixed cheeks short, triangular, the genal angle produced into a long, round, slightly curved spine. Eye rather large, projecting forward and about opposite the posterior glabellar lobes. Neck furrow extends across the fixed cheeks. Whole surface very finely tuberculated.

Measurements.—A cephalon: length 4 mm.; width 4.5 mm.; length bulbous part of glabella, 2.5 mm.; width 2.5 mm. Another: length 2 mm.; length bulbous part, 1.5 mm.; width 1.5 mm. There are one or two which are a trifle larger than the first one given above.

Locality.—So far the species has been found only in the middle Chazy limestones in Mr. Robert McCollough's sugar bush, a half mile south of Chazy village, New York.

Genus *SPHÆREXOCHUS* Beyrich.

Sphœrexochus parvus Billings.

Plate XXXVI, fig. 22.

Trilobite, genus undetermined. Billings, 1859. Canadian Naturalist and Geologist Volume IV, page 468, figure 37.

Sphœrexochus parvus Billings 1865. Paleozoic Fossils Canada, Volume I, page 180, figure 150.

DESCRIPTION.

Glabella almost globular, length and breadth about equal. There are three pairs of glabellar furrows: the first two pairs faint or not visible at all; the posterior pair deep, curving round to meet the neck furrow, isolating the posterior glabellar lobes. Neck segment narrow and the furrow deeply impressed. Fixed cheeks small, rounded at the genal angles, and with a wide border all around. Eye evidently large, opposite the next to the last pair of glabellar lobes and close to the furrow which outlines the glabella. There is a narrow rim anterior to the glabella. The whole surface is finely tuberculated.

Measurements.—Cephalon: length 3.5 mm.; width 6 mm.; width of glabella, 3.5 mm. Another cephalon: length 3 mm.; width 4mm.; width of glabella, 2.75. A glabella: length 8.5 mm.; width 8 mm.

Locality.—Common all through the Chazy limestone at Chazy, Valcour Island, Valcour, New York and Isle La Motte, Vermont.

Family PHACOPIDÆ Salter.

Genus *DALMANITES* Emmrich.

Subgenus PTERYGOMETOPUS Schmidt.

Pterygometopus annulatus Raymond.

Plate XXXVI, figs. 24, 25.

Pterygometopus annulatus Raymond, 1905. Aneals Carnegie Museum, Volume III, p. 376, pl. 14, figs. 24, 25.

DESCRIPTION.

Cephalon.—Cephalon short, broad, gently rounded, with a very short triangular projection in front of the glabella. Glabella shows three pairs of furrows. Frontal lobe large, sloping gently down to the front. Second pair of glabellar lobes strongly angulated, outlined by deep furrows. Second pair of furrows directed forward at about 30°, short, and the lobes back of them, small. Posterior lobes very small. The posterior part of the glabella differs from that of *P. callicephalus* in being much narrower. Fixed cheeks bear the gena' angles, which are rounded and without trace of spines. Free cheeks small. Eyes large, extending from the neck furrow to the first pair of glabellar furrows.

Thorax.—Total number of thoraic segments not known. Axis high, about one-third the width, tapering gradually. Segments narrow, turning down sharply at the sides. Segments on pleura deeply grooved.

Pygidium.—Pygidium somewhat triangular in some specimens, while others are so broad as to give a rather rounded outline. Axis high, outlined by deep furrows. It tapers somewhat to about the middle of the pygidium, then remains the same breadth to its end. It does not reach to the end of the pygidium and the space behind it is smooth. Axis has from ten to twelve sinuous annulations and the p ura show six to eight ribs which are single for a part of their length and then bifurcate. They reach almost, but not quite, to the margin. In some specimens the ribs bifurcate quite close to the axis, while on others the rib remains single more than one-fourth its length. On some specimens the anterior portion of the rib continues much nearer the margin than the posterior part, thus forming a very characteristic appearance. On the axis are small pits between the annulations, which give a double curve to each side of each annulation. Both cephalon and pygidium are finely tuberculated.

Measurements.—A cephalon: length 8.5 mm.; width 17 mm.; width between eyes, 7.5 mm. Another: length 7 mm.; width 12 mm.; between eyes, 8 mm. A pygidium: length 10 mm.; width 13 mm.; axis 3.5 mm. wide in front. Another 8 mm. long; 10 mm. wide; axis 2.5 mm. wide in front, 6 mm. long.

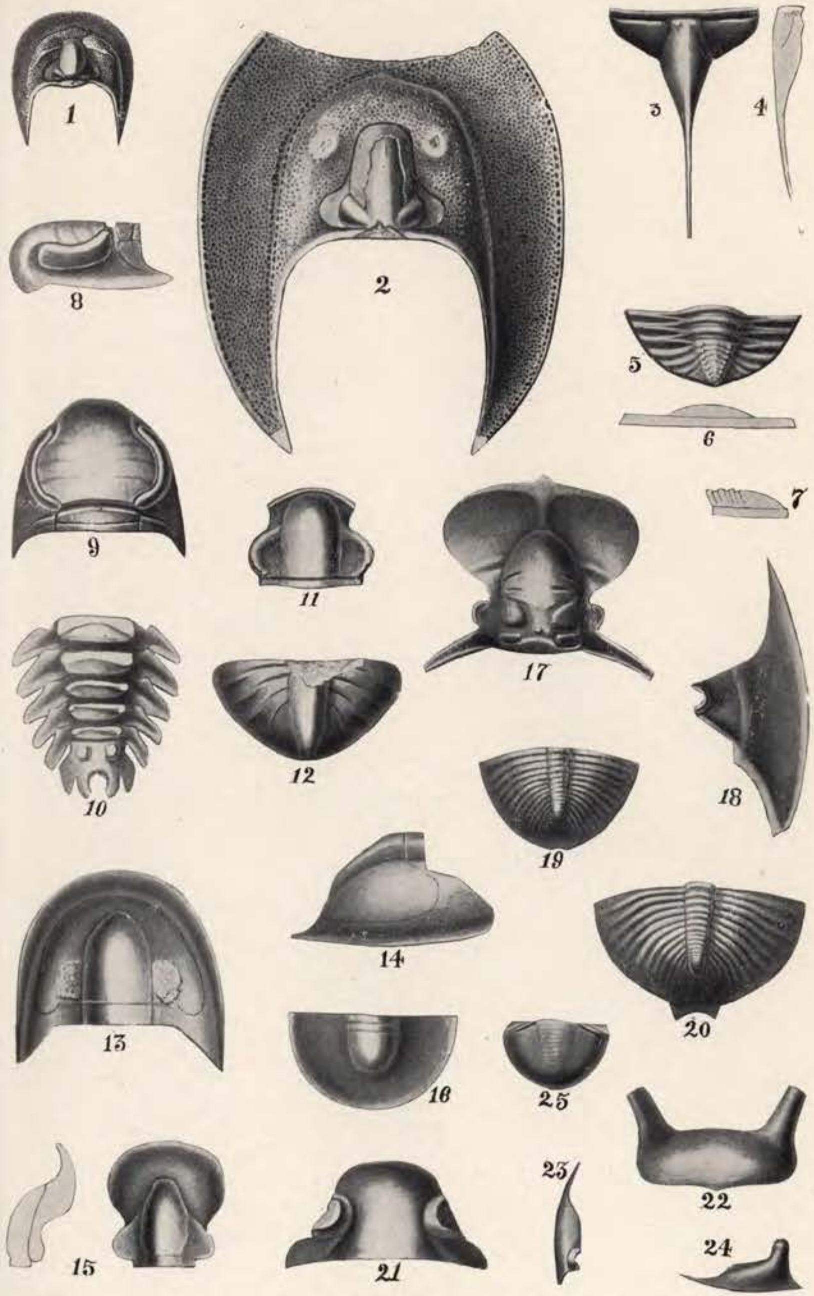
Locality.—All through the Chazy at Valcour Island, New York.

Plate XXXII.

EXPLANATION OF PLATE XXXII.

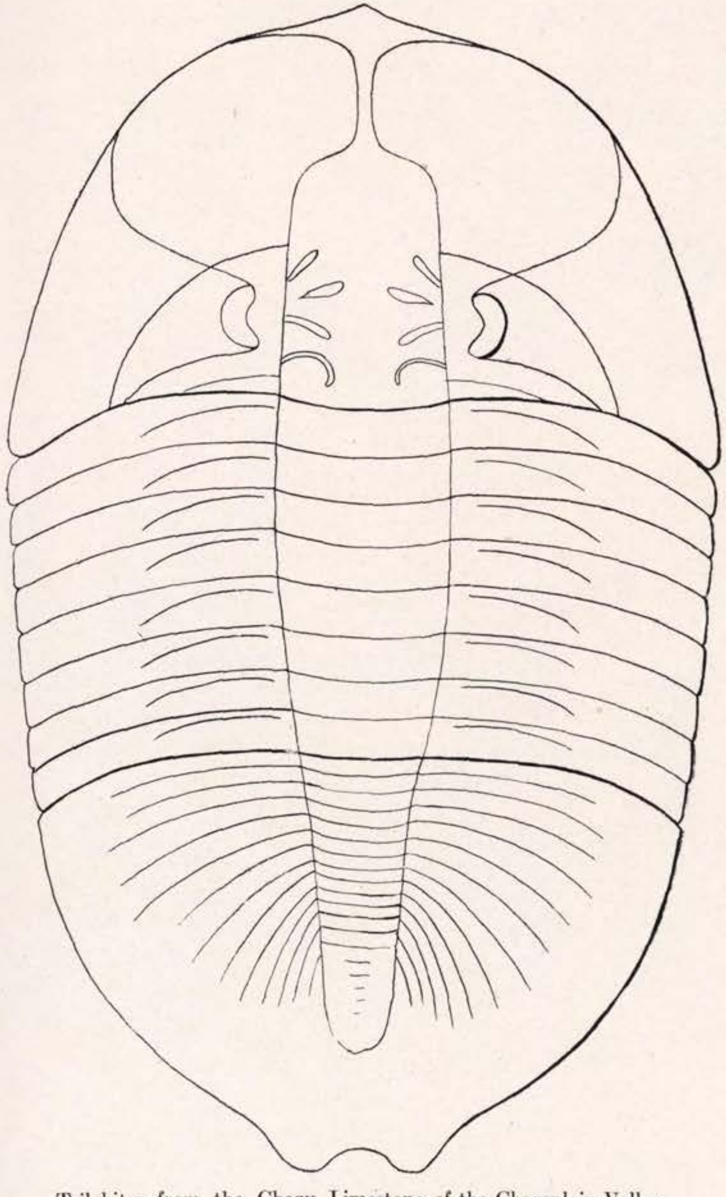
Where not otherwise indicated, the figures are natural size.

1. *Eoharpes antiquatus* (Billings). A cephalon, enlarged two diameters.
2. *Eoharpes ottawaensis* (Billings). An imperfect cephalon, enlarged two diameters.
3. *Lonchodomas halli* (Billings). A cranidium, enlarged two diameters.
4. The same species. Side view of a cranidium, showing upward slope of the rostrum. Enlarged two diameters.
5. The same species. A pygidium and two thoracic segments. Enlarged four diameters.
6. The same specimen, posterior view. Same magnification.
7. The same, side view.
8. *Remopleurides canadensis* Billings. Side view of cephalon, twice natural size.
9. The same specimen, dorsal view. Same magnification.
10. The same species. Pygidium and last five thoracic segments. Four times natural size.
11. *Bathyurus angelini* Billings. A cranidium, enlarged one-third.
12. The same species; a pygidium. Same enlargement.
13. *Bathyurellus brevispinus* Raymond. A cephalon, enlarged two diameters.
14. The same specimen; side view. Same magnification.
15. The same species. Dorsal and profile views of a cranidium, enlarged two diameters.
16. *Bathyurellus minor* Raymond. A pygidium, enlarged four diameters.
17. *Basilicus marginalis* (Hall). A small cranidium.
18. The same species. Free cheek of a somewhat larger individual.
19. The same species. A small pygidium.
20. The same species. A slightly larger pygidium, showing lobes on the posterior end. The drawing is not correctly made, as the lobes on the specimen are rounded and not pointed. See the next plate.
21. *Vogdesia bearsi* Raymond. A cranidium, the eye-stalks broken.
22. The same species. Front view of a larger specimen, showing height of eye-stalks.
23. The same species. Dorsal view of a free cheek.
24. The same specimen, lateral view.



Trilobites from the Chazy Limestone of the Champlain Valley.

PLATE XXXIII.



Trilobites from the Chazy Limestone of the Champlain Valley.

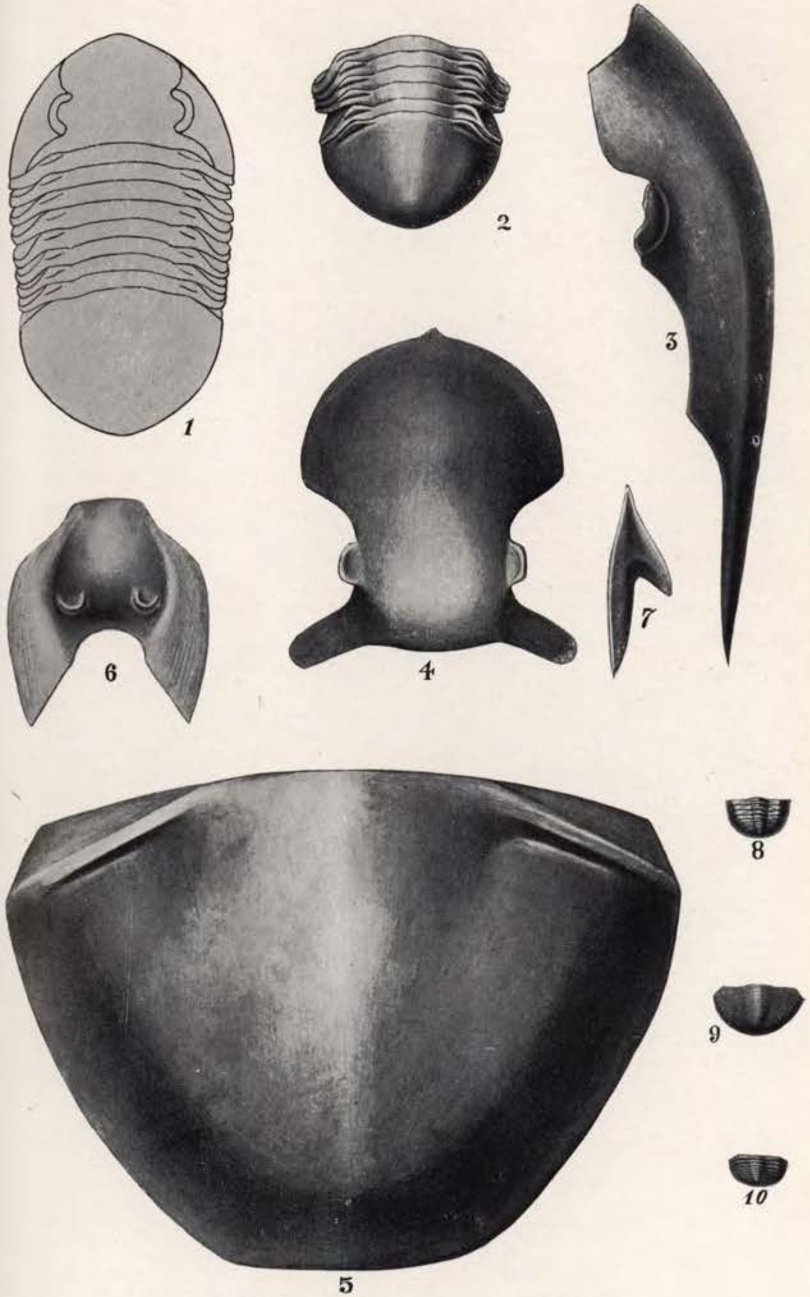
An outline drawing of a restoration of *Basilicus marginalis* (Hall). One half the natural size indicated by fragments in the Carnegie Museum.

Plate XXXIV.

Plate XXXIV.

1. *Onchometopus obtusus* (Hall). Outline of a complete specimen. The axial lobe of the thorax is represented as wider than it really is. See the measurement in the text and the photographs on a later plate.
2. The same species. A pygidium and five thoracic segments.
3. *Isotelus harrisi* Raymond. An imperfect free cheek.
4. *Isotelus platymarginatus* Raymond. A small cranidium.
5. *Isotelus harrisi* Raymond. A large pygidium.
6. The same species. Hypostoma.
7. The same species. Side view of another hypostoma.
8. *Basilicus marginalis* (Hall). Pygidium, enlarged four diameters.
9. *Isotelus beta* Raymond. Pygidium, enlarged two diameters.
10. *Basilicus marginalis* (Hall). Pygidium, enlarged four diameters.

Plate XXXIV.



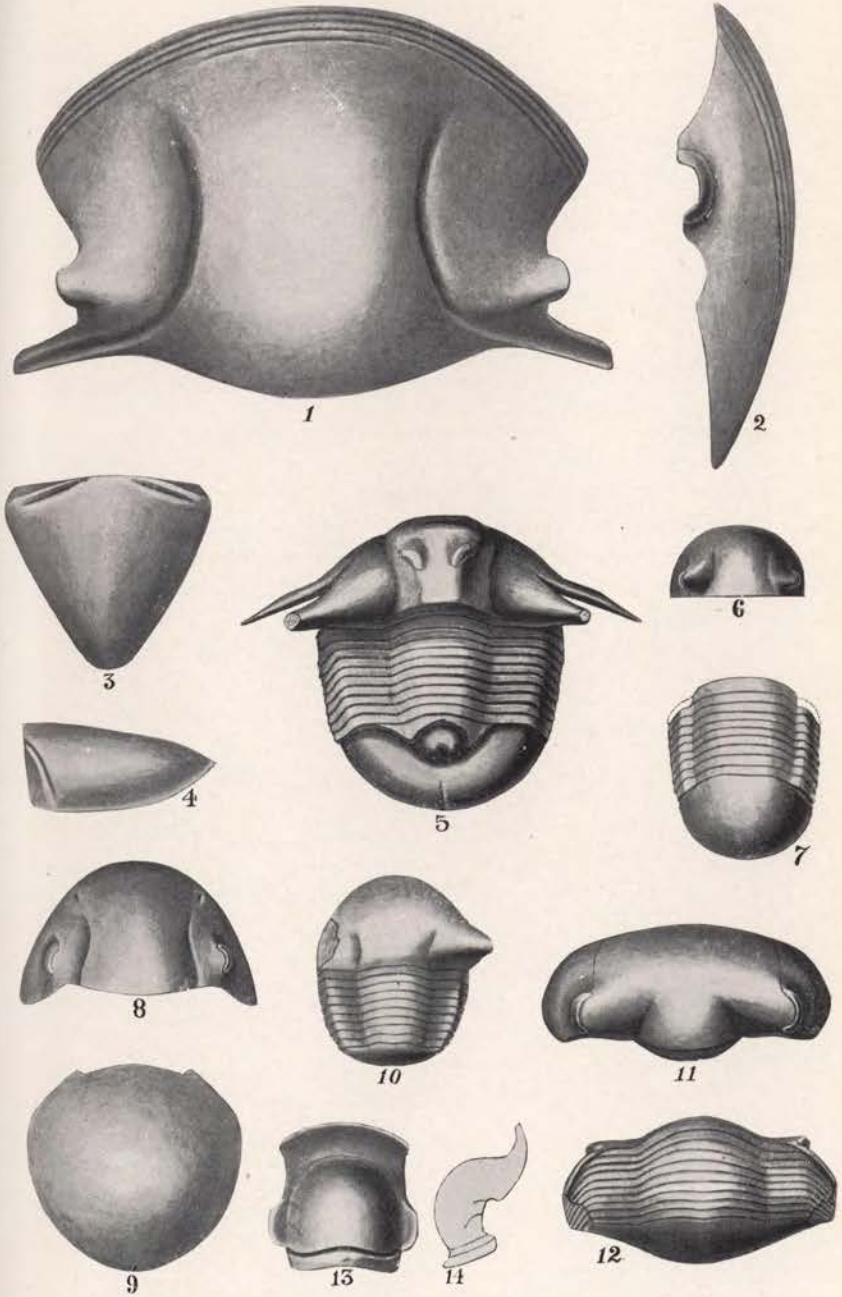
Trilobites from the Chazy Limestone of the Champlain Valley.

Plate XXXV.

PLATE XXXV.

1. *Bumastus limbatus*, Raymond. Cranidium.
2. The same species. A free cheek.
3. *Isoteloides angusticaudus*, Raymond. Pygidium.
4. The same specimen, side view.
5. *Thaleops arctura*, (Hall). Enlarged two diameters.
6. *Bumastus globosus*, (Billings). A small cephalon.
7. The same species. Thorax and pygidium of a larger individual.
8. *Bumastus erastusi*, Raymond. A cephalon of average size.
9. The same species. A pygidium.
10. *Illænus punctatus*, Raymond. A small specimen, the cephalon distorted by pressure. Twice natural size.
11. *Illænus bayfieldi*, Billings. Cephalon of one of the typical specimens.
12. The same specimen. Thorax and pygidium.
13. *Prætus clelandi*, Raymond. Cranidium of the type. Enlarged two diameters.
14. The same specimen. Profile view.

PLATE XXXV.



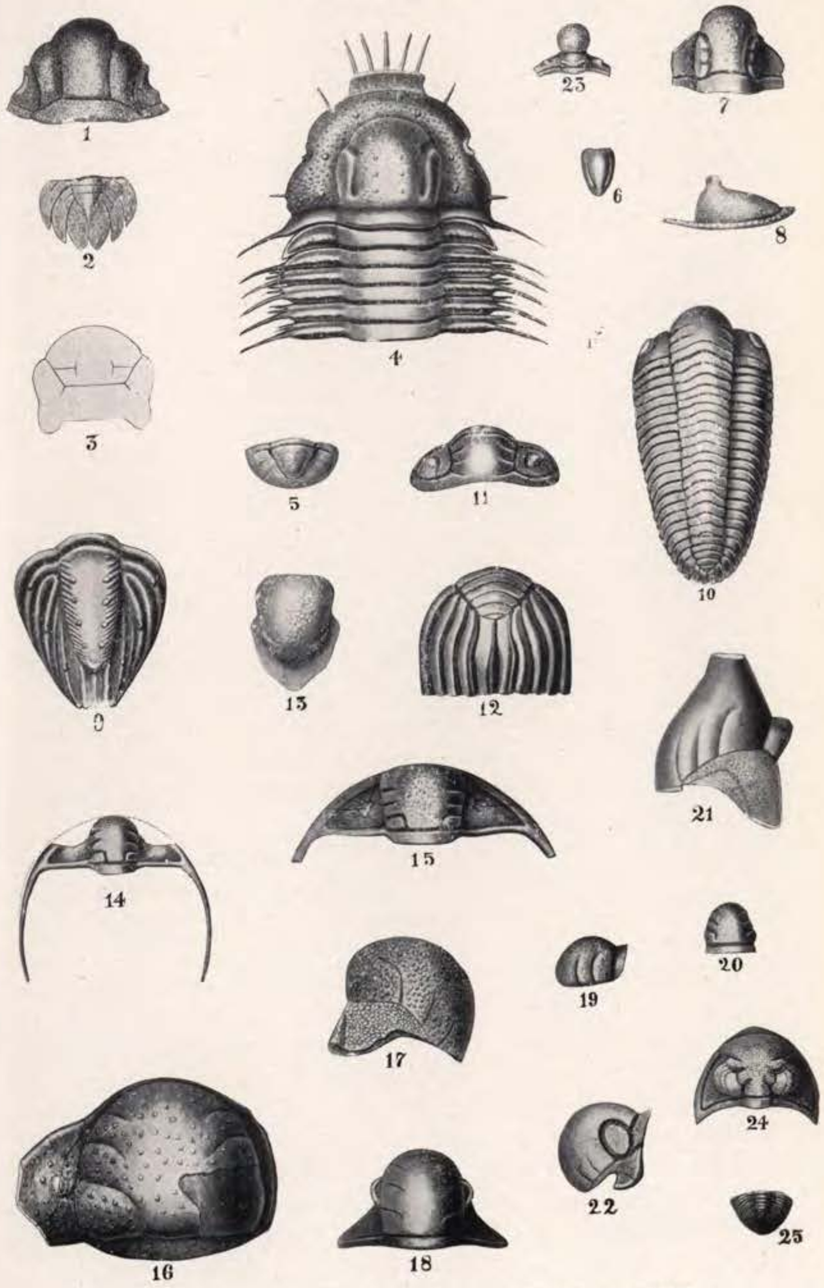
Trilobites from the Chazy Limestone of the Champlain Valley.

Plate XXXVI.

EXPLANATION OF PLATE XXXVI.

1. *Amphilichas minganensis* (Billings). A cranidium.
2. The same species. A small pygidium, imperfect at the front. Enlarged one-third.
3. The same species. Outline drawing of the hypostoma, twice natural size.
4. *Glaphurus pustulatus* (Walcott). A cranidium and part of the thorax. Only such spines as show on a single specimen are represented. Twice natural size.
5. The same species. A large pygidium, enlarged three diameters.
6. The same species. Hypostoma, enlarged three diameters.
7. *Cybele prima* Raymond. Glabella and portion of fixed cheeks, enlarged two diameters.
8. The same species. A free cheek, enlarged two diameters.
9. The same species. A pygidium, enlarged four diameters.
10. *Pliomerops canadensis* (Billings). Dorsal view of an entire specimen.
11. The same specimen. Front view of cephalon.
12. The same species. The pygidium of a large specimen.
13. The same species. The hypostoma.
14. *Ceraurus pompilius* (Billings). A cranidium, one-third larger than natural size.
15. *Ceraurus hudsoni* Raymond. A cephalon with incomplete genal spines. One-third larger than natural size.
16. *Pseudosphærexochus vulcanus* (Billings). An incomplete cephalon, twice natural size.
17. *Pseudosphærexochus vulcanus billingsi* Raymond. Side view of an incomplete cranidium, twice natural size.
18. *Pseudosphærexochus approximus* Raymond. A cranidium, twice natural size.
19. *Pseudosphærexochus chazyensis* Raymond. Side view of a specimen with two glabellar furrows, twice natural size.
20. The same species. A small glabella, three times natural size.
21. *Nieszkowskia satyrus* (Billings). Side view of an incomplete cephalon.
22. *Sphæreoxochus parvus* Billings. Side view of an incomplete cephalon, enlarged two diameters.
23. *Sphærocoryphe goodnovi* Raymond. A cephalon lacking the genal spines. Enlarged two diameters.
24. *Pterygometopus annulatus* Raymond. A cephalon, one-third larger than natural size.
25. The same species. A small pygidium.

PLATE XXXVI.



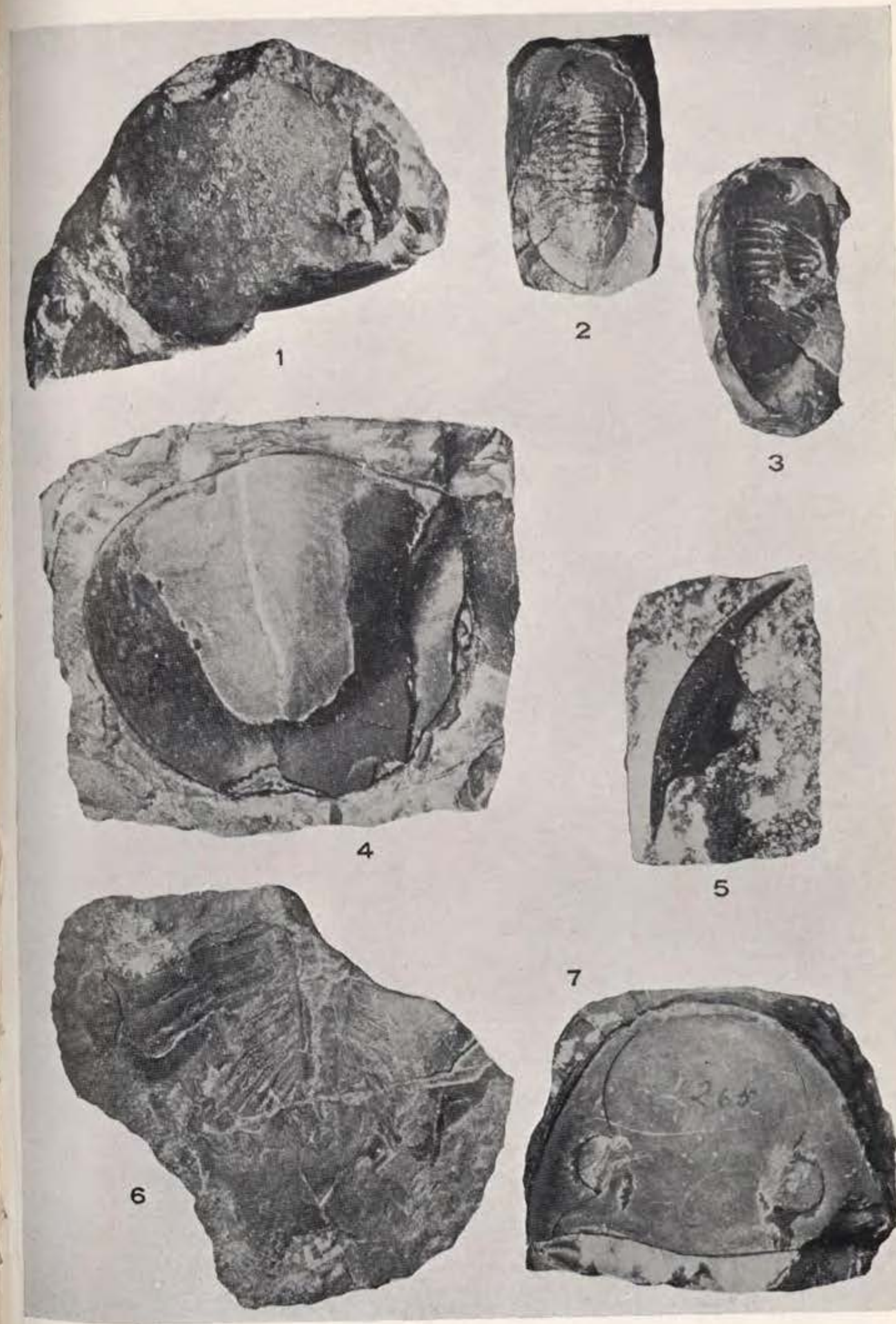
Trilobites from the Chazy Limestone of the Champlain Valley.

Plate XXXVII.

LATE XXXVII.

1. *Iso'elus harrisi*, Raymond. A cranidium from Isle La Motte, now in the Vermont University Museum.
2. *Isotelus platymarginatus*, Raymond. A cast taken from the natural mold shown in figure 3.
3. The same species. A natural mold from Isle La Motte, Vermont. Vermont University Museum.
4. The same species. A large pygidium, from Acidaspis Point, Valcour Island, New York.
5. The same species. A free cheek from the lower part of the Chazy at the southern end of Valcour Island. About three times natural size.
6. *Basilicus marginalis*, (Hall). A large pygidium showing the peculiar notch in the posterior margin. Sloop Bay, Valcour Island, New York. Yale University, Museum.
7. *Isoteloides angusticaudus*, Raymond. A cephalon from Isle La Motte, Vermont. Vermont University Museum

All photographs made at the Carnegie Museum by L. S. Coggeshall. Drawings by Sydney Prentice.

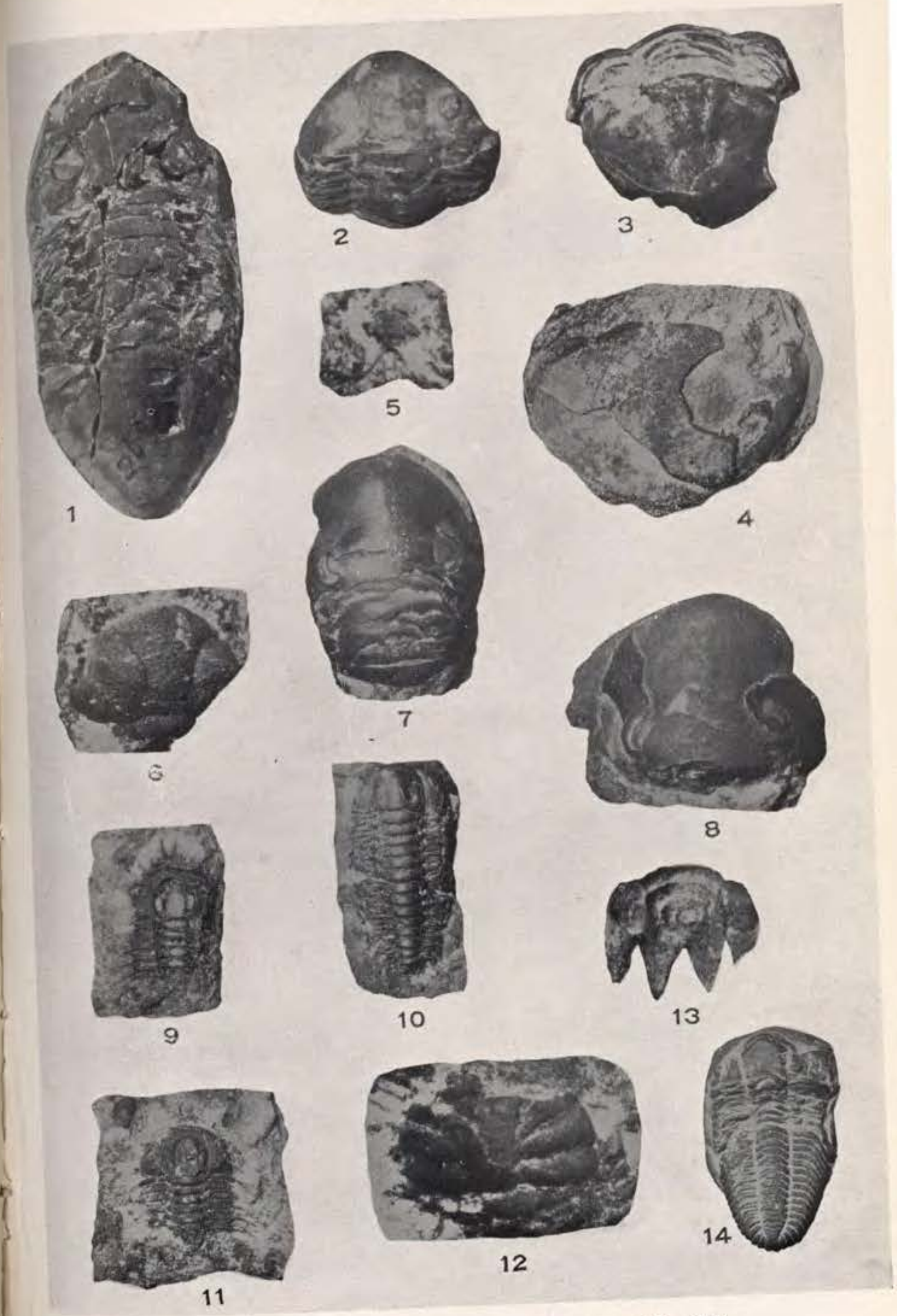


Trilobites from the Chazy Limestone, of the Champlain Valley.

Plate XXXVIII.

PLATE XXXVIII.

1. *Isoteloides angusticaudus*, Raymond. An entire, but imperfect specimen from Isle La Motte. Slightly larger than natural size. Vermont University Museum.
2. *Onchometopus obtusus*, (Hall). Cephalon and thorax of an enrolled individual in the Vermont University Museum. From Isle La Motte, Vermont.
3. The same specimen. Thorax and pygidium.
4. The same species. A pygidium from Valcour Island, showing the large punctæ of the shell.
5. *Ceratocephala narrawayi*, Raymond. The cranidium of the only specimen known. From McCullough's sugar-bush at Chazy, New York. About three and one-half times natural size.
6. *Amphilichas minganensis*, (Billings). A young individual whose dorsal furrows do not reach the neck-furrow. About three and one-half times natural size. From McCullough's sugar-bush at Chazy, New York.
7. *Nileus perkinsi*, Raymond. The cephalon and part of thorax. This specimen is from Isle La Motte, and is now in the Vermont University Museum. Holotype.
8. *Nileus perkinsi* Raymond. Paratype in the U. S. National Museum. From Isle La Motte, Vermont.
9. *Glaphurus pustulatus*, (Walcott). A photograph of one of the specimens. From Chazy, New York.
10. The same species. A large entire specimen from Isle La Motte, Vermont. Vermont University Museum.
11. The same species.
12. *Heliomera sol* (Billings). A glabella from the lower part of the Chazy at Chazy, New York. About three and one-half times natural size.
13. *Nieszkowskia* sp. A pygidium from McCullough's sugar-bush at Chazy, New York. About three and one-half times natural size.
14. *Pliomerops canadensis*, (Billings). A small specimen from Valcour Island, New York.



Trilobites from the Chazy Limestone of the Champlain Valley.

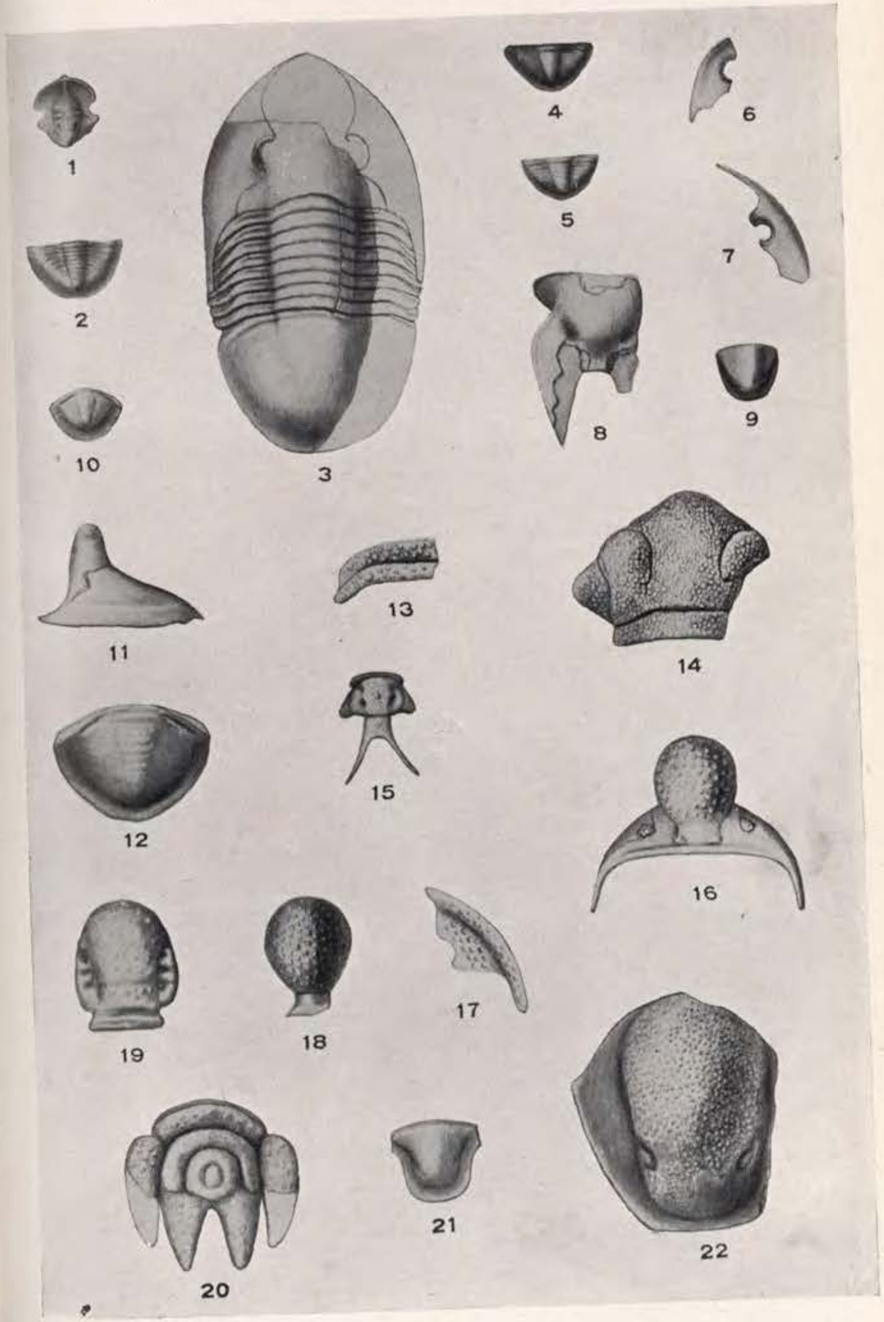
Plate XXXIX.

PLATE XXXIX.

1. *Basilicus marginalis*, (Hall). A very small and somewhat imperfect cranidium from McCullough's sugarbush, Chazy, New York. X 4.
2. The same species. A pygidium, from the same locality. X 4.
3. *Isotelus platymarginatus*, Raymond. A drawing made from the cast of the natural mold shown in figure 3, Plate XXXVII. X 2.
4. *Isotelus beta*, Raymond. A pygidium. X 2.
5. The same species. Pygidium and one thoracic segment. X 2.

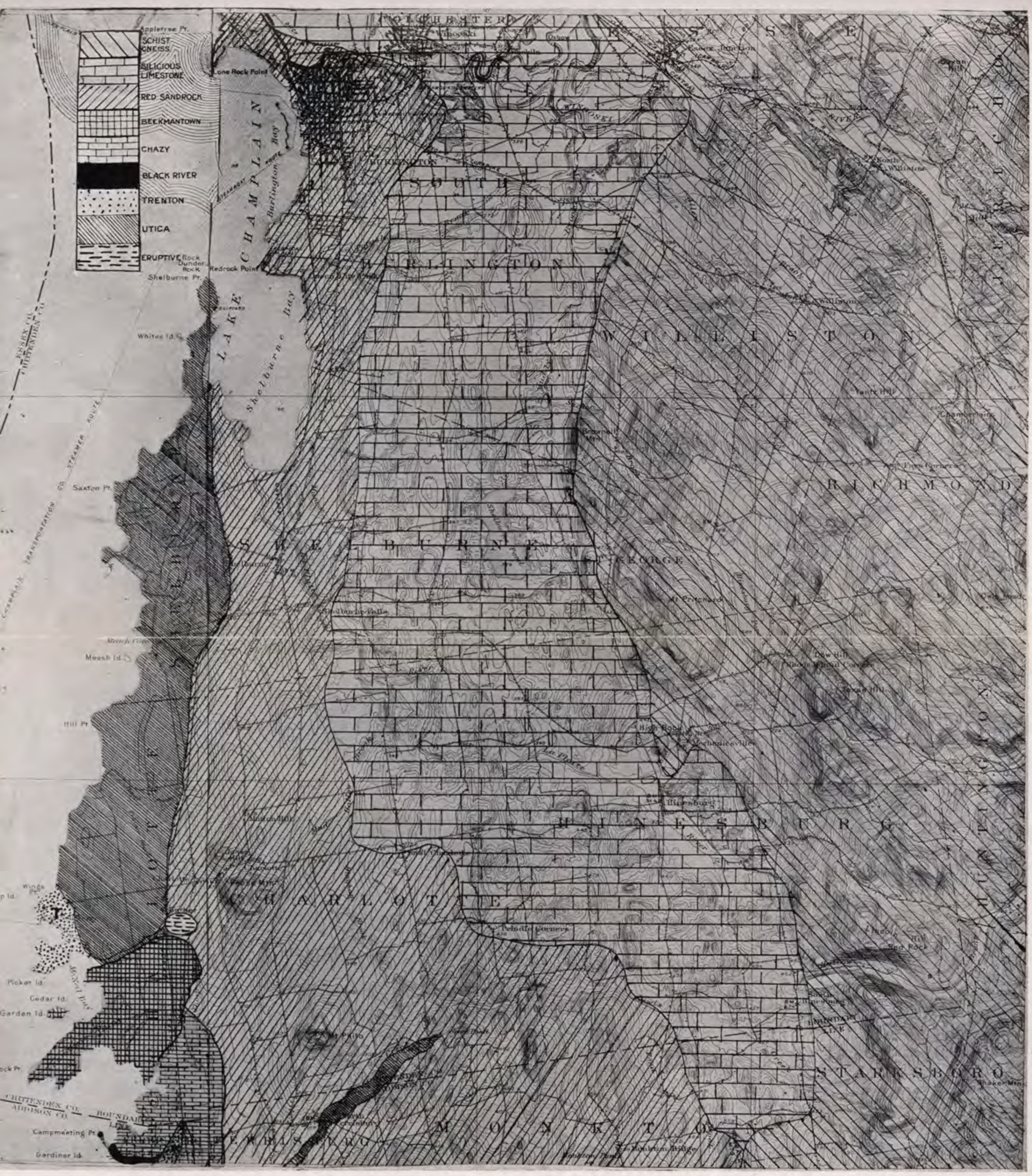
6, 7. The same species. Two free cheeks. X 2. 4 to 7 are from specimens collected at Chazy, N. Y.

8. *Isoteloides angusticaudus*, Raymond. Hypostoma found associated with, and supposed to belong to this species. Natural size.
9. *Bumastus globosus*, (Billings). Hypostoma supposed to belong to this species. Natural size. Valcour, New York.
10. *Vogdesia bearsi*, Raymond. A small pygidium. Natural size.
11. The same species. Side view of a free cheek and eye. Natural size.
12. The same species. A pygidium, natural size. 10, 11, 12 are from specimens collected at Sloop Bay, Valcour Island.
13. *Amphilichas minganensis*, (Billings). Part of the pleuron of a thoracic segment. X 2.
14. The same species. A small imperfect cranidium with dorsal furrows which do not meet the neck ring. X 4.
15. *Ceratocephala narrawayi*, Raymond. The cranidium of the holotype. X 4.
16. *Sphærocoryphe goodnovi*, Raymond. A cephalon. X 4.
17. The same species. A free cheek. X 4.
18. The same species. A glabella. X 4.
19. *Cybele prima*, Raymond. A glabella. X 4.
20. *Nieszkowskia* sp. A pygidium. X 4.
21. *Nieszkowskia* or *Pseudosphærexochus*. Hypostoma sup-, posed to belong to one of these genera. X 2.
22. A large hypostoma belonging to one of the *Ceraurida*, but too large to belong to any of the known species in the Chazy. Natural size. From Cooperville, New York.



Trilobites from the Chazy Limestone of the Champlain Valley.

Plate XL.



Geological Map of the Burlington Quadrangle.

Geology of the Burlington Quadrangle.

G. H. Perkins.

In making numerous topographical maps in various parts of the United States, the National Survey has carried on its work in certain arbitrarily established areas known, technically, as "Quadrangles." Only a small part of Vermont has been mapped by the National Survey, owing mainly to the unwillingness of the Legislature, before which the matter was brought, to make any appropriation towards the cost of the work, tho the general Government offered, as usual, to bear the larger part of the expense.

Fortunately, however, the area about and south of Burlington has been surveyed and the map drawn and published by the U. S. Geological Survey so that any one who desires a copy can get it easily.

The U. S. map includes none of the eastern half of Chittenden County and only half of the western side. The map given on Plate XL includes not only the Burlington Quadrangle, but also the eastern edge of the New York Quadrangle which includes Willsboro, etc., since this, thru the generosity of New York, reaches across the Lake and adds the western part of Chittenden County to the otherwise abbreviated map. Most of Shelburne Point and the whole of the lake shore south is thus shown. On this account, it might have been as exact to have written the above title "Geology of the South Western Portion of Chittenden County."

There is no need for any definite outlining of the region under discussion, for the boundaries may readily be made out by brief consultation of the map. The scale is very nearly two miles to an inch. For convenience it has been reduced to one-half the size of the government maps from which the outlines are copied. It may be added that, in filling in the geological areas upon the topographic map, no attempt has been made to more than outlinet he different rock areas. As will be noticed, a small part of the northern border of Addison County is shown, but this is also shown on Professor Seely's map of the geology of that county.

The Burlington Quadrangle includes the towns of Burlington, South Burlington, Williston, Shelburne, Charlotte, Hinesburg, Colchester, tho only very little, a larger part of Essex, Richmond and somewhat of Jericho, Huntington, Starksboro, Monkton and Ferrisburg. As made up the map includes a tract seventeen and a half miles from north to south and fifteen and a half miles from east to west; an area of about two hundred and seventy square miles.

During the past two years the field work of the Survey in this part of the State has largely been carried on within the above limits. Among the difficulties which confront the geologist in this region the two greatest are, the metamorphism of the rocks in the eastern part, by which they have been altered beyond recognition, and, so far as present knowledge goes, the entire absence of fossils from the great tract of limestone which covers the central part of the quadrangle from north to south. The rocks along the shore of Lake Champlain do afford fossils, sometimes abundantly, sometimes sparsely, but always sufficiently to enable the accurate determination of their relative age. Then, too, there are wide spaces, especially in the western part of the region, that are completely covered by soil so that the rocks cannot be found, and where or how the beds on each side come together must be conjectural.

The eastern part of not only the Burlington Quadrangle, but of the whole county, is covered entirely by the gneisses, schists, etc., of the Green Mountain series. West of these metamorphic rocks we find, wherever the soil does not conceal them, the limestones, sandstones and shales of the Cambrian and Ordovician.

As the map plainly shows, a much larger space is occupied by the metamorphic rocks and the silicious limestone than by all the rest.

After these comes the Cambrian. The various members of the Ordovician, aside from the limestone mentioned, are exposed only in small patches, here and there.

Considering briefly each of the different formations found in the Quadrangle taking them in order of age, we have the following:

ERUPTIVES.

The dikes of this area were considered sufficiently for our present purpose in the last Report. Little need be said in addition, but a few dikes have been noticed not mentioned heretofore. The hill of brown, coarsely crystalline igneous rock south of the R. R. station at Charlotte, known as Barber Hill, is well known. It is easily affected by frost, etc., and turns lighter as it weathers. The material is Bostonite. In the bed of Lewis Creek, just south of the bridge on the

PLATE XLI.

Contact of Silicious Limestone and Slate, Hubbell's Falls, Essex Junction.
The fallen tree lies along the line of contact.

road from North Ferrisburg to Monkton Ridge, there is a mass of intrusive rock, probably Bostonite, of a porphyritic character. It is much broken and jointed. It does not appear on the east side of the creek, but is first seen in the bed of the stream and disappears in the heavy bank of drift on the east side. It is from 20 to 30 feet wide.

METAMORPHIC ROCKS.

The whole of the eastern part of the Burlington Quadrangle is covered by Schist and Gneiss. As would be expected in the vicinity of such mountains as those just east, these rocks are often very greatly folded, compressed or otherwise disturbed.

Until much more thorough examination than has hitherto been possible can be given to this region it will not be wise to assert too definitely that they are of any given age. Of course they were made from previously formed rocks and these must have been Ordovician, Cambrian or Precambrian. Very likely in the mass of the mountains there is rock older than Cambrian and it may possibly be that some of these gneisses and schists that cover the flanks, foot hills and adjacent lands are older than Cambrian, but I am inclined to believe that those we find in the territory shown on the map are made from Cambrian and Ordovician strata. At least I have not found any reason for assigning them an earlier source. And I should say the same of the rocks found in the county east of the Quadrangle, at least as far as the actual mountain slopes and, probably, the surface rocks of the Green Mountains.

As to the deeper masses that form the axis or foundation of the range, I have nothing now to say. Deep in the mountain mass there may be older rock than appears on the outside.

So far as appears on the map, the gneiss and schist forms all or nearly all of the accessible rock of Essex, Williston (except that in this town there is a little of the silicious limestone mentioned later,) Richmond, Huntington, Starksboro, St. George and the eastern half of Hinesburg.

Elsewhere in the Quadrangle the rocks are all sedimentary. Continuing, as we have started, from east to west we find on the map a great belt of

SILICIOUS LIMESTONE.

As the map, Plate XL, readily shows, this rock enters the northern limit of the quadrangle and continues on into Charlotte and Hinesburg and half thru them in a belt three to four miles wide and more than twelve long. Then there is a sudden jog in the exposures on the west and about half is set off towards the east and the str p continues to within a mile of the southern limit in Monkton.

The limestone is throughout the greater portion of its exposure gray, compact and highly silicious, but there is much variation in color and composition in places. In some parts of its area it is shaly, but there is not much of this material. At what is locally known as the Lime Kilns the rock is lighter and much more calcareous and here it has been burned for making lime for many years. The gorges at the Twin Bridges and the several small cuts between Winooski and the Lime Kilns are thru this rock. On each side of Shelburne Pond the stone is very light, in parts almost or quite white, and has been quarried in times past as marble.

Besides the permanent manufacture of lime at the Lime Kilns, there are, here and there, old kilns that were built to supply some local need in years long past. The rock lies for the most part in ridges having a north and south axis, tho there are exceptions to this.

Nowhere are the elevations very high, the largest being High Rocks or White Rock a little north of the village at Hinesburg. Here the mass is 150 feet above the road that runs by it and 538 feet above sea level.

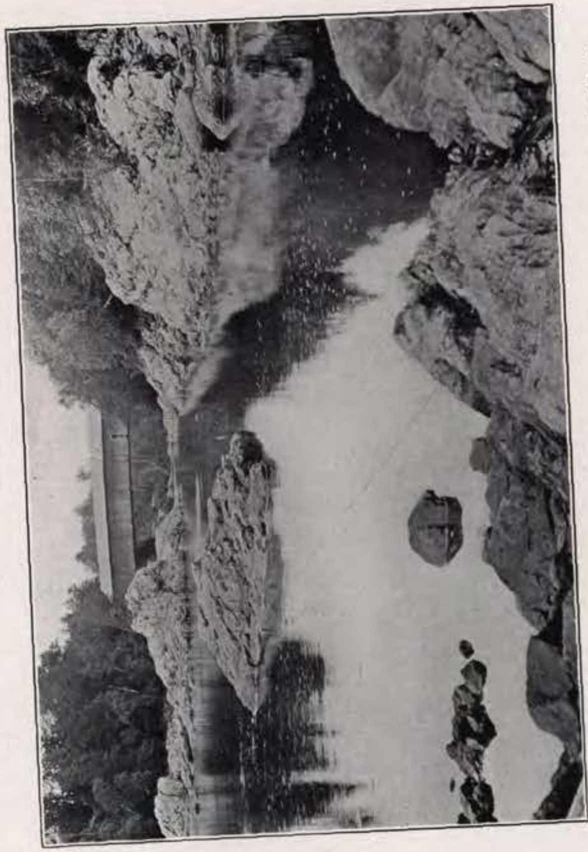
Plate XLI shows the most eastern outcrop of the limestone where, at Hubbels Falls near Essex Junction, it is pushed against the shale. The stray tree trunk chances to lie along the line of Junction, and Plate XLII gives a view a little farther down the Winooski River where it occurs on both sides of the stream. It is the only rock that appears along the river, the outcrops being interrupted by wide intervals where no rock is seen, until, just below the second falls at Winooski Village, where it stops, and on the opposite side of the river, Red Sandrock appears.

Plate XLIII is one of the most southern exposures in Hinesburg near the Monkton line.

In many places this stone is much disturbed, but for the greater part of its extent it dips at no great angle to the east. There are several quarries from which stone has been taken for road material and the harder layers are admirably adapted for this purpose.

All the roads which go from what is known as the Williston Road, that is, the main road from Burlington to Williston, south to Hinesburg, as far east as that just beyond Williston Village, pass over this rock. As shown on the map, there is, in addition to the main belt of silicious limestone, a small outcrop in Williston about a mile west of the village. The appearance and character of the limestone at the Lime Kilns and of most of that seen throughout the area is so different that, until recently, I have thought it most probable that they were different in age. This may be correct

PLATE XLII.



Eastern Outcrops of Silicious Limestone in the Winooski River, below Hubbells Falls, Essex Junction.

PLATE XLIII.

Outcrop of Silicious Limestone. Southern part of Hinesburg.

Plate XLIV shows Mount Philo as seen from the west. In all the towns thru which the belt passes there are fine exposures of this Red Sandrock. The dip is usually not large, 5°–10°, and towards the east.

But at Mt. Philo the strata are greatly disturbed and at Rock Point, as shown on Plate XLIV of the last Report, the strata are not only thrust up, but thrust over so that now the Cambrian Sandrock rests directly on the Utica, as described in the Report. Plate XLV shows this position of these Cambrian and Utica beds at a different point from that given on the plate referred to. Here the Utica is seen only as a narrow band just at the water's edge. Elsewhere it is as thick as the sandrock. Plate XLVI shows the end of Rock Point a little south of the overthrust and here, as always south of the Point, only sandstone appears. A large mass that has fallen from the cliff is shown in the plate.

Plate XLVII shows an outcrop in which the rather thin strata are of different shades of red and the southerly dip is shown also.

BEEKMANTOWN.

As has been stated, it is probable that the great bed of silicious limestone is of this age, but it is at present placed in it only provisionally, waiting for more complete information.

There is, however, rock that affords fossils that fix the location of the beds from which they have been obtained beyond doubt.

This is at Thompson Point, and there are also exposures of this age on each side of the Rutland R. R. track east of McNeil Bay. These are clearly shown in Dr. Brainerd's map, Plate XLIXa in the preceding Report. Plates L, LI of the same Report show views of the bluffs of this limestone at the lake. For a fuller discussion of the Beekmantown, the reader is referred to the Sixth Report, pages 245-251.

CHAZY.

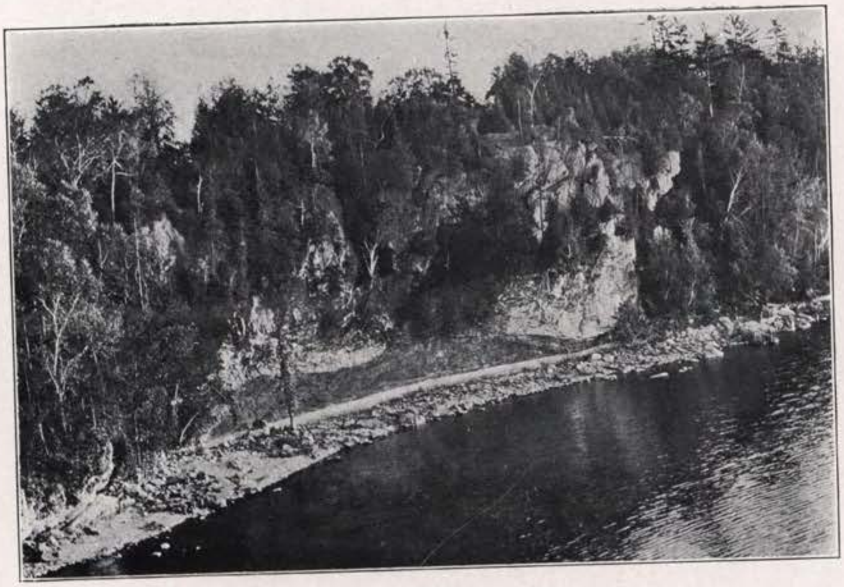
The rocks of this age, so well displayed on the large islands in the lake north of the region we are studying, do not appear again until we come to a small outcrop in Charlotte, a few rods south of the road from the station to McNeil Point. There is a second and larger outcrop on each side of the main road to Thompson Point, east of the station at Charlotte, and the largest is the quite extensive exposure about the south side of Ball Bay and up on the east shore to the Cove, and on north-eastward across the R. R. track.

The first two exposures mentioned are too small to be

PLATE XLIV.

West side of Mount Philo. Red Sandrock.

PLATE XLV.



Southern portion of Overthrust, Rock Point.

shown plainly on a map of the scale used, hence they are omitted. Most of the rock in these Chazy beds is of the usual sort found in similar beds elsewhere—a dark gray, rather hard, often very fossiliferous limestone.

BLACK RIVER.

There is very little of the limestone of this period to be found within the limits of this Quadrangle. Indeed, outside of Grand Isle, there are few outcrops anywhere in the State.

In the Quadrangle there is a narrow strip, too small to show on the map, just east of the Trenton in Charlotte, and another larger, tho of small area, seen at the lower south-west corner of the map and at the end of Campmeeting Point in Ferrisburg. These outcrops are better shown on Dr. Brainerd's map to which reference is made above.

TRENTON.

Altho much more fully developed than the Black River or even the Chazy, the Trenton does not appear extensively within the Quadrangle.

There is one area that is wholly of this age in Charlotte, forming the lake shore and reaching a mile or less inland, including what is known as Cedar Beach, McNeil Point and thereabout.

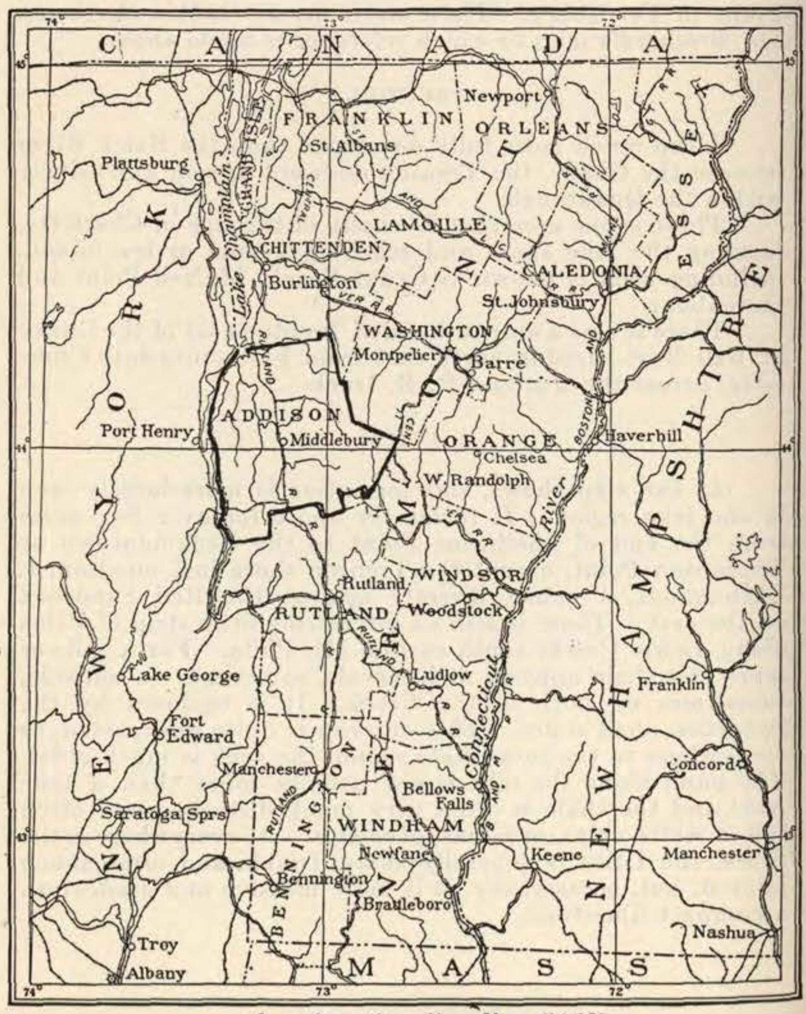
There is also a narrow band of Trenton east of the Chazy at Ball Bay, running north-east from Ferrisburg into Charlotte, across the Rutland R. R. track.

UTICA.

As the map shows, this formation is more largely seen in the lake region. It forms the shore for over five miles from the end of Shelburne Point to the Beekmantown at Thompson Point, except the Trenton shore just mentioned. Throughout, it comes directly against the Red Sandrock on the east. There is also an interesting little strip of Utica along Lewis Creek, south-east of Mt. Philo. For a mile or more this shale appears at intervals, sometimes on one side, sometimes on both of the Creek. It is enclosed by the Sandrock onall si des. This outcrop is quite unexpected, as everywhere in the immediate region the rock is much older. The band along the lake is not usually more than a mile wide and the shale is often very much disturbed and often full of white veins, or seams, of calcite. As everywhere in the State, the Utica is generally shaly, friable and often much jointed, but, occasionally, it is more massive and grades into a compact limestone.

PLEISTOCENE.

As elsewhere stated, there is no rock in this region between the Utica and the Pleistocene. The long interval during which so many thousands of feet of rocks of various kinds were laid down appears to have left no record in Vermont except here and there in a few places, as the lignite of the Tertiary at Brandon and one or two other very small areas. So much has already been published in former Reports and also in this, upon the sands, gravels, etc., of the Pleistocene those materials which, except where ledges of the older rocks appear, form the surface of the country, that there is less need for speaking of this period in this connection.



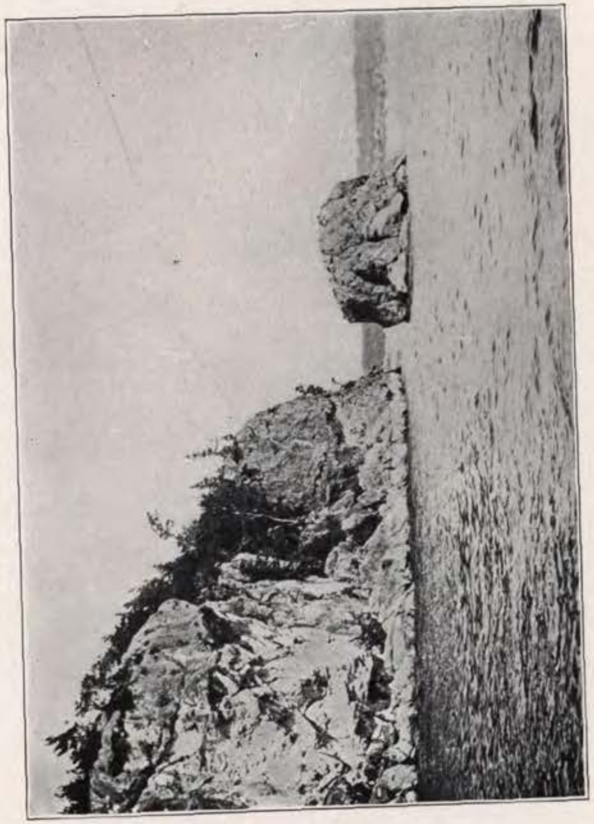
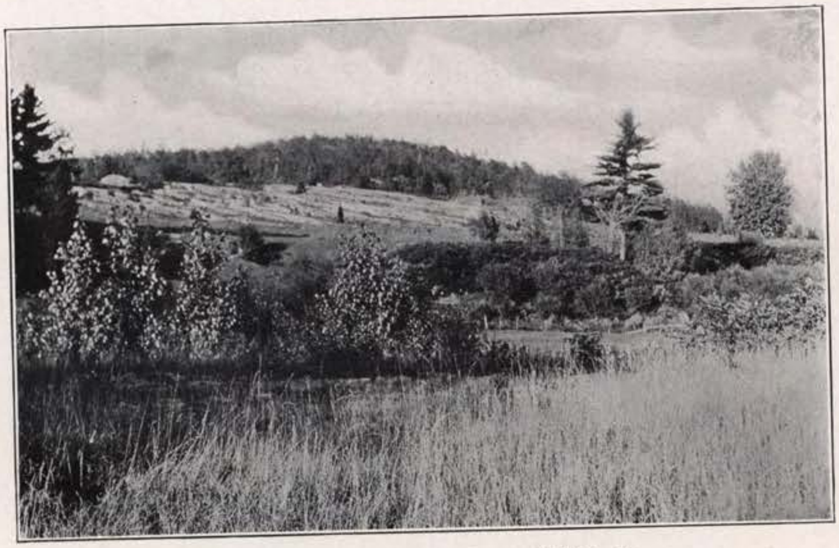


Plate XLVI.

Western end of Rock Point, Cambrian.

PLATE XLVII.



Outcrop of Cambrian Sandrock near Malletts Bay.

Preliminary Report of the Geology of Addison County.

H. M. Seely.

Addison County, the middle one in the western tier of counties of Vermont, has Chittenden directly on the north, and Rutland on the south. Its western boundary is Lake Champlain, its eastern is essentially the crest of the Green Mountains, though two of its twenty-three towns lap over on the eastern side of the mountains.

The distance from the north to the south boundary is very nearly thirty miles; that from the west to east a little over thirty-three miles.

The town of Middlebury, taken as a center of the county, has the line 44° latitude passing through it, and that of 73° longitude.

The height of the land varies from the lake shore level, 97, to the top of the Green Mountains over 2,000 feet, that of Middlebury, at the post office, as established by the U. S. Geological Survey, is 366 feet above sea level.

The surplus waters of the county drain almost wholly north and west, and reach Lake Champlain very near its northern boundary.

The valley portions of the county lying between the lake and the foot of the mountain is diversified by various uplifts of rocks, these usually running in a north and south direction, the western slope being often abrupt and sometimes precipitous.

The rocks are mostly concealed; those of the lake towns by a stiff clayey soil, those farther from the lake by lighter, and in some localities by a sandy soil.

The solid rocks themselves where exposed by the waters of the lake, or by uplifts in the interior, are found to belong essentially to strata near the lower portion of the geological series known as Lower Silurian, or by the later term, Ordovician.

The fossil contents of the rocks are comparatively abundant along the lake, but, as a rule, decrease eastwards, the forms fading out as the masses have been more disturbed and metamorphosed.

The chief facts of the geology of the county are fairly well known, the results having been obtained through the study of many observers. Some observers have come under the authority of the State, assisted by legislative appropriations, to make a geological survey. Others have found the county a field for illustrating or carrying forward some larger work they had on hand, and their observations may be mentioned as incidentals. Others, again, have entered the field for a love of the science and the attraction of the new facts to be discovered, and these may be grouped as a volunteer force.

From all of these classes, as well as from each individual, we have our knowledge of the geology of Addison County.

There have been two state surveys, the first with Professor C. B. Adams as chief geologist, the second with President E. Hitchcock in charge, each with a small corps of assistants.

Addison County shared with the other counties of the State the results of the first geological survey, carried most energetically forward by Professor Adams.*

During the three years, 1845–1847, for which legislative appropriations had been made, this survey was largely pioneer work. All the counties were visited and some often revisited; many examples of rocks, minerals, soils and fossils collected, a geological map of the State made; three reports of annual progress published, and many notes of geological facts and geological structure prepared; all this work leading up to the publication of a final report which should mbody the large results of the survey.

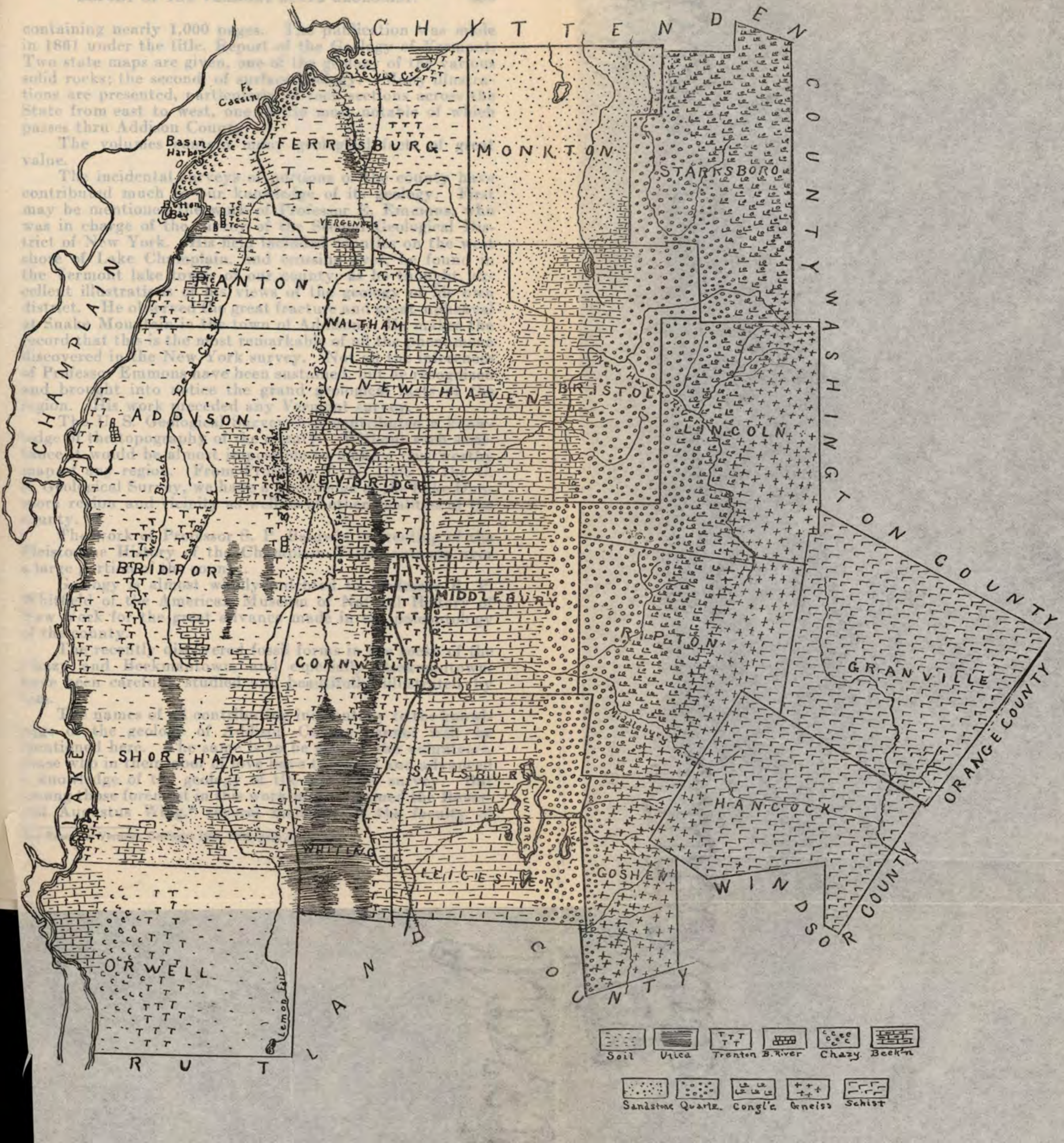
The county shared fully in this work of Professor Adams. Collections of rocks, fossils and minerals were prepared for the various institutions of learning in the State and one was deposited in the museum of Middlebury College. Special study of the rocks of some of the towns of the county was made, particularly of the town of Addison in which occurs the Snake Mountain uplift.

A fourth thin publication of a few pages was made after the third annual report had been printed. The county ought to have shared in a final report which Professor Adams had hoped to make and for which he had gathered abundant material. But for this crowning work of this first State survey, the State Legislature failed to make an appropriation for publication. The failure involved a great loss, both to the State and to science. This is to be noted, Professor Adam's work was of high order.

The results of the second survey, that made under the direction of President E. Hitchcock, carried on during the years 1857–1860, were embodied in two quarto volumes

*See Report of Vermont Geologist 1903–1904, page 3 and on.

PLATE XLVIII.



Geological Map of Addison County.

containing nearly 1,000 pages. The publication was made in 1861 under the title, Report of the Geology of Vermont. Two state maps are given, one of the geology of the various solid rocks; the second, of surface geology. Many illustrations are presented, particularly of rock sections across the State from east to west, one of the most notable of which passes thru Addison County.

The volumes contain many geological facts of great value.

The incidental surveys of portions of the county have contributed much to our knowledge of its geology. First may be mentioned the work of Professor E. Emmons, who was in charge of the survey of the Second Geological District of New York. His field included counties on the west shore of Lake Champlain, and crossing over, he found in the Vermont lake towns of our county, as he thought, excellent illustrations of his views of the geology of his own district. He observed the great fracture and great upheaval at Snake Mountain in the town of Addison. He makes the record that this is the most remarkable of all the phenomena discovered in the New York survey. Not all the inferences of Professor Emmons have been sustained, but he recognized and brought into notice the grand geological facts of the region. His work preceded any Vermont survey.

The U. S. Geological Survey has contributed a knowledge of the topography of the county. Without such assistance it would be almost impossible to make a trustworthy map of any region. From Professor T. N. Dale of the U. S. Geological Survey, we have a knowledge of the Lake Dunmore region and vicinity as well as of other localities of the county.

The work of Professor S. P. Baldwin in treating of the Pleistocene History of the Champlain Valley extends over a large portion of the county.

Geology is almost wholly indebted to Professor R. P. Whitfield of the American Museum of Natural History of New York for the great advance made in the paleontology of the county.

The recently discovered fossil forms in the rocks of the Chazy and Beekmantown, and especially Beekmantown, have been carefully studied and beautifully illustrated by him.

The names of all contributing incidentally to the knowledge of the geology of Addison County cannot well be mentioned here. The same is to be said of the volunteers, those who in their labor of love have taken up and advanced a knowledge of the geology of the last state survey. But among those foremost in this work may be named the Reverend Augustus Wing,* several members of the faculty of

*See Report of Vermont Geologist 1901-1902, page 23 and on.

Middlebury College and Professor G. H. Perkins of the University of Vermont and now State Geologist of Vermont.

The group of the Middlebury College faculty consisted of President Brainerd, Professors Seely, Eaton, Boyce, Kellogg, and Higley. To President Brainerd fell chiefly the measurements and charting; to Professor Seely largely the collection of fossils and, to a small extent, their naming. Subsequently, to the united work of the group of college professors, Professor Seely and Professor Perkins were associated in further development of the Fort Cassin locality. The East Beekmantown field was in all probability first recognized, collections made, and its existence brought to the notice of geologists during the summer excursions and prospecting of Professor Seely.

In the line of volunteers in the study of the geology of Addison County the Rev. Augustus Wing, preacher, teacher and self-instructed geologist, stands first. This will presently appear.

The time at which the second State Report was made was one of transition in geological thought. Suggestions and questions appear but are left unanswered. It is to be noted that President Hitchcock introduced and mapped a formation not previously known. The so-called Eolian Limestone was to include a group of variously formed and named rocks having a thickness of near 2,000 feet, with undefined boundaries. The type was the marbles and associated rocks of Dorset Mountain, at that time renamed Mount Eolus, and included like marbles stretching south thru western Massachusetts and Connecticut and eastern New York, previously styled Stockbridge Limestone. North were the marbles of Rutland and Middlebury as well as the various rocks of Otter Valley. The Eolian had a wide development in Addison County. That President Hitchcock was not wholly satisfied with this disposal of rocks as to age and character that had challenged solution by other eminent geologists is very evident by his surprising words. A few are here reproduced.

"Geological Position, Origin and Equivalency. We quite despair of satisfying ourselves and others on these points as to the Eolian Limestone. The facts are very remarkable.* * * We have tried to work out the relative position of this formation and its character, * * * but how the strata came into the positions they now occupy is a question of great difficulty."

The great thickness of the limestone rocks seems a great perplexity as to age and horizon, and on later pages discussion occurs as to this. Carboniferous, Devonian and Lower Silurian are suggested, including a range of thousands of feet, but the whole matter is left undetermined.

This problem as to the age and horizon of the rocks of the Eolian left unsolved by a master of the science, was one that appealed to Mr. Wing. He came to the conclusion to ascertain, if possible, the geological age of the limestone slates and quartzite of the Otter Valley. He brought a persistence as well as an enthusiasm that carried him beyond every discouragement. He visited and, in most cases, revisited nearly every exposed rock within his selected field, this field lying chiefly in Addison County and collected fossils wherever fossils could be found, making, at the same time, careful observations as to position and relationship.

Mr. Wing solved his problem, tho it took him ten years. The results were so satisfactory and complete that they have never since been questioned.

Briefly stated they were that the Eolian Limestone was not of a single formation but included rocks of the age of those on the lake shore, those now known as Beekmantown, Chazy, Black River and Trenton. The slates were mostly Utica slates and these lying chiefly conformably above the Trenton. They had been deposited in order upon the underlying sands of the Potsdam; they belonged to the Lower Silurian age.

Wing's conclusion in regard to the present condition of the rocks was that, after deposition, this had been brought about by some mountain-making movements, the strata having been folded, compressed, broken and, in many places, displaced, the fossils by the same movement having been obliterated. These rocks, he conceived, now occupy in the county a great trough or synclinal which is higher on the north, the whole having a southward dip. The east side of this rock cradle is the quartzite at the foot of the Green Mountains; the west is formed by the great uplift of the Red Sandrock. This is now east, by some miles, from the lake shore and broken thru north and south left the great fault. The rocks within the syncline broken in the same direction, having been abraded by subsequent aerial and glacial agencies, give the present topography and character to the Otter Valley.

With Wing's solution of the problem, a far-reaching one, of the age of the rocks of Otter Valley, the perplexing term, Eolian Limestone, follows the lead of Emmon's Taconic and Logan's Quebec, and disappears from the nomenclature of present geology.

The later volunteer geological work, since that of Wing's in the middle of the seventies, has been done mainly by various members of the teaching force of Middlebury College and the University of Vermont. The field has been most notably the strata above the Potsdam, along the lake shore and the lake shore towns, and these rocks include the Ordovician.

A few facts have been added to our knowledge of the upper formations, the Utica, Trenton and Black River; but a notable advance has been made in the study of the Chazy, while in the once Calciferous, now Beekmantown, the new facts have seemed almost revolutionary. General statements of results may be made here, while special notice of the geology of various localities may be reserved for later consideration.

For present convenience, going now from above downwards, it is to be said that the addition to our knowledge of the Utica rocks consists mostly in finding them more widely distributed and in localities not previously known. So also with the Trenton and Black River, new localities have been marked, more complete defining of boundaries and new measurements of thickness of strata, but no notab'e finds of fossils have occurred.

It may be here noted that the term Birdseye, a name used in the New York and Vermont reports for a formation of rocks between the Black River and Chazy, does not seem to apply to our rocks, since, after careful search in various places at the horizon where it should be found it does not appear in our county, nor in the State, and such a formation probably does not exist in Vermont.

The Chazy, a formation most appropriately named from a beautiful display of strata at Chazy, N. Y., appears in Professor Emmon's report in 1842. To this mass of Emmon's original Chazy rock, Professor James Hall, four years later in his Paleontology, added strata both above and below. Professors Adams, Thompson and Hitchcock made valuable contributions to our knowledge of the Chazy rocks of Vermont. Yet after all that these masters of science had contributed there remained much uncertainty as to the Chazy formations.

Careful measuring and mapping of the original and typical Chazy was necessary as a means of comparison of the rocks of Addison County.

This was done also with other localities along the valley of the Champlain wherever undoubted Chazy appeared.

Some of the results of these surveys, briefly stated, will help to the understanding of our county Chazy. The lower and upper boundary rocks have been established and so, when all the members are present, the formation has for its base a ferruginous sandstone, which from its large development at the island locality has been named the Isle La Motte Sandstone. This, with other fossils, carries the characteristic fossil *Lingula limitaris*. The upper strata varying somewhat bear most usually a tough magnesian limsetone destitute of fossils, weathering with an iron stain, while just above is a layer of flinty sandstone.*

*See Report of State Geologist 1905–1906, Pages 179–184, Limiting Layers of Champlain Chazy.

Emmons makes the thickness as 130 feet, but probably he included only the middle portion. Hitchcock estimated it at its best development to be nearly 300 feet. But later observations and measurements have more than doubled this last estimate, as within our county the thickness has been found to be 700 feet. At Valcour Island it has a thickness of 890 feet.

The formation is essentially of limestone, with few sandstones and fewer slates. Yet the limestones differ much in structure, composition and fossil contents, and so much so that for purposes of study they have been separated in three groups named from below upward, Divisions A, B, C.

Division A, resting on the Beekmantown has, as has been noted, the Isle LaMotte Sandstone at its base. Some of the beds above are almost wholly made up of fossils. Layers called Encrinal Limestone in the surveys have a place here. Among the rocks made up of crinoidal fragments is a particularly compact mass 10 feet in thickness, in places holding a bright red ovoid form, *Bolboporites americanus*; this sawn into slabs forms thedec orative Lepanto Marble.

Division B forms what was originally known as the Chazy and is still the best known of the divisions. Its characteristic fossils, *Maclurea magna*, easily distinguishes it. Still it contains many other fossil forms. It yields the material that has been sawn into floor tiling and is so widely used.

Division C is rich in fossils, particularly in Brachiopods and Bryozoans, a good number of the latter still waiting to be studied and described. Chambered shells, both straight and coiled as well as univalves and trilobites abound. The Dove Limestone forms a part of this division.

Among the fossils of the Chazy, not enumerated in the Vermont surveys but recently recognized, are two genera, one the Stromatocerium of Hall which was formerly thought to be limited to the Black River and the genus Strephochetus, a calcareous sponge.

Species of both these genera appear in all the divisions, particularly in B.

On Isle La Motte *Stromatocerium** forms such massive blocks that a peculiar wavy tiling is sawn from it, while in the same horizon *Strephochaetus* forms masses which, when quarried into blocks, is in demand for bridges and foundation structures.

The Beekmantown formation, formerly Calciferous, and earlier Calciferous Sandrock, was recognized by Hitchcock in his Vermont Geology described as a sandy limestone, compact and thin bedded. He mentions several varieties but in no definite order as he had made no sections. He

See Report of Vermont Geologist, 1903–1904, page 144. THE STROMATOCERA OF ISLE LA MOTTE, VT.

had collected only four or five fossils within the State, though in the further progress of the survey he added two more distinctively belonging to the formation, seven in all. The thickness he estimated at 300 feet. With such scant fossiliferous material and uncertain order of the rocks, it perhaps was not strange that the thought came to some that the Calciferous as a formation might be dispensed with altogether, the lower sandy layers being relegated to the Potsdam and the upper limestone strata to the Chazy.

This would simplify the arrangement of these rocks, and at the same time some embarrassing uncertainties would be removed. Such a disposition of the Beekmantown with our advanced knowledge would now be impossible. New significance has come to these rocks. The uncertainties have been removed, and the rocks have really an orderly arrangement, are of unexpected thickness and contain, especially the upper division, a great wealth of fossils.

The early applied term, Calciferous Sandrock, very properly describes many of the basal rocks, but others occur and sometimes of great thickness, such as Magnesium limestone, pure limestone and rarely slates.

The thickness of these diverse rocks is approximately 2,000 feet. Of fossils all classes of animals below vertebrate are represented. Mollusks, both with chambered and unchambered shells, particularly abound, and so also many trilobites. New genera as well as many new species have been added to the science of paleontology.

Addison County leads all other districts in the number of fossils newly found and, as well, shares in the great breadth of the typical rocks of the formation. It will be noted in proper place that the rocks appear at the lake shore in the towns most north and south, through also the central towns and, as well, crowd up to the foot of the mountains. The exact eastern border of the formation must be left for yet more careful observation.

The magnitude of the Beekmantown formation is comprehended only as one goes north and south from this county as a center. North it accompanies Lake Champlain, keeps along the St. Lawrence into Canada, sweeps through the Gulf and reaches Newfoundland.

South it passes up the valley of the Otter and on through the Hudson touching the borders of Massachusetts and Connecticut and New York west and east, and on to Long Island into New Jersey and, probably, crosses Pennsylvania and Virginia into Tennessee. And when all the geological facts are in, will it not be found that the valley quarries of limestone and masses of marble, those known early as Stockbridge and later as Rutland, are largely comprehended within the Beekmantown? We will wait expectantly that future careful observations will give an affirmative answer.

In the study of the Beekmantown, with its widely varying rocks, it has been helpful, as in the case of the Chazy, to recognize Divisions based on differences of composition, structure and fossil contents of the rocks. The boundary below rests upon the Potsdam, which most often is a sandstone with occasional fragments of a brachiopod related to the lingula, while above it reaches the basal sandstone of the Chazy, also containing a lingula. The rock masses lying between these boundaries and having a thickness of near 2,000 feet, group themselves into five divisions, which in ascending order, have been called Divisions A, B, C, D and E. A very brief general description of the five divisions is here given.

Division A conforms in most features to the early known Calciferous. It is made up largely of a magnesian limestone, dark blue gray in color, often weathering yellow. Some of the layers have nodules of white quartz and near the top masses of black chert. Thickness, 310 feet. No fossils have been found.

The thickness of the various divisions was measured in Shoreham. It will be noticed that Division A has a thickness a few feet greater than that attributed early to the whole formation.

Division B is characterized by massive beds of nearly pure reticulated limestone, flinty in compactness, weathering white so that an exposed cliff looks like white marble. Beds of pure and magnesium limestone are interstratified. The division is very unlike the early known Beekmantown. Thickness, 295 feet.

The rare fossil, earliest of chambered shells, *Orthoceras primogenium*, is found in the pure limestone, while some of the magnesium layers contain certain hemispherical masses early called *Stromatopora*. These Professor Hall later named *Cryptozoon*, and of these three distinct species have been recently described.

Division C, sharply separated from B and D by structure and composition, is made up of alternating layers of magnesium limestone and sandstone. Weathered portions very nearly resemble fine grained wood. Thickness, 350 feet. Worm burrows large, and small, and a few obscure fossils indicate the life of the period.

Division D is made up of a great variety of limestone; some pure, others magnesium and still others sandy. A tough banded form of rock characterizes a portion. Thickness, 375 feet.

The division is particularly fossiliferous. The forms here found have roused great interest in the formation; they have been the key to our knowledge of the Beekmantown. They will be noticed as localities bearing them are studied.

Division E is made up largely of tough magnesium limestone with occasional pure limestone and rarely of thin bands of slate. The upper layers are of a ferruginous magnesium limestone notably tough and flinty. Thickness, 470 feet.

Many fossils occur in this division, while in all probability many remain to be discovered and described. The slaty as well as the upper magnesium layers contain many ostrocods.

Thus have been evolved from the Calciferous formation of our county, with its rocks of uncertain composition and order of 500 feet in thickness and scant half score of fossils, a series of divisions of rocks with known structure and orderly arrangement of 1,800 feet in thickness with a wealth of fossils, this formation now the Beekmantown.

The fossils now known as Beekmantown have come most largely from the rocks of Addison County and particularly from Fort Cassin and Shoreham.

Charlotte, Colchester and Providence Island in Vermont, have added to the number, while from New York, Valcour and Beekmantown, and especially Beekmantown, have contributed.

Fort Cassin afforded Professor Whitfield,* in his publication of this fauna, thirty-seven new species, and all but five were new to science.

Subsequently Whitfield added, from the same locality and Shoreham, as many more species, while other fields have increased the number.

A few forms have been added by other observers. And the number is not complete, as no doubt there is a large waiting list to come from better material yet to be found by more complete examinations of known localities. Division E, especially, as well as possible new fields, is likely to give many additions.

From obscure and fragmentary material too poor, thus far, for description, as well as from the incomplete examination of known rock, there still remains, without doubt, a large "waiting list" to be added to these enumerated forms.

Further brief notice of the rocks of the county may be taken here with the expectation that they will be more fully considered when the localities where they occur are studied.

The Potsdam lying below the Beekmantown, now recognized as the upper member of the Cambrian, appears slightly fossiliferous in some localities containing fragments of brachiopods. The Red Sandrock of Snake Mountain and of other localities, as well as the grey quartz rock at the flank of the Green Mountains, regarded as earlier Cambrian,

*Bulletin Am. Mus. Nat. Hist., Vol. 1, p. 293.

are awaiting more careful examination as to character and relationship.

It is to be noted here that the rocks along the lake shore are but little disturbed and quite fossiliferous. East of the Snake Mountain fault, in most localities, fossils become obscure or wholly disappear.

The Utica Slate in this eastern region is somewhat metamorphosed but not sufficiently so as to convert it into good roofing material. The Trenton changed by metamorphism becomes a compact, valuable building material.

The old time term, Sparry Limestone, seems to include Trenton rocks that have undergone strain, partial breaking and refilling of cavities by calc spar or, rarely, by quartz.

The Pre-Cambrian is represented only by travelled stones, as an occasional great boulder has come across the county line from the west or north.

Dike stones occur in place only in a very few localities, and these near the border line north.

The Green Mountain Gneiss, east of the gray quartz up and over the mountain, may be left until the geology of the eastern tier of towns is under consideration.

The prevailing rock most valuable of all, broken from these named rocks and concealing them, the soil, with its incidentals, sand, clay, peat, may be simply mentioned but not here discussed.

The topography of a district is so largely disclosed by the descent of its surface water that this subject finds its place here, and as the Otter River so fully represents this subject, its description properly follows.

The early name, Otter River, may very well displace the popular one, Otter Creek. It is a stream of three counties, receiving the waters of many affluents, some of these themselves bearing the name of rivers.

An observer favorably placed may see on the west side of Dorset mountain two slight, parallel depressions, each carrying down a thread of water, both of which, are said, to have come from the same mountain pond. At the foot of the mountain the twin streamlets part. The waters of the one going south find their way to the ocean by the Battenkill, Hudson and New York Bay, while those going north reach the same Atlantic through the Otter, Champlain, Richelieu, St. Lawrence and the Gulf.

If the river is likened to an enormous elm leaf with its ribs and crumpled midrib laid down upon the rocks of western Vermont, the little thread of the Dorset stream is the very tip, its waters reaching Lake Champlain after a course of nearly 90 miles. The Dorset stream, joined by waters from Mount Tabor and Danby, towns in Bennington County, goes north through the heart of Rutland County, increased along the way by brooks and creeks and rivers coming in from the east and west. Among the larger of these is the creek from Wallingford which, with Mill River, joins the Otter at Clarendon. Mill River has gathered its waters from Mount Holly far up the west side of the Green Mountain. The work of this river has helped to make a pass over the mountains and this valley bed the Rutland railroad has appropraited in making its ascent to the summit.

East Creek, with its branches, carries the waters gathered from Mendon and mountainous heights and adds them to the Otter near Rutland. Tinmouth River, heading in Danby, brings the waters gathered from the western elevations of the valley and joins the Otter at Center Rutland. Furnace River comes in from the north-east at Pittsford, its waters mostly from the mountains forming the east border of Chittenden. Mill River, the second of the name, the last to be mentioned in Rutland County, joins its waters near Brandon village. Leicester River, near the southern boundary of Addison County, is the highway for the gathering of springs and brooks from the heights of Goshen as well as from Silver Lake and waters stored for a time in Lake Dunmore. Middlebury River has its beginning far up the mountains, the headwaters of one branch coming from Hancock, those of another from Ripton in which last town they unite and, passing through East Middlebury, they enter the Otter a little south of Middlebury village. The New Haven River, the last affluent to be mentioned as coming in from the east, carries the water from a large area, a north branch coming from Starksboro, a south one made up of many smaller from Lincoln, these joining in Bristol, and the enlarged stream, still receiving tributaries, passes thru New Haven and joins the Otter below Beldens Falls.

On the west the Lemon Fair River, a peculiar one, reaches the Otter in Weybridge.

This river has its upper waters in Orwell, is rapid at Richville, but farther on passes with slow current through Shoreham, Bridgeport and Cornwall to the north part of Weybridge, having gathered the waters of many small streams before it joins the Otter. Dead Creek, essentially parallel to the lake shore, collects the many slow going small streams to itself from the lake towns, Bridport, Addison, Panton, and in the latter town unites with the Otter.

This record of the Otter and its branches gives but a hint of what the stream and its affluents now are, as well as have been. These have largely made the Otter Valley with its topography. By them are gathered the surplus waters of an area of 925 square miles. By them the rocks of central western Vermont have been sculptured, giving a new face and a new surface to the sun. New passes have been notched over the mountain, while unweighed millions of

tons of pulverized debris stranded along the river banks have made thousands and thousands of acres of fertile intervale. And the quick water of both the smaller and larger streams dashing down rapids or leaping over falls are the source of power where industries center in mills and factories. And where the waters are naturally dammed back the river becomes a navigable stream, as between Middlebury and Pittsford there is a stretch of water, for boats, of 25 miles where the river goes meandering with its loops and oxbows. So, too, below Vergennes, as will be noted later, the Otter becomes a natural canal for larger craft, which the federal government has adopted and cares for as a portion of its inland waterways.

FERRISBURG.

The township Ferrisburg, the most northwestern of Addison County, offers an example both of geological and physical geography quite unique; a microcosm by itself. It has lake and islands, promontory and peninsulas, sharp capes and rounded headlands, a shore with high bluffs, gentle declivities, gravelly beaches, pebbly deltas, sandy and clayey waterlines, straits and shallows, broad bays and safe harbors.

Within the borders are springs, brooks, creeks, rushing rapids, precipitous falls, and navigable rivers. There are lowlands with intervale, sunken lands and swamps, and uplands containing rocky strata, these bearing marks of the wasting action of air and water, frost and moving glacier.

It holds the completion of three drainage systems, the surface waters of an area of near 1,200 square miles, finding thru Lewis Creek, Little Otter and Otter their final way into the lake.

The unbroken rocks include the Lower Silurian or Ordovician, made up of Beekmantown, Chazy, Black River, Trenton and Utica. Then occurs the amazing, almost ageless, geological gap reaching from the Utica to the Pleistocene, a gap that may properly be termed the Ep-Utican.

The term Eputican is here used to indicate the great interval existing in the rocks of western Vermont—the geological gap reaching up from the top of the Utica to the bottom of the Pleistocene—in which, through cycles of years, were deposited in other localities those grand masses which have been distributed as Eras; as the Era of the Upper Silurian, Devonian, Carboniferous, Triassic, Jurassic, Cretaceous, and Tertiary.

The upper surface of the Utica is often grooved and polished by the agencies of the Glacial Epoch, while directly upon the planished surface rests the clay of the Champlain Epoch.

Among the incidents of the Eputican Interval was the destruction of exposed rocks and, especially in Addison county, the wearing out of the Otter Valley.

It was the time of the great uplifts, and faults of the Snake Mountain range also occurred here, the faults that are disclosed on the bottom rocks of the Otter and Little Otter.

In this interval occurred also the Dike period, during which fused masses of rock came up through crevices in Ordiovician rock, filled the moulds in which they were cast and stand out as notable walls where the more perishable limestone has weathered away.

The Pleistocene, often resting on glacial grooved rocks is represented by Champlain clays or by sand from salt seas or glacial deposits with their rare fossils, and later by peat deposits along slow-flowing streams, and last of all and best of all, the rocks, by the enveloping soil of pulverized material mingled with the debris of past animals and plants.

Our further observation may go south from this northwest angle of the towns. Ferrisburg shares with Charlotte on the north the beautiful Ball's Bay, a huge bowl scooped out of the Beekmantown rocks on the north, and Chazy on the south, the excavation having probably been assisted by a fault, an uplift of Chazy B crowding Beekamntown E. The three Cove Islands and the steep cliff east on the mainland have thus far resisted the action of the lake, and stand as memorials of the highest strata of the Beekmantown.

The corrugated rocky shore south is of Chazy B. In many localities fine forms of *Maclurea magna* and *Orthocerata* display themselves. A deep indenture has left Long Point prominent, this the south-west boundary of Ball's Bay. Black River rock as well as Chazy is involved in the formation of the neck of this peninsula.

Gardiner's Island, south and west of Long Point, is of Chazy. To the south and east of the peninsula, Black River appears in mass, while farther east, inland, the road crosses a ridge made up of both Trenton and Utica.

The waters of the two large creeks, Lewis and Little Otter, find their way between Long Point and Bluff Point into the lake and within less than 100 rods from each other.

On the south, the Chazy forms the shore of the lake past Appletree Point to Harris or Porter's Bay with perhaps this one exception. In an early note of the rocks of this shore this remark occurs, "Uplift of Potsdam"; this is at the extreme end of a little bay setting in south of Bluff Point. There has been recent opportunity for verifying this observation, but it is probably correct.

Now between this Porter's Bay and the sandy shore of Field's Bay the waters of the Otter find their way over and around the delta into the lake. Here, north of the mouth

of the river, is a peninsula mostly of solid rock on which breastworks of earth and stone were thrown up in the war of 1812–1814 and the cannon planted here most effectively turned back the British fleet that was seeking to ascend the river for the purpose of destroying the shipyard and ships at Vergennes. This little peninsula has become historic as

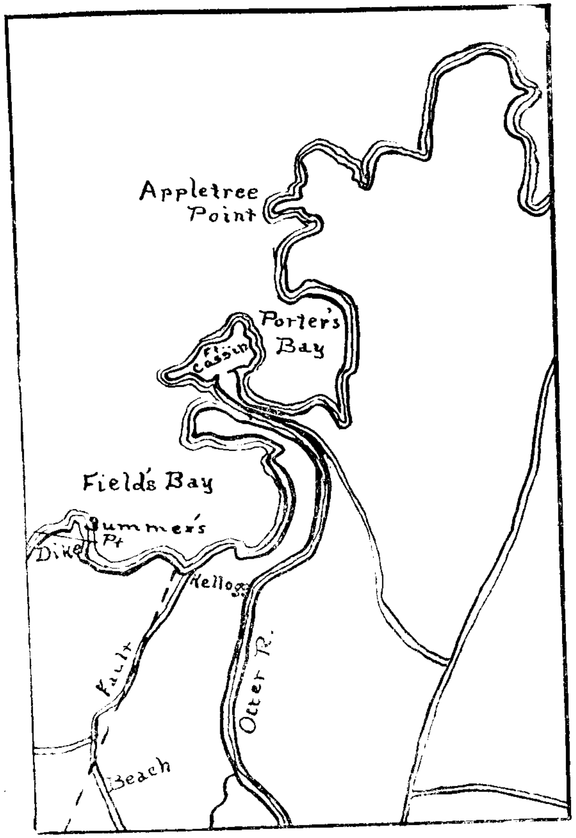


FIGURE 23.
Map of Fort Cassin and Vicinity.

Fort Cassin, and is now classic in geological literature from the number and character of the fossils found in the rocky deposits.

The road on the higher land running essentially north and south past school-house No. 9, is on the Chazy; so also the road leading down to Fort Cassin until the rock disappears under the lake deposit.

The connection of the peninsular rock with that on the upper land is concealed and the geological horizon was for a time quite in doubt. The present accepted opinion is that this bit of rock by a break uplifted them to its present position, the strata belonging really to D Beekmantown.

Much of the original rock had apparently been deposited in quiet bays into which the shells of mollusks and hard parts of other animals had drifted and there incased in a calcareous mud.

The fossils of Fort Cassin will be noticed in other paragraphs.

Across Field's Bay, at Kellogg's, Beekmantown rocks also occur, but their fossils indicate a higher horizon and belong to Division E.

The road running up and south from Kellogg's follows essentially the line of a fault; the rocks on the east are Chazy, Black River and Trenton reaching the Beach place, while those on the west are upper Beekmantown capped by Chazy.

And the Chazy rocks form the low plateau along the nearby upland of the lake west to Basin Harbor. This region has afforded notable examples of the middle Chazy fossil *Maclurea magna*, the most elegant ever obtained having come from the locality near school house No. 10, and south of the road from beneath the soil of a garden cultivated at that time by Mr. Joseph Newton.

The lake shore south and west from Kellogg's, a region most interesting and instructive, has at first Beekmantown rock at the water line. A little to the west at Summer's Point is a rare phenomenon, the only lake shore dike of the county, a dike or almost a table of Bostonite* breaking up thru the stratified rock. A similar dike is found inland, very near the north border of the towns.

Going on westw rd the base of the Chazy appears as a sandstone; the Isle La Motte Sandstone, with a characteristic fossil, *Lingula limitaris*, then follows on the various calcareous strata with their many fossils of this lower or A Division. The strata seem gradually rising out of the water and B Division appears and continues until Basin Harbor is reached. Just before reaching Mile Point on the shore on the way, the rocks in the cliff and fragments in the water make a notable display of the little calcareous sponge, *Strephochetus ocellatus*,† as tho this was especially its home, a little organism often appearing as bird's eyes looking out of the containing stone. The microscopic structure of this fossil, like all members of the genus, with tangled canals, appears wonderfully striking when set beside that of *Solenopora compacta*, a little fossil to be noted farther on. Attention has been called previously to this strange form, particularly in the Vermont Report for 1901–1902, pp. 151–161. And in Report for 1907–1908, pp. 187-188, it is shown that a portion of the undissolved silicious materials remaining over from treatment by dilute acids appears in the form of minute stars and bars or Stellae and Rabdoliths.

*See Trap Dikes of Lake Champlain Region, Bulletin U. S. G. Survey No. 107, p. 18. Kemp and Marsters, 1893.

†See American Journal of Science, Vol. XXX, p. 355, November, 1895. A New Genus of Chazy Sponges, Strephochetus.

The rocky exposures of Basin Harbor have long been noted for their fossils. This harbor of itself, like a bowl scooped in the lake shore rock, is characterized by Professor Thompson in his VERMONT as one of the best in the State. He might have truthfully added and one of the smallest.

Going south the little off-shore island, Scotch Bonnet, is of Black River rock. The rocks along the shore show higher and higher horizons of the Chazy until they reach a point like the end of a sickle and form the north-west boundary of Button Bay. From the sandstone west and south from Kellogg's, to Button Bay Point, the strata of the Chazy have been rising.

In this preliminary survey the unique opportunity for careful study could not be fully improved. No doubt many new facts are waiting. Certainly accurate measurements are still needed which will enable the observer to compare this field with other localities more carefully studied. In the upper Chazy rock at Button Bay Point there is a sparsely scattered rounded fossil of half an inch to one inch in diameter which is found abundantly at the same horizon on Isle La Motte. It has borne different names, has been obtained from different horizons, is still of doubtful relationships. The accepted name is *Solenopora compacta*.

The species has been known by the following names:
Stromatopora compacta, Billings.
Tetradium peachi, Nicholson and Etheridge.
Solenopora spongioides (?) Dybowski.
Solenopora (?) *compacta*, Dawson.
Tetradium peachi var. Canadense, Foord.
Solenopora compacta, Dwight.
Solenopora compacta, Nicholson.
Horizon, Black River, Billings.
Trenton, Dwight.
Chazy, Seely.

The illustration, Figure 24, is from a drawing by Professor Dwight of Vassar College, after that by Foord. Its horizon is that here given, very near the upper limit of C Chazy.

Turning now the sickle point and entering the embayment one finds, to the north and east, not solid rocks but clayey banks which continue along the bow formed at the lake shore until he reaches, half way to the handle of the sickle, a little round island, perhaps of Utica rock, which at low water may be attached by a low causeway to the main land. Now southward Utica, Trenton, and Black River rocks appear and the southern boundary of Ferrisburg is reached.

Along the shores of this bay, as well as at other localities not here designated, are banks of clay of varying height. Season by season frost and rain and high water attack these banks. A portion of the material falls to the water line and is worked over by the waves. The finer material makes

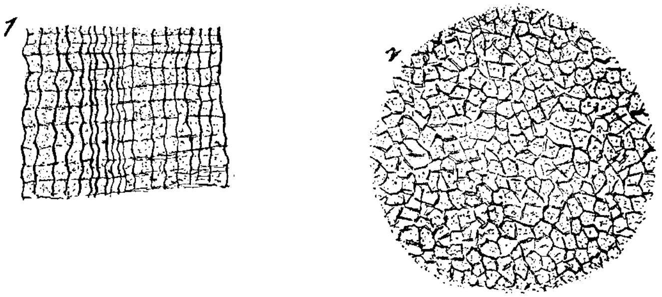


FIGURE 24—*Solenopora compacta*, Billings.
1—Longitudinal Section x 40. 2—Transverse Section x 40.
Drawn by Prof. W. B. Dwight from Foord's figures.

a roily cloud with the water and is carried out into the lake. The coarser particles mostly remain at the water line and here is revealed the further contents of the clay. Shells of bivalves of the Champlain period such as *Mya*, *Saxicava*, *Macoma* and the like, once incased, are now released.

The waters of the lake at times bring in the shells of species of mollusks now living, so that the old and new are mingled. Should these mingled shells by any chance become fossilized the geologist of long hence would be perplexed to account for the occurrences of various forms from different waters within the same rock.

Besides shells, concretions, some of strange imitative forms, are loosened from the clay. These argillo-calcareous bodies have apparently been formed within the clay after deposition. A form particularly abundant in the banks of the bay has the shape and size of a turned wood button-mold, a disk with a hole in the center, plane on one side and convex on the other. The abundance of these has given the bay its popular name, Button Bay.

The lake shore clays contain lime, and the suggestion is that the lime finds a perpendicular plant or root as a nucleus about which it gathers, as the root decays, in a disk form, the complete decay leaving the hole in the center. The concre-

tions have a general likeness in composition, but they vary too much to be regarded as true chemical compounds.

Returning north to the sickle point of the bay there is found a remarkable mass of Black River rock, in a way in range with Scotch Bonnet north, but much larger, which, broken from the rocks of the mainland, has resisted wave and ice action; this is known as Button Bay Island. A unique feature, too strange to be described in words, is the occurence within the mass of a stratum compacted wholly of two characteristic fossils of the Black River, *Stromatocerium rugosum* and *Columnaria alveolata*, the latter popularly designated Petrified Wasp Nest. This island has furnished our Vermont museums with their most valued illustrations of Black River fossils.

This examination of the rocks along the west and south border of Ferrisburg has been made possible, by the action of the waters of Lake Champlain, these waters having a mean height of 97 feet above the sea level, varying, however, between low and high stages from 93 to 101 feet.

Now, inland, a new but most common phenomenon occurs; the solid rock is mostly concealed, the surface is a covering of clay or, rarely, of sand. The conditions are as tho the waters had prevailed, the land having gone down or the waters having arisen. Clays and sands such as are found along shores and off shores hide mostly what is beneath.

Repeating the accepted explanation; at a comparatively recent period in geological history the water really did prevail and the solid rocks were at the bottom of a great lake, this great glacial Champlain lake extending to the foot of the Green Mountains. By a depression of the land at the north, later, it became an arm of the salt sea connecting north and east with the Atlantic. Still later a grand elevation made much of the lake bottom dry land, with its clay stretches and sand beaches with their contents. The lake towns of the county particularly shared in all these changes, and the land is the old Champlain sea bottom, yet modified by the ever acting physical agents.

It is a matter of personal regret to the writer that he cannot revisit the points already described and verify every statement. Also in some of the statements to follow, his notes are in many cases too scant, particularly of the north and east part of the county. Yet it is hoped that the student and future observer will be helped and not hindered.

The fertile fields of much of the western and middle part of the town are covered with clays. Inland from Button Bay, north, is Dead Creek. Essentially parallel with this, west, is the general highway which farther west is bordered by a long line of rock, chiefly Black River. Still farther east, across the Otter, in various places are clay beds, a portion of which have been economized as brick yards.

The Little Otter, just west of Ferrisburg Center, makes history for itself by leaping down Beekmantown rocks, giving the water power there developed. This history may be suggested. Back in geological ages during the great Eputican age a mighty movement of the solid rocks of the locality took place. The rocks could not withstand the earth rolling and earthquaking they were subject to. The Beekmantown rocks rose up and pushed over the Chazy, Black River, Trenton and Utica. During the tremendous thrust a profound fault was made, the Beekmantown abutting against and over-riding the Utica. This phenomenon, this overlapping of the Beekmantown, may be seen beneath the railroad bridge as well as that of the highway.

To the east the uplands are largely covered by soil but, when exposed, they at times contain partly metamorphosed Trenton fossils. The western slopes of the hills are of shaly debris, probably from breaking down of the Trenton. Near the north-east boundary the Utica appears in places, and here, too, appears the second dike of the county.

Very few new observations can be offered upon the rocks of East Ferrisburg. As to the character of Shell House Mountain, Marsh Hill and other eminences one must consult what has previously been given by Hitchcock.

Before leaving Ferrisburg, and especially Fort Cassin, certain historical facts regarding discovery, horizon and naming should here be recorded.

A favorite holiday excursion in the middle eighties of last century by the writer and several of his colleagues of the college was a morning ride by rail to Vergennes, thence down the Otter to its mouth in the little steamer, landing at the dock at Fort Cassin and then, by skiff, out and among the nearby islands and promontories of Lake Champlain.

The fossils inclosed in the Fort Cassin rock had a strange look. What could they be? Trenton and Chazy rocks are close by. These remnants of chambered mollusks, could they be Conrad's *Trocholites* so admirably figured by Hall? Then the rock must be Trenton. But the associated fossils certainly could not be Trenton. Turning to the Chazy; if Chazy, they belonged to a new and deeper horizon that had not been hitherto examined. While discussion continued the collection of new forms increased. By the best of fortune Professor R. P. Whitfield, of the American Museum of Natural History, of New York, consented to examine these fossils that seemed new and to report upon them. They came under his eye and hand. The masterly result of his study, with his illustrations, is to be seen in Bulletin Am. Mus. Nat. Hist. N. Y., Vol. I.

The result? From the little Fort Cassin promontory came the addition at that time of thirty-one species of fossils new to science, ten that had also been previously known, and still other undescribed forms too poorly preserved to be described. Later Professor G. H. Perkins, of the University of Vermont, joined the writer in a good number of successful explorations. Professor Whitfield also studied these additional forms and published his results in subsequent numbers of the Bulletin.

The geological horizon of Fort Cassin and its fossils was, for a time, in doubt. Professor Whitfield placed the fossils in the New York formation, the Birdseye, and they went into geological literature as Birdseye. The U. S. Geological Survey made a large collection and it was said that the authorities, without hesitation, placed them as Chazy. The writer thought first they were probably Trenton, but later considered them as belonging to layers of the Chazy which, up to that time, had escaped observation.

Assuming that Professor Whitfield's views were correct, weeks were spent by the writer and friends in most careful search among the islands and shores of the lake with the expectation of finding Fort Cassin rocks at places where the Black River and Chazy rocks approached each other. But in every case the Black River rested directly upon the Chazy without any Birdseye between. Both Stave Island and Providence Island were found to contain Fort Cassin fossils, but they could not be used to determine the horizon.

However it was found that all the divisions of the Calciferous lay on the north shore of Ball's Bay; here were in order A, B, C, D, E and Division D contained Fort Cassin fossils, Calciferous rocks above, Calciferous rocks below.

It was the geological acumen of President Brainerd that fitted the key and opened the door to the mysteries of the Fort Cassin horizon. The little peninsula, a mine of fossils, was not Trenton, nor Birdseye, nor Chazy, but the upper part of divis'on D Calciferous, 1,000 feet below the horizon in which it was first placed All subsequent observations have confirmed this horizon of Fort Cassin.

The group of Beekmantown fossils which were obtained at Fort Cassin is so peculiar and of such interest that many of the more characteristic species are shown on the plates at the end of this paper. A list of all the species found hitherto, and, as the locality appears to be pretty nearly exhausted, of probably the entire fauna of the locality or nearly so, is given below. In regard to the nomenclature of the Cephalopods, it may be well to explain that the names in brackets are those given by Dr. R. Ruedemann, as stated at the close of this paper in CEPHALOPODA OF THE CHAMPLAIN BASIN. Some of the names of gastropods and other forms have also been changed, but it has not been thought best at this time to undertake a complete revision of the nomenclature used by Professor Whitfield. It may also be added that many of the species given in the list have been found elsewhere, notably Providence Island and Valcour Island in Lake Champlain. Nowhere, however, has such a variety and abundance of these singular forms been found within a small area as at Fort Cassin.

List of Beekmantown Fossils Found at Fort Cassin.

TRILOBITA.

Asaphus canalis, Con.
Bathyurus caudatus, Billings.
Bathyurus conicus, Billings.
Bathyurus perkinsi, Whitf.
Bathyurus seelyi, Whitf.
Bolbocephalus glandicephalus, Whitf.
Bolbocephalus seelyi, Whitf.
Bolbocephalus truncatus, Whitf.
Harpes cassinensis, Whitf.
Nileus striatus, Whitf.

CEPHALOPODA.

Cyrtoceras acinacellum, Whitf.
Cyrtoceras confertissimum, Whitf.
Gomphoceras cassinense, Whitf.
(*Cyclostomiceras cassinense*, Ruedemann.)
Gomphoceras minimum, Whitf.
(*Cyclostomiceras minimum*, Rued.)
Lituites eatoni, Whitf.
(*Schrœderoceras eatoni*, Rued.)
Lituites eatoni, var. champlainesis, Whitf.
(*Schrœderoceras cassinense*, Rued.)
Lituites internestriatus, Whitf.
(*Trocholites internestriatus*, Rued.)
Lituites seelyi, Whitf.
(*Tarphyceras seelyi*, Rued.)
Nautilus champlainensis, Whitf.
(*Tarphyceras champlainense*, Rued.)
Nautilus kelloggi, Whitf.
(*Eurystomites kelloggi*, Rued.)
Nautilus perkinsi, Whitf.
(*Tarphyceras perkinsi*, Rued.)
Orthoceras bilineatum, Hall.
(*Spyroceras bilineatum*, Rued.)
Orthoceras brainerdi, Whitf.
(*Cameroceras brainerdi*, Rued.)
Orthoceras cornu-oryx, Whitf.
(*Orygoceras cornu-oryx*, Rued.)
Orthoceras explorator, Billings.
(*Cameroceras brainerdi*, Rued.)
Orthoceras sordidum, Billings.
(*Endoceras montrealense*, Billings.)
Piloceras explanator, Whitf.

GASTEROPODA.

Bellerophon cassinense, Whitf.
Calaurops lituiformis, Whitf.
Clisospira lirata, Whitf.
Ecculiomphalus compressus, Whitf.
Ecculiomphalus triangulus, Whitf.
Ecculiomphalus volutatus, Whitf.
Euomphalus circumliratus, Whitf.
Helicotoma similis, Whitf.
Holopœa arenaria, Bill.
Holopœa cassina, Whitf.
Holopœa turgida, Hall.
Lophospira cassina, Whitf.
Maclurea acuminata, Bill.
Maclurea affinis, Billings.
Murchisonia cassina, Whitf.
Murchisonia obelisca, Whitf.
Murchisonia prava, Whitf.
Ophileta complanata, Van.
Pleurotomaria difficilis, Whitf.
Pleurotomaria etna, Whitf.
Raphistoma compressum, Whitf.
Raphistoma hortensia, Bill.
Subulites obesus, Whitf.
Tryblidium conicum, Whitf.
Tryblidium ovale, Whitf.
Tryblidium ovatum, Whitf.
Tryblidium simplex, Whitf.

BRYOZOA.

Rhinopora prima, Whitf.

BRACHIOPODA.

Hemipronites apicalis, Bill.
Orthis evadne, Billings.
Protorthis cassinensis, Whitf.
Protorthis minima, Whitf.
Riberia compressa, Whitf.
Streptorynchus prinordale, Whitf.
Triplesia lateralis, Whitf.

Not found at Fort Cassin, but found in rocks of the same age at points not far distant are:

Murchisonia confusa, Whitf.
Isochilina cristata, Whitf.
Isochilina gregaria, Whitf.
Tsochilina seelyi, Whitf.
Cryptozoon steeli, Seely.
Cryptozoon wingi, Seely.
Wingia discoida, Seely.

Several slabs with prominent casts of large Algæ have been found at Fort Cassin, but they have not been determined specifically.

In the matter of names it may be briefly said that East Beekmantown, Clinton Co., N. Y., has offered the writer opportunity for geological observation during a small part of the vacation of the summers of 1884–1888. A creek at this locality, known at its lower lake level as mud Creek, has, at its highest reaches, a rapid current with rocky sides and bottom with large and tough boulders in the stream. These boulders yielded, from time to time, to the persevering hammer a good number of fossils that had not been described or figured in the books. Some exposed ridges farther up offered noble examples of *Ophileta* such as the writer had gathered from Bridport and Shoreham rocks. These Vermont rocks were Calciferous. It was the quick and safe conclusion that these Beekmantown rocks were Calciferous and that here was an unrecognized locality of Calciferous fossils.

Professor Whitfield had become interested in these new fossils and in the summer of 1888 we met, went over the creek and the ledges, gathered with the help of friends, an addition to our collections. The results of Professor Whitfield's study are embodied in an article in Vol. II of the Bulletin.

The geological authorities of the state of New York later made extensive collections at East Beekmantown. And now there has been an accumulation of fossil forms from Valcour mainland, Shoreham, Providence Island, Ball's Bay, Fort Cassin and Beekmantown, enough to warrant the slipping off of the early undescriptive name Calciferous, and the putting on of one named for a locality.

We have been accustomed to follow the lead of the New York geologists. Dr. Clarke chose Beekmantown and Beekmantown has been accepted rather than the more appropriate term Fort Cassin.

PANTON.

Panton, with its bounds of Ferrisburg on the north, Addison on the south, Otter on the east, separating it from Waltham and the lake on the west, is divided into two nearly equal parts by the slow running waters of Dead Creek. Champlain clays form the largest surface part of the town, one largely of level fields. The lake exposes solid Utica rocks on the northwest shore along the historic Arnold's Bay, clayey banks farther south, and rocks of Chazy(?) along the south west shore.

Along the highway near and essentially parallel to the lake shore, much of the Lower Silurian rocks appear as a wrinkling uplift, particularly Beekmantown, E Chazy and

Black River. Some of these rocks are found on the roads connecting the two principal highways. At the village of Panton, one of the churches is set upon the Black River, and the second one upon the Chazy.

As far as at present observed the rocks of Panton are scant of fossils. The E Beekmantown contain many Ostracods, not yet fully studied. Until more fully examined it is not safe to say that no beds of D Beekmantown have been raised to the surface offering new localities for the gathering of Fort Cassin, and even new fossils.

The Utica rocks of Panton contain fossil graptolites and trilobites, but these now in a very fragmentary condition. The *Diplograptus pristis*, Dr. Rudolph Ruedemann, of the New York State Museum, at Albany, has found, in a very nearly full state of preservation among the New York Utica rocks, and has given to science, life-like figures of the graceful little animal.

For years the trilobite was an enigma to paleontologists. Its appendages as well as method of locomotion and respiration were unknown. Now, however, the structure (of the sub-class) has been made plain by the study of the form *Triarthrus becki*, the Utica rock Trilobite.

The names Green, Viliant, Matthew, Walcott, and Beecher are attached to this study. Professor G. H. Perkins has been fortunate in finding almost complete examples in the Utica rocks at Alburgh. From fortunate finds in the Utica rocks near Rome, N. Y., specimens, most perfectly

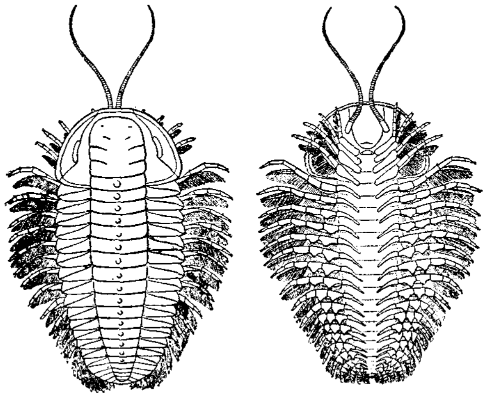


FIGURE 25.
Triarthrus becki.

preserved, the organic matter having been replaced by pyrite, have been obtained. By the most wonderful skill of Professor Chas. E. Beecher, this aged old form of *Triarthrus becki* has been recovered, every portion revealed, the antennæ exhibited, and the most delicate details of organs of locomotion and respiration shown. Of the two thousand species of trilobites, this is the best known.

This further is to be noticed of a portion of the towns. Baldwin says, in his Pleistocene History of the Champlain Valley, American Geologist, Vol. XIII, page 172, that a well defined Esker, a ridge of coarsely stratified drift, runs through East Panton and Addison from Vergennes to Snake Mountain, rising about 150 feet above the plain and sloping steadily to the south. It rises above the clays but is partially buried in them. Merwin, in the Report of the Vermont State Geologist 1907–1908, page 120, interprets the phenomenon differently, regarding it as the result of wave lines with pebbles and patches of gravel on a limestone ridge.

The whole region gives evidence of the former action of ice and wave.

ADDISON.

Addison, next to Panton, is one of the four towns that succeed each other south, having common features in that they have practically a square outline, are bounded west by the lake, and east by a row of interior towns, and once were included in the Glacial Lake Champlain. Like Panton, its surface is divided into two fairly equal parts by Dead Creek, formed within the town by the east and west branches. Exceptions to the usual northward flow of this and the surrounding region are found in the contents of Hospital Creek and Ward's Creek, which, breaking thru lake-bordering rock, flow westward.

The southwest corner of Addison is full to overflowing with political history. It was here at Chimmey Point that European civilization first established itself within the borders of Vermont. Here, in 1731, the French took possession of the region. Just across the lake, here a narrow stream, arose the fortress, Fort Frederick, with its accessories and successors. With this bulwark and outpost, Chimney Point shared the struggles, defeats and victories that have made Crown Point memeorable.

The geological history of Addison, which we can read only in part, is as notable as its political. Though like the adjoining towns it has shared in the wide influence of glacial movement, and like them was covered by the Champlain and marine sea, still it stands apart from all these towns, having in some features a geological record wholly its own. This will appear in further study.

For convenience we may consider successively the lake border, the intermediate region, and the eastern border. The western border is of a crumpled and slightly elevated lip of the series of rocks from the Chazy up to the Utica and the solid mass most often capped by Champlain clays.

Beginning at Chimney Point, here at first appears the Chazy. Following the highway north the road crosses the upper portion of the Chazy, then the Black River lying to the east.

If one goes back and follows the shore, the Black River disappears from view, being broken and covered by clay. There follows, as one may suggest, a compact hardened mass of Trenton which has resisted the action of the lake and stands prominent as the picturesque Wright Point. The rock is covered by clay. However, at lake level, where water and rock meet, the clay is season by season removed and there are exhibited fine and coarse striæ covering the rock, fresh as tho just made. The broken masses of rock bordering the water yield to the hammer elegant examples of Trenton fossils.

Still north the mouth of Hospital Creek is probably a gap in the Black River where wave and ice have broken the brittle rock, an example of many coves and bays occurring along the lake.

The Trenton rocks well hold their own along the shore north, carrying many characteristic fossils, Brachiopods, Trilobites and others. Particularly to be noticed, the abundant occurrence, both as individuals and masses of the mushroom Bryozoan, a form bearing since first observation many names, now resting as *Prasopora lycoperdon*, a fossil most helpful in determination of rock masses largely metamorphosed.

Still north and beyond Norton's Bay the Utica appears at times as the lake shore rock. And here is a rare opportunity for measuring the thickness of the Trenton in Vermont, the Black River being on the east and the Utica on the west. The measurement gives, for the entire formation at this place, a thickness of 314 feet.

Still north are the prominent localities, Elm Point and Potash Bay. Unfortunately exact notes are not at hand to accurately mark the rocks of this interesting shore with its points and embayments.

Across Addison from west to east one passes over the bottom of the ancient Champlain sea, this bearing at its borders, east, evidences of ice and wave action all modified by the weathering of subsequent ages.

As already noticed, this old time sea bottom is now drained north by Dead Creek and the branches forming it. And now stands out on the east that unique feature of all the region, Snake Mountain.

Here and there not far from the foot are uncovered patches of all the Ordovician rocks. The south town road meets the north and south road near Hank's, and here is a display of Beekmantown. On the nearby parallel road, at A. Smith's, the Chazy with its fossils appears. Then follows, in remarkably quick succession and in their natural order, the Black River, Trenton and Utica, these crowding upon the precipitous foot of the mountain.

And here rises a mountain with composition and character entirely different from that heretofore found. The masters of geological science have come hither, observed, thought and according to their light, have given out their conclusions.

Professor E. Emmons, in 1842, in his Report of the Second Geological District of New York, gives a brief and appreciative description of the phenomenon. Apparently he was drawn across Lake Champlain to observe this broken uplift. He says, "Seven miles to the east, Snake Mountain rises boldly from the midst of the plain * * * *. The fracture here spoken of is the most interesting and remarkable of all the geological phenomena which have been disclosed during the New York Survey."

Professor C. B. Adams, in his Second Annual Report of the Geology of Vermont, 1846, gave a section of the rocks of the mountain as these appeared to him and called the uppermost by the name of Red Sandrock. The term Red Sandrock Series was accepted as designating the whole uplift.

Professor Rogers of the Pennsylvania Survey, after a visit in 1851, gives his views of the region and attempts to correlate the rocks with those of his own state.

Pr fessor E. Hitchcock, in his Report, 1861, approves Adams' observations and offers an illustration apparently modified from that of Adams'. He characterizes Snake Mountain as one of the most noted localities in Vermont as respects geology. Further fragments of Hitchcock's description—"The height above the lake is 1,220 feet and above the sea, 1,310. * * * * *. The elevation has its maximum east of G. Wilmarth's house, * * * * * the west side of the mountain presents for two miles a nearly perpendicular face. * * * * the sandstone slopes east at a varying inclination 10°–20° and disappears at the Otter River."

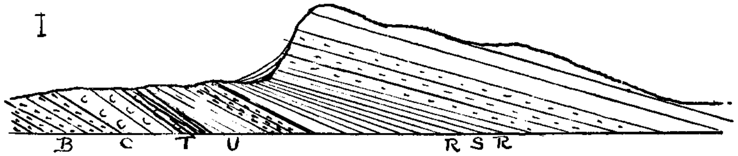
The eminent teachers of science, already mentioned, recognized the prominent features of this remarkable phenomenon; the uprise of a notable mass of rock, a great fault, the strata being broken to a profound depth and extending miles north and south. They readily accepted the conclusion that the strata of sandstone was in its natural order, lying directly upon the Utica or other slates, and probably it might correspond to the Medina sandstone of the New York series of rocks.

Later investigation showed that the phenomenon was even greater than they had conceived; that the sandrock instead of being a later rock than the Trenton, Utica and the others, was really older, was the Potsdam or upper rock of the Cambrian, that its present superior position had

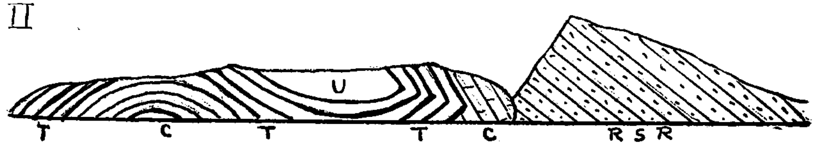
come about by displacement of strata; that in the stress and strain of the profound faulting, the eastern part of the break had been lifted up and thrust over the west, so that the older Cambrian now rested on the younger Utica.

This overthrust of the Cambrian upon the Utica is best seen at the north part of the mountains; more nearly the middle, the Cambrian abuts against the broken and somewhat elevated edge of the Ordovician strata, while

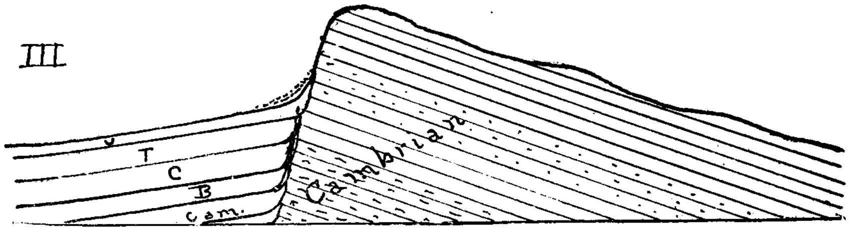
Snake Mountain, Addison



Adams'-Hitchcock's Figure. Sandrock resting directly and comformably upon the Slates. Exact locality not given.



Wing's Figure. Great break recognized. The sandrock abutting against Chazy and Trenton folding the strata back and over the Utica. South end of Snake Mountain. Exact location not given.



B Beekmantown. C Chazy. T Trenton. U Utica. RSR Red Sand Rock

FIGURE 26.

Theoretical figure. Great break opposite the highest part of the mountain. Strata as now recognized. Raised and crushed as they abut the Cambrian. Cambrian to the north end pushes over the stata as a cap.

farther south, at an unnamed locality, Wing found that the thrust had crumpled and folded the Ordovician until the natural order was wholly reversed.

Further personal notes, indicating the character of the north part of the mountain, mention the occurrence at the order of a shelf of sandrock 15–20 feet thick, capping the underlying Utica. A small stream of water finds its way over the lip and falls as a broken shower upon the debris below, making a cave-like depression in the strata.

Under the table sandstone and slate are in contact and in places it can be seen that the sandrock had been thrust westward above the slate, over-riding it at an angle not far from seven degrees. Here and there a tongue of sandstone has penetrated the slate; examples of sandrock may be gathered with sides blackened by their grinding contact with the black slate.

From this north end of the mountain, over the clay fields of the north-eastern part of the town, Professor Baldwin, as noticed under Panton, illustrates what he regards as a well defined Esker reaching as far north as Vergennes.

One can hardly turn from Snake Mountain without questioning himself as to two matters, the time of its elevation, and the forces combining to elevate and shape the structure.

Of the time, the period of its elevat'on and shaping, some phenomena to be observed in the Champlain Valley will help to answer, tho the answer may be quite vague.

In this valley, as before noticed, there is a great gap in the geological series, this between the old time Utica and the recent Champlain, a passing Eon, during which elsewhere a world of rock and mountain had been built. Here is a great non-historic interval, the Eputican Interval.

Yet remnants of geological phenomena that must have occurred during this interval remain. The dikes and dikestones of the Champlain islands and headlands were erupted then.

They pass up thru the Utica showing their origin to be later than the Ordovician, so they must be placed in the Eputican Interval.

Rock movements and rock quakes along the streams of the Valley occurred within this Interval as will hereafter be noticed. And the mountain itself helps to complete the enormous calendar of time. The Cambrian has risen up and enfolded the Utica and this certainly took place in the Eputican. It rose before the Glacial for the eastern side of the mountain is scored by ice, which no doubt over-topped the highest point.

It should be noticed that the top of the mountain in all probability stood out as an island in the later Champlain sea. The time of these phenomena was the great Eputican Interval. The forces! Whatever force makes movements among the rocks must be taken into account, whether it be the changes in the volume of the rock, pressure from without or other cause. The rocks, solid as they are and inflexible as they appear, are nevertheless on the move, adjusting and re-adjusting themselves, the movement so slow as to be imperceptible or with earthquake rapidity.

The force making the movement among the Vermont rocks was apparently largely a pressure from the east, from the ocean. The upper strata may have been thrown up into folds and these snapping with a precipitous face to the west.

What great obstacle or hindrance to this westward movement occurred, near what was later East Addison, must remain unknown—the Adirondack uprise seems too far away—but apparently a wave of deep down rock rose up into a fold of tremendous proportions, the stiff rock, pressed beyond its yielding capacity, snapped in a great break, the Cambrian strata appearing in great force, a sharp precipice high up in the air looking westward towards the lake.

The aerial forces operating thru the remainder of the great interval smoothed and weathered away how much of the sharp features of the broken fold can hardly be imagined.

The Eputican Interval closes and now a new force! The Glacial Epoch comes and the ice which plowed and scored the whole country especially exerted its tremendous power upon the higher impediments in its path. It broke away unweighed tons of Cambrian rock from the fractured fold and scattered them as boulders over the region reaching the foot of the Green Mountains.

Whatever the time of uprise and whatever the forces of elevation and sculpture, this monument looks over the cycles of the grand interval, the coming and going of the Champlain ice and sea, the reclothing of the land in green, the coming of man upon the earth, and to which we may look almost as a reverent memorial of the long past, venerable when the pyramids and sphinx were young.

BRIDPORT.

Bridport contains all the various rocks found in the towns already described. These, however, are mostly in a horizontal position leaving the surface level; the north-east border tho is an exception, as here they have beene levated and much crumpled and distorted.

The surface drainage is towards the north, the branches West and East which flow thru Addison and unite in Panton to form Dead Creek have their origin in the south part of the town. The slow moving Lemon Fair River cuts into the south-east corner of the town.

The Champlain clays hold their own over much of the surface, hiding mostly the underlying Ordovician and Cambrian rocks. Along the shore, going from the north border south, the lake discloses Utica rocks just north of Port Franklin and again, further south, near and at thelo cality formerly

Jones' Wharf. The Utica here yields many examples of *Diplograptus pristis*, tho in a fragmentary condition.

Farther south, at the ferry landing opposite Crown Point village and still farther south, Black River and Chazy appear.

The upper division of the Beekmantown with *Isochilina* comes to the surface in certain places in the south portion of the town, particularly near the head of West Branch and again on the road connecting Bridport Village and Shoreham, not far from the border line. On the west part of the town, but quite a distance from the lake, there are a few uplifts of Trenton and Chazy. The rock exposures north and east in the vicinity of Bridport Village are of Utica rock.

In the north-east part of the town is repeated, on a small scale, the rocky condition found in the vicinity of Snake Mountain; the Beekmantown very near the north-east border and then farther south and east, a rapid succession of the Utica, Trenton, Black River and Chazy; then follows the Cambrian.

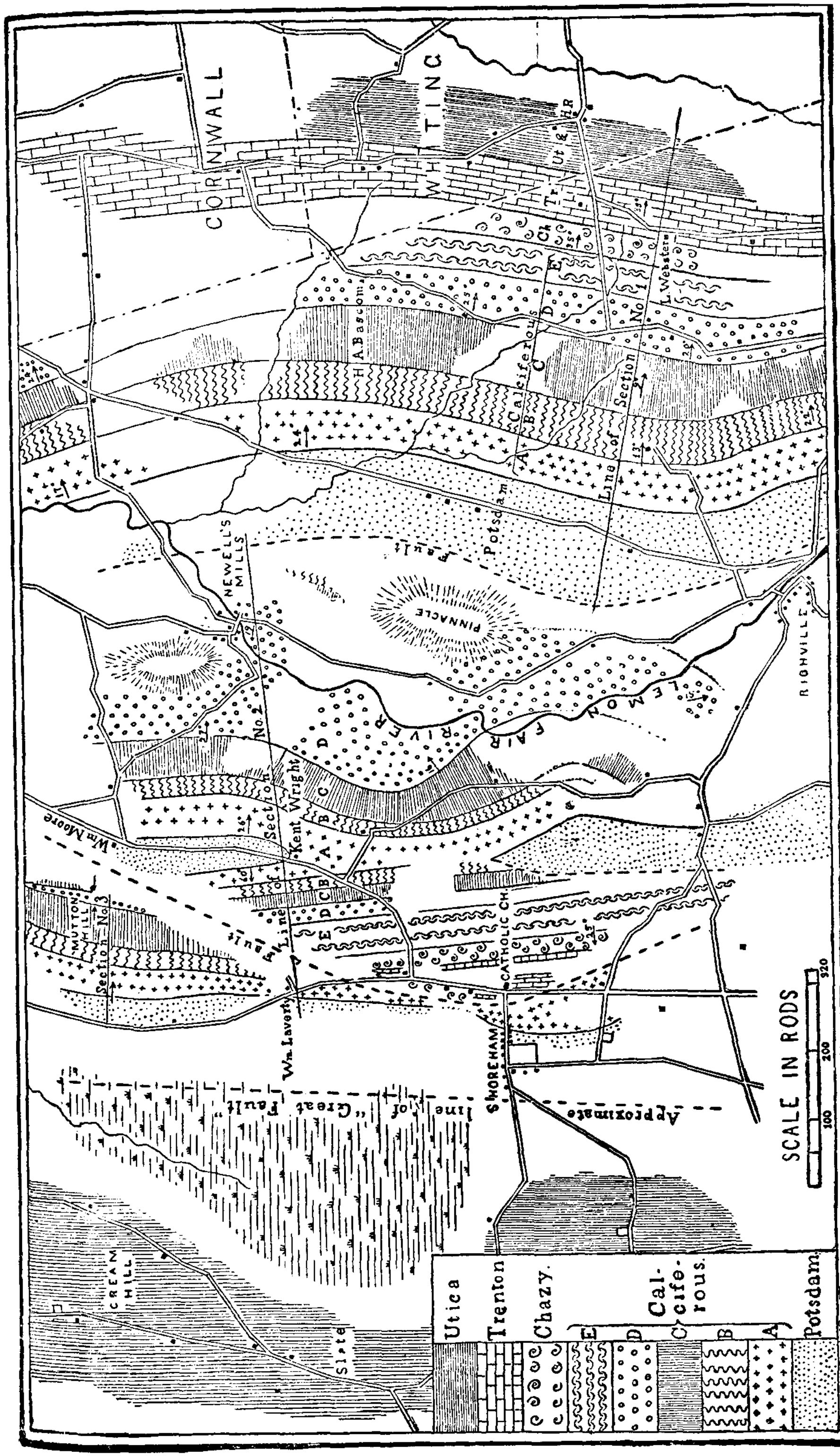
The historic Amherst road, built in preparation for an attack on Montreal, from Chimney Point to No. 4, now Charlestown, N. H., the western part made by Gen. John Stark, passed thru the entire town south-east on to Shoreham and Whiting, leaving here and there traces still distinguishable.

SHOREHAM.

This town in its western part nearly duplicates the one just north. Its eastern portion, however, is peculiar to itself, as is its drainage system, that of the Lemon Fair River. The Lemon Fair gathers its head from many scattered streams, even in the extreme south of the town of Orwell, and the west of Whiting, and makes many turns to get around uplifts that bar its northward course. It passes thru eastern Shoreham, slips off to the south-east corner of Bridport, as has been mentioned, cuts away a nearly square corner of northwestern Cornwall, then passing the greater length of Weybridge, this Mud-Maker loses itself in the Otter River. The Fair has been rightly regarded as a sluggish stream except at spring or other overflow time, then it is a full river. In Shoreham, however, it is for the most part a lively stream.

The uplift of the Potsdam at and in the vicinity of Richville gives a water power prized since first settlement of the town. And farther north, in the Beekmantown, water privileges are afforded at Newell's Mills.

Going back to the lake shore the rocks of the Utica appear at Five Mile Point. Hand's Cove, historic as the point of departure by Allen and his men on their successful venture against Fort Ticonderoga, has along the north side a display of



EAST SHOREHAM. VT.
FIGURE 27.

Utica. Larabee's Point, still a steamboat landing, is geologically the most interesting locality of the shore. Here, within a small space, three formations of rocks are exhibited. Lower down is what is believed to be the Beekmantown, then directly upon this is the Black River without the usual occurance of the Chazy be-

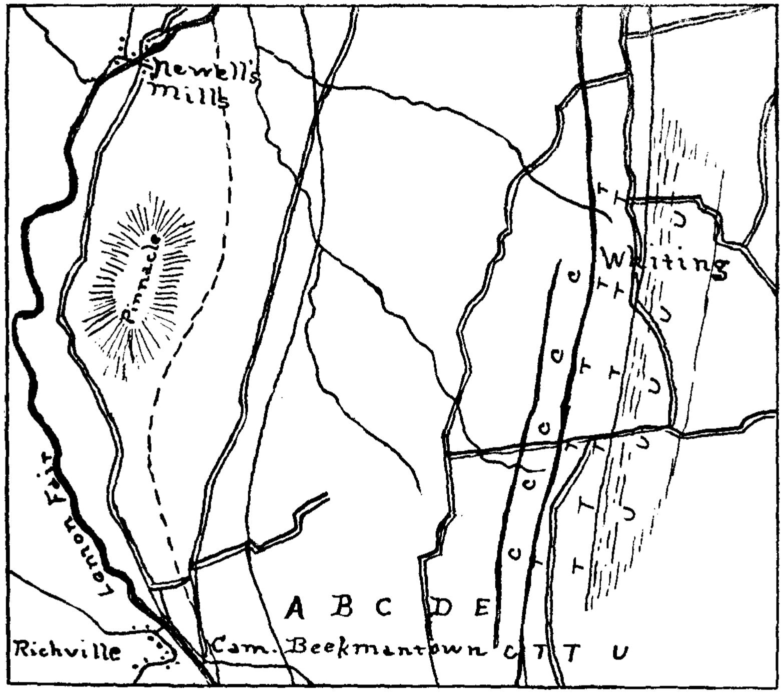


FIGURE 28.

Map from near Richville, eastward. In a narrow space are found upper Cambrian, Cam.; Beekmantown, five divisions, A, B, C, D, E,; Chazy, C; Trenton, T; Utica, U; and Pliestotocene.

tween, while above the Black River is a mass of fossiliferous Trenton. The interest centers in the deposit of Black River, a formation so full of varying fossils, so persistent along both shores of the Champlain, here particularly notable for its compact character, receiving cutting and polishing like a marble and often called Black Marble.

In the early forties, Dr. E. W. Judd, the pioneer of sawing marble by gangs of toothless saws, had discovered and worked this quarry, taking blocks to Middlebury to be sawn into slabs or to be turned into pilasters. For interior work these highly polished slabs are very decorative. The slabs of themselves, however, are quite brittle. Slabs and blocks exposed to sun and rain lose their sparkling jet and weather to a dull lead color. Only for interior decoration is this now prized as a marble.

Eastward, at Cream Hill and localities farther south, the Utica appears above the clay. Still, to the east, the rocks of the upper Cambrian or Potsdam and all the members of the Ordovician strata are wrinkled in a north and south direction, often closely crowded upon each other. In the vicinity of Shoreham Village, the Potsdam holds many fragments of Brachiopods, but too much broken to admit of specific determination. At and east of the Catholic church follow the Trenton, Black River, Chazy and the various divisions of the Beekmantown. The upper Beekmantown division is here particularly full of fossils. Beekmantown rocks prevail thru much of the town, but will not be fully described. Mutton Hill is largely of Beekmantown with Potsdam on the west slope The roads north and east at Newell's Mills are of Beekmantown. In the vicinity of Richville, Potsdam prevails.

The south-east corner of the town from the Pinnacle to the Whiting line exhibits one of the most complete and remarkable displays of continuous formation of rocks possible. Over this region, probably, passed the Amherst Road. The rocks near Chenett's have afforded the best examples of Hall's fossil, *Cryptozoon*, ever observed, this particular species being *Cryptozoon steeli*, banded from the center outward like agate, and with a tinge of purple.*

Beginning east of the Pinnacle, which of itself is Beekmantown, there follow Potsdam and all of the Divisions A, B, C, D, E of the Beekmantown, then Chazy, a skip of the Black River, then Trenton and Utica reaching over and past the border line of Whiting.

ORWELL.

This town, the south-west one of the county, has some sharp contrasts with those before described.

The drainage, with the exception of the small streams forming the head of Lemon Fair, is to the north-west, reaching the lake within the border of the town itself.

The great feature of the western boundary is the great uprise of rock between East Creek and Lake Champlain, now known as Mount Independence, east and a little south of Fort Ticonderoga, N. Y. Here a heavily wooded tract of near 250 acres looking northward became politically historic in 1775–1777 with a breastwork on the north and a picketed fort on the top. Here, separated by a ferry of 80 rods from Ticonderoga, was the parade ground, the supply camp as well as the burying ground of the American forces that barred Burgoyne's way south.

Geologically, Mount Independence is a mass of Beekmantown rock A and B. The soldiers found what often

*Shoreham near Chenett's, Cryptozoon steeli. See Report Vermont Geologist, 1905-1906, Plate XLIII p. 184.

occurs with this formation, a black chert, a flinty mass, which in extremity may be used as a poor substitute for real gun flints. The rock near the water edge has been largely quarried as a flux in iron-making at Port Henry.

In the dolomite B, the fossil *Cryptozoon* has its proper horizon. Here, at Fort Independence, Mr Wing discovered a fossil which he denominated as *Stromatopora*, which, however, on further study proved to be *Cryptozoon wingi*.* Very few fossils are to be found on Mount Independence.

The Chazy as a formation thins out as it is traced south. Here, in Orwell, at a locality a little north-east of the Village, the *Maclurea magna* distorted is found, the containing rock having evidently been subjected to much pressure.

The Trenton rocks along the roads and east of the village have undergone compression and metamorphism and so the fossils are quite obscure. The only recorded example, so far as the writer is aware of the fossil *Receptaculites* in the Vermont Trenton, was first obtained by Mr. Wing and later by the writer near the highway north-east from the village.

VERGENNES.

Returning now to the north part of the county we come to Vergennes, a little patch clipped from the adjoining towns of Ferrisburg, Panton and Waltham; a little patch indeed, 400 by 480 rods in extent, a little less than two square miles; notable from its early founding as a city, historic as a shipyard as well as for its early activity in furnishing the government shot, shell and munitions of war.

All these activities of the city have been made possible by the geological character of the region. The Otter, so quiet above and below the falls, here plunges by broken streams down into a chasm in all probability of its own making, a fall of a little less than 40 feet.

We may try to interpret the geology of Vergennes; and in this interpretation must be included the Otter Valley higher up. During that vast, silent, faintly recorded Eputican Interval, the Valley was subject to tremendous earthbreak movements, profound cracks were made in the strata, essentially across the Valley. The strata south of the fracture were lifted high up above those on the north side, leaving great precipices looking to the north. The Beekmantown rising up on the south slipped past the Chazy, Black River and Trenton and abutted against the Utica. Aerial agencies, sun, rain, frost, ice streams have, thru the ages, been putting a new face over all the region, giving valley, rapids and falls. The softer rocks, crumpled and crushed

*Cryptozoon wingi. See Report Vermont Geologist 1905-1906, Plate XXXVIII, p. 163.

by the earth movements have largely disappeared, leaving, chiefly the hard Beekmantown rocks at the surface.

Vergennes occupies the last of these great fractures. The southern lip of the Beekmantown has been wearing slowly down. The Utica, and possibly other formations, have gone more rapidly and a great plunge of water into the bowl below goes on continuously.

To the original inhabitant these falls were no doubt a rocky bar, forbidding his easy entrance into the country above, and up and around which he must carry his light craft. To the man with busy brain how different! To man with busy brain and hopeful purpose it is the tireless power making the wheels go round, and the wheels lift the saw, whirl the stones, and lift the shaping hammer without weariness, without rest.

Vermont is called, and properly, a state without a sea border and yet Vergennes is a place at the head of navigation. Here below the falls was once the busy dock-yard where was shaped the flotilla which Macdonough guided to victory at Plattsburg. Ever since, this canal-like outrun of the Otter has been federal waters and cared for by national appropriation.

The rocks are so much concealed in the vicinity that at present it is not possible to say just what formations are represented, but at the north it is quite plain that Chazy, Black River and Trenton, in a broken condition, as well as the Utica, are present. The material for the extension of the Industrial School comes from a quarry that is probably Black River.

An interesting point in the rocks, showing the near approach of the Beekmantown to the Utica, is found on the west side of the river at a place just back of a small office of the nail factory. Here a portion of the water above the falls is conducted thru a tunnel in the Beekmantown into a canal in the Utica, a small aqueduct connecting the slight gap. There is a slight topographical descent, but in geological horizon there is a thrust of from 500 to 1000 feet upwards. Actual points of contact of Utica and Beekmantown are still awaiting discovery.

A depression may be noticed in a field at the left hand as one goes from the station to the city, and a well worn track leading to what is denominated a medicinal spring. It is easy to suggest that under the clay covering there is a break in the Utica. The sulfuretted and ferruginous waters examined by the writer in different parts of the State have, in the main, come from the Utica rocks most frequently where there is a sharp bend or dislocation. The iron pyrites often found in the slate indicates the probable source of the soluble ingredients of the water.

WALTHAM.

This smallest town of the county, of only about nine square miles, is bordered on the west by the irregular course of the Otter, separating it from Panton and Addison, while only by a line with many notches is it separated from Vergennes, Ferrisburg and New Haven.

The political history, so like that of Weybridge and the adjoining towns, may be most briefly noticed; the sparse settlement before the Revolution, the inrush of marauders from the north, the breaking up of newly founded homes, the haling of the men to a dreary captivity in Canada, the slow return after the war, the re-establishment of settlers and friends, and then the coming of a period of prosperous farming and successful and varied industries. A good soil and good surroundings were the basis, a solid one, for the prosperity that followed.

The geology of Waltham repeats, in the main, tho on a smaller scale, the history of East Addison. In the center and eastern portion is an uplift of Cambrian rock, and here occurs Buck Mountain which, following the authority of Hitchcock's Vermont Geology, lifts itself into the air to the height of 1,035 feet. The great uplift of Cambrian forming Buck Mountain has at its western side the later formations, Chazy, Black River and Trenton.

The slope eastward passes down over the Cambrian. Some uplifts of rock within the town reveal the formation of rock or, in some cases, a stream does the same. Onapproaching Vergennes by the road from New Haven depot an outcrop near the house of S. Burroughs appears of Black River or Trenton or both. A little stream running southwest discloses on a cross road a deposit of Black River and near the school-house of District No. 2, on the same stream, rocks of the Chazy are to be seen.

WEYBRIDGE.

Omitting the west part of New Haven for the present in our southern progress, we reach Weybridge, a peculiarity of which is the amount of river surface within and forming its borders. As previously noted, the Lemon Fair River loses itself in the last bend of the Otter after flowing thru the chief part of the town. And then the Otter itself flows largely around and within the town bordering it on the east and mostly on the north, while by loops and bows it turns south and runs at all points of the compass until it is fully confirmed on its northern course near the angle of Waltham.

A straight line separates it on the south from Cornwall, while notched ones mark the western boundary between Addison and Bridport.

The Otter in its irregular course has ound its bed largely in the Beekmantown and pursues its way with slower or swifter course along rapids and down falls. These falls of the Otter on the border or within, came early into prominence and going north are, or have been, known as Paper Mill, Beldens, Huntington, and Weybridge Falls.

The rocks of Weybridge have, in the main, been so metamorphosed that it is difficult to pronounce with confidence as to their formations. Yet the constitution and structure of the deposits will help to place them and the following statements will not be far misleading. As before stated the Otter seems to keep near the Beekmantown in its course. Going over the rocks from the south-east corner of the town on the way to the Monument and north, higher rocks in the Ordovician appear. So well metamorphosed and compacted are a portion of these that they are firm enough to be quarried into a good building material. Probably these are Trenton.

Farther to the west and near the center of the town comes in a strange tongue of slate which increases south in Cornwall and Whiting, and in Rutland County thickens, widens and being more completely metamorphosed, forms a good portion of the workable slate.

CORNWALL.

On the south of Weybridge is Cornwall, a town rich in political and literary history, yet equally rich in geological interest. From the north and the west, characteristics of the adjoining towns, Weybridge and Shoreham, seem to flow over the border and still the geology of Cornwall is unique in itself. From the south-eastern to the north-western border occur all the formations of rocks that pertain to western Vermont.

At the south-east corner, drowned in a cedar swamp, the latest geological formation, a carbonaceous deposit, is now in the process of making, while to the northwest the rocks of the dim, far-away Cambrian appear at the surface, and between these, pinched, crumpled and dislocated are to be seen the Beekmantown, Chazy, Black River, Trenton, Utica and Champlain. These are crowded in too closely to be exhibited on a map of small scale. Fortunately a few of the strata in these formations have escaped metamorphism and their fossils have been well preserved. Particularly has this been the case with the Beekmantown where *Ophileta*, *Or.hocereta*, *Trilobita*, *Sponges* and other characteristic forms are obtainable. So also in some of the other formations.

The rocks are mostly thrown up into ridges or monoclines running north and south with a gentle slope east, while the western exposure is steep and even precipitous.

The uplifts of the Beekmantown, especially, exhibit this character, a type being seen in Ellsworth Ledge. The north and south direction of the ridges is shown in the same rocks, as, going south, the Beekmantown appears again guarding both sides of the road; then again, still much farther south, it appears on the west side of the highway. The same formation appears as a ledge separating West Cornwall from Shoreham.

In the Ordovician formations the Chazy has its place but thru metamorphism the division lines are often indistinct. The Trenton sometimes with its fossils flanks the Utica as this mass comes in from Weybridge and goes on south. Near the southwest part of the town are quarries of building stone, one of these in particular has had from early time an excellent reputation, that of giving a sharp clear fracture and leaving a clean face so that no cutting or tooling is necessary. Various authorities will cite the front of the chapel building of Middlebury College as an illustration of the elegance and value of the stone. These quarries, known as Peck's, are thought to be Trenton.

The Utica rocks of the town have not reached that character or that degree of metamorphism that would make them valuable as roofing slate.

WHITING.

Whiting, on the southern rim of Addison County, was noted before its geological character was ever investigated for its agricultural productiveness, especially for its great yield of wheat and corn. It was thought to be particularly well situated as it was on the great thorofare from Albany to Burlington, its chief road north and south being a portion of a cord on which town after town was threaded on a northern journey.

One may well assert that the geology of the town compares well with the quiet industrial and social character of the town, with no strange rocky features, so far as at present known. Swamps, continuous with those of East Cornwall, have a broad expanse along the Otter River in the north east part, while in the northwest part the Utica comes over from Shoreham.

The slate running down from Weybridge and Cornwall passes southward thru the town, the metamorphism of the rocks scarcely permitting the junction with the Trenton to be clearly distinguished.

From Wing's map of this region it is evident that the Chazy is present in the south-middle portion of the town, and here unites with a larger exposure of the rocks of this formation in Sudbury, south.

The main features of the town are here given, but the whole field of Whiting calls for fresh and careful investigation. Facts of great geological interest are probably awaiting such careful research.

MONKTON.

Returning to the north row of towns of the county, one finds the middle, Monkton, twice and a half as large as Whiting, while its geological character is extraordinarily different. In certain aspects it is true that Monkton resembles the town on the south and west of the county. It has been subject to the same glacial action, has been mostly covered by the same Champlain sea, its fields up to the foot of Hogback at the bottom of this sea and after the glacial epoch has experienced the same cycle of weathering.

But the rock beneath the clays and soils is wonderfully different As has been noticed in the several towns studied, there have occurred narrow folds or uplifts, north and south, of Cambrian rock, but Monkton, like a chart unrolled, displays the Cambrian over the whole surface with the exception of a line on the eastern border.

The bodies of water are of small interest, the early prized mill sites scant indeed. Monkton Pond, a miniature lake north of the center of the township, is the largest body and is visited rather for its botanical than its geological interest. Pond Brook, rising in Bristol Pond, courses wholly thru the eastern part, taking swamps on its way and with other branches helps to make up Lewis Creek in Hinesburg, while the Little Otter gains a large portion of its water from the middle and western portion of the town.

The surface rock, the Cambrian, beneath the soil is pimpled over with hills and mountains, Mount Florona an example, as well as scarred by ridges, Hogback Mountain being an exaggerated illustration. Various peculiarities diversify the town and add to its geological interest. Professor Adams, in his Second Annual Report, describes and figures a remarkable phenomenon existing in the north-west corner of the town, popularly known as the Oven. Hitchcock follows Adams in description and illustration. Here, on a hill that comes down from Charlotte, is a clear cut anticline, like a gothic roof and is a complete illustration of the flexibility that really exists in the most rigid rock when submitted to slow, unvarying, tremendous pressure. Adams calls attention to the fact that altho the rock is a very compact sandstone and altho some strata exceeding a foot in thickness are very pure quartz, yet their continuity is not interrupted in the least by the extraordinary flexure to which they have been subjected. Other plications and graceful curves occur on the hill. The writer, on visiting the weird place, found nothing to add to the description given by Adams.

The Monkton kaolin beds in the north and central portions of the town have had for a long time a notable reputation. The kaolin was early thought to be the result of the decomposition of feldspar and in this particular case of the decay of graphic granite. This remains the explanation, as no better has been found.

In the early days of Vermont's varied industries the iron ore bed very near the south boundary of the town was a deposit of great interest and value. This brown hematite was taken to Bristol where, by several forges, it was manufactured into excellent iron.

The great ridge, Hogback Mountain, 2290 feet high, separating Monkton from Starksboro, is the most northern of the gray quartz uplifts.

North of the south-east border of the town, just west of the quartz, is an irregular deposit of highly metamorphosed limestone, Beekmantown or Cambrian, but probably the latter. No contact with the quartz rock was found tho the two approached each other closely. The rock is much like the Winooski marble, light pink in color and corrugated in structure. Slabs of this rock would yield a most elegant material for indoor work. The difficulties of transportation as well as the apparently limited amount of the deposit do not very much encourage the expense of quarrying.

BRISTOL.

Bristol, next town south of Monkton, has, along its northern border, the characteristics of this neighboring town, but elsewhere it has features peculiar to itself.

First, however, as to its waters and drainage. Two small ponds appear among the quartz rocks of the middle east and in the middle north just by the border is a larger pond, Bristol Pond, draining north, especially noticed on account of the plants growing along its shores. From the northeastern part of the town come down the waters of Beaver Brook and Baldwin Creek which unite with New Haven River in the eastern part of the town, as this river, coming across from Lincoln, flows to the northwest, and running a little past the center of the town, turns at a sharp angle nearly south and then west across the western border into New Haven. This stream is one of the notable features of the town, giving by its power, support to many industries.

The iron ore bed very near the northern border was a locality of great interest in the first half of last century. The great industries of the country were not at that time centered at a few favored points, but almost universally distributed. Besides the ore here raised, supplies were obtained from Monkton as well as from Moriah, N. Y., across the lake and wrought up in Bristol, 100 tons or more of wrought iron being annually produced.

The western part of the town shared with others nearer the lake in the glacial action and the overflow of the inland sea during the Champlain epoch, the sandy deposits reaching to the foot of Hogback and South Mountian.

The uplying features of Bristol may be roughly enumerated as three, the low productive fields, the sandy terraces and the quartz mountains. Bristol village, on a terrace nearly 600 feet above sea level, is most favorably situated at the base of Hogback, the mountain, here 1,850 feet high. A wonderful break here occurs, making Bristol Notch, the great notch, giving passage to the New Haven River as well as to the streams of travel east and west. At the village the stream from the terrace to the broad lower fields below gives power for the mills, a power that has been prized and economized for a century and a half past.

The mountain uplift, Hogback and South Mountain, leaves mostly the eastern part of the town a rugged upland. The water falling upon the quartz rocks dissolves but little of the solid matter and remains a most desirable supply of domestic water. South is Little Notch, up which goes a road and down which comes a stream, and from this vicinity, Middlebury village has its supply of pure water.

The exposed rocks west of the quartz uplift are mostly calcareous. Some, however, have the exact amount of magnesium to form a true dolomite. Some of these deposits are of economic value. Thus far no fossils have been found that would indicate the geological formation, but from stratagraphical position and chemical composition these rocks may, in all probability, be regarded as belonging to the Beekmantown.

NEW HAVEN.

New Haven, just west of Bristol, has a much angled outline peculiar to itself and as a town shows results all over its surface of the glacial and sea effects of the Champlain epoch. The present features of its water courses are exhibited by Otter River, which forms the line dividing the town from Weybridge; second, the small streams gathering their waters from cedar swamps, one in the middle south and another in the northeast part of the town, these waters flowing north and forming the head streams of the Little Otter of Monkton and Ferrisburg, and third, the New Haven River. This latter is a great feature of the southern portion of the town, the waters of which are gathered from towns farther east as Starksboro, Lincoln, and Bristol, and named for this town, New Haven River. It enters from Bristol at

New Haven Mills, runs southwesterly and then northwesterly across the southern part of the town and falls into Otter River near Brooksville.

At the entrance at the Mills and again near the exit at Brooksville, are rapids or falls and at each of these points valuable water power is developed.

The fast rocks underneath the soil are largely Cambrian and Beekmantown. The Cambrian touches a small northwest portion bordering Ferrisburg and Waltham. A small north-east portion, bordering Bristol, has been considered Cambrian; this, however, still needs verification.

The middle and southern part of the town is of Beekmantown.

The Beekmantown is revealed by the course of the river, especially at New Haven Mills and Brooksville, the rapids or falls in each case being over rocks of this formation. Uplifts occur in various parts of the town, often with small precipitous faces. Illustrations are seen on the New Haven River, just west of the entrance of Muddy Branch, along the narrow highway bordering the stream south and west of the Nash place, as well as in the rugged masses in the rocky fields to the south; also the southern cedar swamp of the town east of A. G. Matthews' has for its east border such an uplift of Beekmantown, while a like, but less noticeable, example is found nearly due west beyond the railroad, buttressing the west border of Spring Grove Camp ground. South and west of New Haven Junction the Beekmantown is also in evidence.

Two other localities deserve mention as well as much more careful investigation. One, a ledge of limestone, perhaps, may be called the Palmer Ledge, near the north part of thea town; second, the Marble ledge exactly on the border of Middlebury.

Palmer Ledge gives a light gray limestone o rare purity, an example having given the writer on analysis a result of 98.37 per cent. of pure carbonate of lime. As before noticed, this unique ledge must have more careful examination before the actual horizon can be known. Awaiting this new survey the opinion may be tentatively ventured that it may be an anticline of the upper, or as may be written, C Chazy; or more probably low down in the divisions of the Beekmantown.

At a locality on the extreme southern line next to Middlebury is the marble quarry worked since the early years of last century, worked, however, somewhat intermittently. The later proprietors have not been much encouraged in their work, the difficulties and expense of quarrying interfering with financial success. Early, much excellent marble was obtained here. In former times these deposits would probably have been classed as Stockbridge marble, but the

PLATE XLIX.

Fault below Middlebury Falls. Overthrow of Beekmantown on Trenton.

more they are studied they are, with more and more probability, assigned to the Beekmantown formation.

MIDDLEBURY.

This Middleboro, with Salisbury on the south and New Haven on the north, names reminding the first settlers of their early home town and of the capital of their Connecticut state, has characters, some like and others unlike the bordering towns.

The drainage is represented by three streams, first in size and importance being Otter River passing thru the whole western part of the town from south to north; Middlebury River coming boisterously from Ripton, running with loops and curves west thru the south part of the town and reaching the Otter; Muddy Branch which by name indicates the kind of soil over which it flows and gathers the waters from many brooks in the northern part of the town and discharges them into the New Haven River. Like the outlying towns it has its Beaver Brook in the south part of the town and emptying into Middlebury River.

The eastern part of the town differs very materially from the middle and western part in that it, for a mile in width, rises on the flank of the Green Mountains, which here are of quartz rock.

The large remainder has a surface very like that of towns nearer the lake which give distinct evidence of Pleistocene history, that is of the effects of the work done in the Glacial and Champlain epochs upon the irregular underlying solid rocks. Besides the soil, sands and clays help to conceal these rocks.

The sands accumulated in banks have proved valuable as an ingredient of mortar and as an abrasive material. The clays, however, have mostly been disappointing The handsome brick made from it crumbles to pieces when moistened; if moulded for pottery and fired, the clay melts down to an unsightly slag. The large content of lime carbonate is thought to account for this.

A wide, sandy stretch east of the middle part of the town may be regarded as a low terrace, probably formed during the later part of the Champlain epoch. Here and there banks of sharp silicious sand occur and are of economical interest.

The solid beds of rock, when recently stripped of their clay covering, show a grooved and polished surface, results referred to the action of ice during the Glacial Epoch.

The most notable monument in the town left in commemoration of the Glacial and Champlain Epochs is Chipman Hill, the unique conical peak just north of the village, a heaped mass of boulders, gravel and sand, geologically a

Kame. This shapely mass, sightly from every direction, has, according to the U. S. Geological Survey, a height of 800 feet above sea level and 434 feet above the Bench Mark of 366 feet recorded on the water table of the postoffice.

The solid rocks of the town, mostly concealed by soil, sand and clay, demand a much closer examination than it has been possible to give them. Awaiting such examination the following general facts are here presented.

From the Green Mountain foot, going westward, one passes over the Cambrian, then the Beekmantown and then over a fault to the Trenton. Thus, at least, reads the writer.

The exact line of contact of Mountain quartz and Cambrian and Beekmantown is still to be sought; that between Beekmantown and Trenton is established, this at the fault to be described further on, where the Beekmantown abuts against the Trenton and crumples it, or slipping by, overrides this formation.

Plate XLIX shows this contact.

Notable features of the rock are disclosed by the occurrence of two lines of marble, one passing thru the middle of the town, the other, now of small note, bordering the Otter.

A line drawn from a quarry on the southern border of the town to the Gibbs quarry on the New Haven border will pass directly over or very near eight marble quarries, each of which has been, in time past, the center of active work.

The age of the marble deposits of the town is a problem demanding solution. The stratigraphy of the whole region should be most carefully worked out. The fossils of the rocks lying near need further examination. Mr. Wing, in his great diligence, found fossils of Brachiopods and Gastropods east of Chipman Hill and within half a mile of a quarry still farther to the east. Obscure, yet these fossils probably may be referred to the Beekmantown. Following Mr. Wing's lead, the writer found in the same vicinity plain evidences of Cephalopods and from these the accompanying figures have been obtained. They very nearly resemble examples that Professor Hall called *Orthoceras primogenium*, a well recognized Beekmantown form.

Awaiting satisfactory proofs of the horizon the suggestion is ventured that the marble beds of the center of the town represent a metamorphosed synclinal of Beekmantown rocks. And may it be possible that the marble bordering the east bank of the river is a part of the upturned broken rim of a metamorphosed Beekmantown anticinal?

This deposit of marble at the river edge is of historic interest. Here the marble industry had its origin. Here Dr. E. W. Judd had discovered marble and as early as 1806 he introduced the method of sawing marble by the use of sand and gangs of toothless saws. This industry he carried on many years with eminent success.

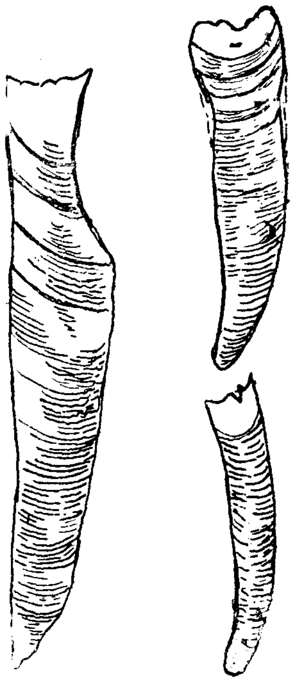


FIGURE 29.
Orthoceras primogenium.

Whatever may be our guesses or even well balanced speculation in regard to the horizon of the marbles of Middlebury, a definite fact here stands out, the marble halts at the river and is halted by a notable fault. Mention has already been made of similar faults within the county, one at Ferrisburg breaking across the Little Otter, the second at Vergennes across the Otter River. In each case the Beekmantown has been upraised and thrust upon and over the Utica, the softer rock subsequently worn away, permits the fall.

The fault at Middlebury differs in this, that the Beekmantown has not been raised so high, but abuts upon what is regarded as the Trenton. At the break, the stream has worn out a basin in the softer stone and a passage way, giving the fall, developing the power that early determined the location of the village.

The period of the occurrence of these great earthquake disturbances, producing faults, must always remain undetermined. This, however, may be assumed that the geological time of the great upthrusts was long before the Champlain Epoch and may be referred to that indefinite period, the Eputican Interval.

The fault that has produced the falls at Middlebury village has marked the configuration of the vicinity. Going south it passes thru the high school grounds leaving a depression, once very sharp but now largely filled, and less noticeable as one follows its course, where the rocks are exposed the line may be determined by the difference in the strata. As an instance, the rocks on the east side of the highway and in the fields on the western side of the river are Beekmantown.

To the north of the falls the water has worn an eddy, and returning passes over the somewhat uplifted contact of the Beekmantown and Trenton and has made a channel for itself over the latter. As one goes north, places may be found east of the stream where the two formations very closely approach each other.

The Hydrographic division of the U. S. Geological Survey, April 1, 1903 to May 1, 1907, made measurements during 1903 and 1907 in the river to determine the volume of water, rapidity of current, and related facts regarding the waters of the Otter, the station being just above the falls.

An abstract of results is here appended.

The rating table for 1906–1907 was 13–17 feet and 945 seconds' foot (i. e. 1 cubic foot in a second) in 13 and 5,270 in 17, taking 14.40 feet, a little above the average. On April 7, 1907, and the same on April 24, 1907, 2,290 cubic feet of water passed the bridge every second of time, and during the day of 24 hours 197,856,000 cubic feet passed.

The fold of rock toward the western border of the town is assumed to be Trenton, tho verifying fossils do not appear. Portions of the rock have been greatly compressed and broken, and subsequently the interstices filled with calc spar. Early in geological study such strata were designated as Sparry Limestone. Here in the eastern part of the uprise they have been quarried for foundation and wall stones.

Whether the fault at the river was the only phenomenon produced by the pressure from the east may never be known. The surroundings, however, are very suggestive, and this, that the strata were thrown into vast folds, that the elevation on which are situated the college grounds, was a portion of a fold much higher than now, raised very gradually by the oncoming force and reached its full height only when the great break at the present river relieved the tremendous pressure.

On this irregular ridge of Trenton may be seen marks of a much later geological time. On the south side of the highway west, is a depression or bowl filled with sand, a reminiscence and legacy of the Glacial and Champlain Epochs.

Thus the town of Middlebury offers studies and problems in geology, and these from the most remote to the most recent times; rocks of Gray Quartz, Cambrian and Beekmantown as yet of unassorted borders, marble and the clearly recognized Beekmantown and then Trenton, all of old history; then the phenomena of the Eputican Interval, the profound fault and crumpled folds of the Trenton; the Pleistocene of Glacial Champlain and recent epochs with sands, clays and recent soil, together with its low sandy terrace, and its towering Kame.

SALISBURY.

Salisbury, the town between Middlebury and Leicester, has an exceedingly varied surface, a small portion swampy, a larger part of moderate uneven height, the eastern rugged and even mountainous.

PLATE L.

Nothozoe vermontana.

The northern and western parts were probably affected by the inland sea during a portion of the Champlain Epoch.

Its running streams are, Otter River, which forms its western boundary next Cornwall and Whiting, a convenient wrinkle of Middlebury River, bows into the north boundary to which the brooks of the northern part of the towns make their way, while the Leicester River leads the overflow waters of Lake Dunmore from near its north-west bank southwestward by many turns and rapids across that town to the Otter.

Salisbury shares with Leicester, in its middle east, the picturesque Lake Dunmore, near four miles long and less than a mile wide. A series of charming cascades from the waters of Silver Lake, form the noted falls of Lana.

The geological character of some parts of the town helped to make Salisbury historic during Revolutionary times. The deep, sandy banks of the Otter offered place for Mrs. Ann Story to scoop out the roomy chambers that sheltered her family and friends during that fierce period. At the same stirring time a rough gash in the sandstone of Moosalamoo offered slight shelter as a rallying place for Allen's Green Mountain Boys.

The ledges in the middle and western part of the town have mostly been denominated marble. Those in the center are in the line which in Middlebury is suggested to be in a marble syncline of Beekmantown rocks. Eastward the Cambrian and Quartz appear in the high bulwarks of the town as Bryant Mountain, 1,122 feet high, Mount Moosalamoo at its highest 2,659 feet, and Rattlesnake Point near 1,900 feet high. West of Lake Dunmore is Sunset Hill, a delightful elevation of 925 feet.

Many geological phenomena seem to center around Lake Dunmore. Fortunately we have the assistance here of the U. S. Geological survey, both in its topographical and geological work.

Taconic Physiography is the title of Professor T. Nelson Dale's study of this and surrounding regions; this is found as a U. S. G. S. Bulletin No. 272. At page 47 and preceding plate XIII much desired information is given.

Professor Dale says, "Lake Dunmore seems to lie in a southward pitching syncline of Quartz with overlying dolomite, the dolomite having been largely eroded. The valley at the northern end of the lake is formed by this syncline. The damming up of the syncline at the south by Glacial or post-Glacial gravels may be the reason for the outlet of the lake not being in its natural place."

Fossils have been sought in this eastern Cambrian. The writer has made search for organic forms in East Middlebury, Ripton and Salisbury, and some personal reference may be given.

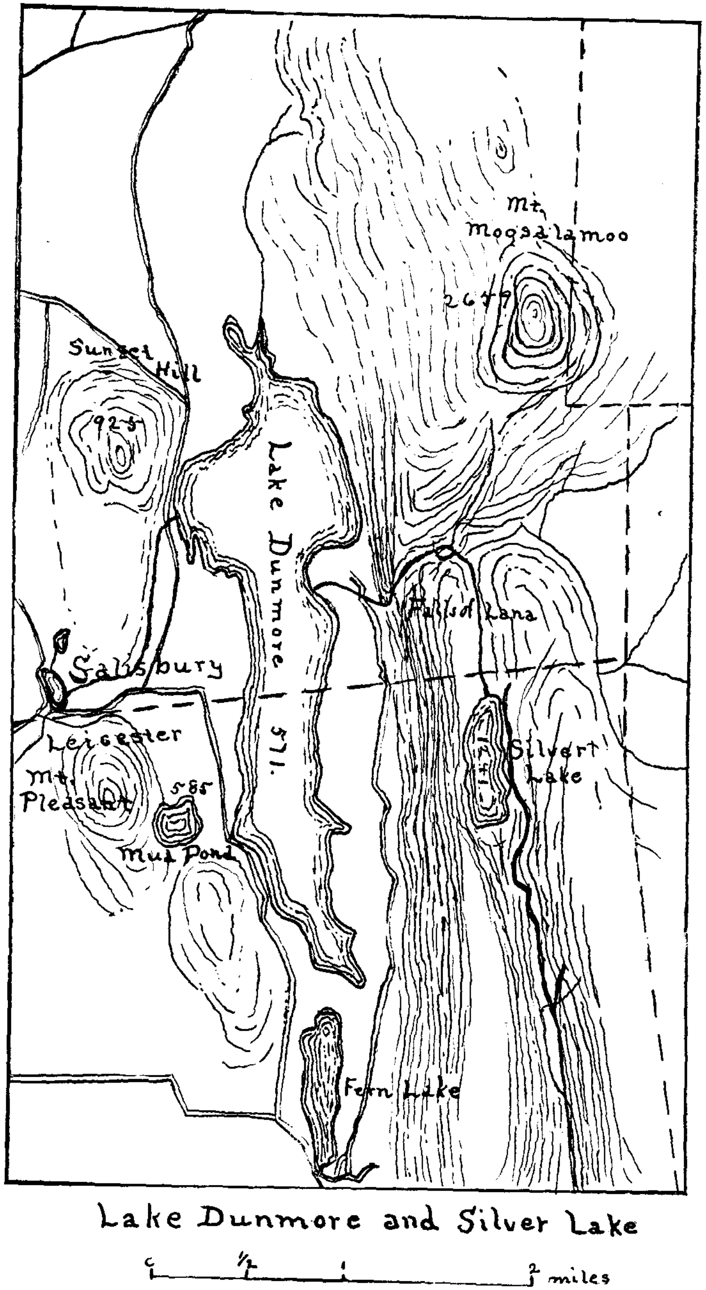


FIGURE 30.

The shelves of the museum of Middlebury College were found to contain a fossil form of uncertain relationship, resembling the valve of a lamellibranch, placed there, probably, by Professor C. B. Adams. This was marked Salisbury, Vermont.

Near the time of this search, there appeared in the Bulletin of the Am. Mus. History of N. Y., Vol. I., plate XIV, pp. 144-145, a description and illustration of a similar form, from Salisbury, Vt. This study was made by Professor R. P. Whitfield of the Museum. Professor Whitfield regarded this form to be the remains or the imprint of a bivalve crustacean, having the appearance of an overgrown *Leperditia*. These imprints, he remarks, correspond to Barrande's figures of the genus, Nothozoe, and he proposes to class them with that genus and names this form *Nothozoe vermontana.*

The clue was small and yet it was hoped that the rare fossil might be located so with the aid of Professor T. E. Boyce, the writer set out on a definite hunt. Hopeful indications were first found in a stone fence boulder having few and indistinct impressions. Later it was found in great abundance in boulders along a stream coming from Mud Pond near the boundary line between Salisbury and Leicester. A very satisfactory collection was made and divided among scientific friends and examples sent to various museums.

Our collection had been made from boulders. We wished to find the rock or ledge from which the boulders came and find the fossil in place. Time was spent and space searched to this end, but without the desired results. We at length unwillingly accepted the suggestion that the ledge, the source of the boulders, was at present concealed by drift.

The examples sent to the Am. Mus. Nat. Hist. N. Y., came under the notice of Dr. Chas. E. Walcott, then of the U. S. Geological Survey, now secretary of the Smithsonian Institution, eminent for his study of Cambrian rocks and fossils, and he found them of great interest. He came up and we went over the field together. The Nothozoe-bearing boulders were found as before, but no examples in place. At Sunset Hill, Dr. Walcott found also some fragments of early trilobites. Later, by perseverance, he found the Nothozoe in place in a wooded hill in Bennington county.

More recently, abundant specimens of Nothozoe have been obtained by Mr. Norton of Salisbury. The Salisbury Cambrian is still a hopeful field for undiscovered fossils.

LEICESTER.

Leicester, the southernmost town of this county tier, has many features resembling Salisbury. It has its low

The material of the Roll cannot be profitably used in burning lime, and the suggestion is that it is largely magnesian in composition.

See also Plate LXXI, page 252.

STARKSBORO.

Coming now to the study of the eastern tier of the towns of the county, we shall find that they stand out sharply in comparison with those on or near the lake shore. Their altitude is greater, they are above the line of what was once the Champlain sea, the rocks are of metamorphic or crystalline character yet, like the lower towns, show the effects of the Glacial Epoch, like them bear the scorings on the rocks and the accumulations of debris in the form of boulders, gravel and sand.

With these eastern border towns the writer has had only slight acquaintance and therefore must direct attention to the reports of Adams and Hitchcock. Scarcely more than the presentation of the chief physical features of the geology will be attempted.

Starksboro is the north one of these eastern towns. Its smaller streams strike south-west from the center of the town, until they reach, or form Lewis Creek. Lewis Creek rises in Starksboro on the east side of the quartz ridge, passes thru the north-east corner of Monkton, the southern part of Hinesburg and Charlotte finally entering Lake Champlain in Ferrisburg.

The surface is uneven and some of it mountainous. Hogback, as already mentioned, bounds Monkton on the east and Starksboro on the west. The center of the town has also a series of elevations and other heights on the east.

The gray quartz at the western foot of the Green Mountains stops with Hogback here in Starksboro. The rocks east of the quartz Hitchcock denominates Talcose Conglomerate and Talcose Schist. Some of the exposures yield good flagging material. The elevated valleys are productive, indicating rock-worn material, of the Glacial and later epochs. Professor Hitchcock notices a high terrace of great length in North Starksboro and this is succeeded southerly by a wide meadow.

From Professor Thompson we learn that in 1840 and earlier a forge in Starksboro produced annually 60 tons of bar iron. The source of the iron ore used is not given; whether the supply came from the town, or more probably from Bristol and Monkton, we are not informed. That the soil from the recent epoch produced timber suitable to be converted into charcoal, we cannot doubt.

LINCOLN.

Lincoln, just south of Starksboro, has a shapely outline on the map; its surface however is very irregular. It approaches Starksboro in many of its features. Its streams and mountains, however, are very characteristic. Of the streams, apparently every drop of overflow water is at length gathered into a single stream, New Haven River. Passing to north-west it finds a depression which further on becomes in Bristol the Great Notch. The branches coming from the north, head in Starksboro, those from the south in Ripton. But larger or smaller they all mouth towards the river which they reach at varying points.

It is in the depression made by these streams, their wider and narrower valleys and their waterfalls that the industrial activities of the people have their source. The physical geology of the town is what has given Lincoln its financial peculiarities.

The bolder features of the town are due to its hills and mountains. Bald Hill and South Mountain separate it mostly from Bristol. Between these is the great depression, Bristol Notch. Near the middle of the north boundary is Mount Pleasant, the second in the county by this name, while the heights of Warren flank it on the east. Cob Hill and Grant Mountain are near the south border, while on the middle east the cone of the giant among these heights, Mount Lincoln, rises 4,078 feet into the air.

RIPTON.

Ripton, with Lincoln and Bristol on the north, is next to the largest town within the county and yet its arable land is less than some of the small towns. Like Goshen, Hancock and Granville it may be regarded as a typical mountain town. The eastern part is represented as being without roads or inhabitants, and many of the roads of the interior starting out promisingly stop at the foot of a hill or mountain. Of the roads that do persevere, one leads to Lincoln, one to Hancock, and one to Goshen. These roads mostly follow up branches of rivers, those that come to an ending have usually found a mill-site with an abundance of timber in the vicinity.

The drainage and streams are much like those of Lincoln. The large North Branch brings the waters of the north and west of the town to the larger stream, Middlebury River, which finds its head in Hancock at the divide of the Green Mountains and in its north-west flow takes in all the various branches that have come down the valley. So Ripton is a town with hills and mountains incised with

PLATE LII.

Roll of Limestone, Differential Folding, Quarry of Leicester Marble-Lime Company, Leicester Junction.

narrow valleys, tho the valleys in rare cases broaden out into notable hollows.

The rock masses from west to east are chiefly quartz, schist and gneiss. The work of the Glacial Epoch has told on the rocks of Ripton, as well as that of more recent times. This is seen in the striation of the rocks, the accumulation of broken material, as well as in the continuous deepening of ravine and valleys. There may be instanced here a single phenomenon indicating former work. This was early thought to be an ancient sea beach and was so named, but later it has been attributed to glacial action and waters. This is described in Hitchcock's Report, Vol. I, p. 152. The locality is in the east part of Ripton, near Flint's, lying partly in Hancock upon the top of the Green Mountains.

"This beach is composed of stratified sand and gravel, and has the proper form of a beach approaching a terrace. It overlooks the whole valley west of the mountain and is 1,806 feet above Middlebury, 1,696 feet above the Champlain clays, and 2,196 feet above the ocean."

GOSHEN.

Goshen, a mountain town as before mentioned, has many characteristics of Ripton, to the south of which it lies. Its drainage indicates on which mountain side it is situated. Its north drainage is through Sucker Brook and from Dutton's Pond through Dutton's Brook to the west, to Lake Dunmore; then, of course, on to the Otter and Lake Champlain. Two brooks drain the southern part of the town, one with its many branches running northwest, a second southwest, and these help to form Mill River in Brandon, headed for Otter River.

A highway threads the middle of the town north and south. The other roads converge towards Mill River and find their way out of Goshen by the same valley as the waters go. Hills and mountains are round about and within the town. The chief of these are Sugar Hill, 2,091 feet high, White Rocks, Lookoff, Flat Hill and near the center of the town, a second Hogback. Gneiss is the underlying rock of the town.

HANCOCK.

Hancock, south of Ripton and Granville and east of Goshen, has the mountainous character of those towns combined. A highway passes from the west to the east connecting Ripton with Rochester; the southern part of the town is too mountainous to admit a roadway. From the center of the town north to Granville there is a road following up a south running stream.

From the extreme west part of the town the waters go to the west side of the Green Mountains, Middlebury River having its origin here. White River has most of its sources in Addison County. South Branch finds its head in the south part of Hancock, while the West Branch, rising in the western part, passes through the center and eastern part of the town, and to this principal stream the smaller streams gather. It is through the valley of this Branch that the east and west road of the town has been constructed.

Gneiss on the west part of the town and schist on the east, are the underlying rocks. Like glacial action has greatly influenced Hancock, leaving its striæ on the rocks and debris in the valleys.

Hitchcock's Report, Vol. I, p. 33 and on, gives description of some of the glacial effects; and Vol. II, plate VIII, fig. I, shows the work of glaciers and glacial waters on this and nearby regions.

GRANVILLE.

Granville, north of Hancock and east of Ripton, occurs with Hancock rather as an overhang of the country east beyond the crest of the Green Mountains. The maps make it the largest town in the county. Probably in this reckoning is included the west part of the town, the mountainous Avery's Gore.

On the west and south, Granville is bounded by the three towns Lincoln, Ripton and Hancock, while on the north and east three counties border it, Washington, Orange and Windsor.

Mad River, which runs north, reaching the Winooski, has its extreme southern head in Granville. But White River has many of its head branches in Granville, and these, flowing southward, join with the Hancock contingent in helping to make up that river. These streams are noted in many instances for their rapid current. The schist, which covers the eastern flank of the Green Mountains, is the prevailing rock of Granville.

(ADDENDUM.)

(FOSSILS OF ADDISON COUNTY.)

Illustrations of the fossils of the county will be mostly confined to forms from the rocks of the Beekmantown formation, as those in other formations have been largely given in the volumes of Professor James Hall and his successors, and in still later work by others as monographs.

The Canadian Paleontologist, Dr. E. Billings, added a good number of Beekmantown species to the small list of

Dr. Hitchcock, found in Canadian localities, these, chiefly recorded in his Volume I of fossils of Canada. These, however, have not been enumerated with our count of the Beekmantown fossils of Lake Champlain. Dr. Rudolph Ruedemann, of the New York State Museum, Albany, N. Y., has,

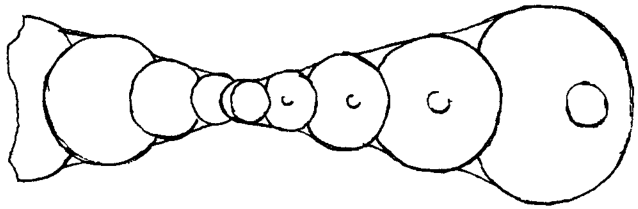


FIGURE 31.

Section of Lituites Seelyi, Fort Cassin.

since Whitfield, added much to our knowledge of the number, character and forms of the Cephalopoda of the Beekmantown, gathered from Valcour Island, N. Y., and Beekmantown, N. Y.

The studies of Dr. Ruedemann with illustrations have been published as Bulletin 90, Paleontology 14, of the New York State Museum, Albany, N. Y. He, following the views of Professor A. Hyatt in regard to relationships of genera of that class of mollusca, has found new names for formerly well recognized genera.

It is, however, from Professor R. P. Whitfield of the Am. Mus. Nat. Hist., New York City, that our larger knowledge of the fauna of the Beekmantown has come.

The originals of his illustrations, as well as his descriptions, may be found in Bulletin of Am. Mus. Nat. Hist., New York City, Volumes I, II, III and IX. By permission, some of these plates have been copied and follow this article. The names there assigned, with very few exceptions, are continued here. Dr. Ruedemann's names are given in brackets.

The wealth of the country in Beekmantown fossils is easily recognized when it is known that a hundred species have been obtained from the formation near Lake Champlain, that of these, seventy occur within the county, sixty of which have been gathered at the little peninsula of Fort Cassin.

Plate LIII.

PLATE LIII.

1, 3. *Nautilus champlainensis*, Whitfield.
Tarphyceras champlainense, Ruedemann.

2. *Lituites seelyi*, Whitfield.
Tarphycera,s seelyi, Ruedemann.

4, 5. *Nautilus kelloggi*, Whitfield.
Eurystomites kelloggi, Ruedemann.

PLATE LIII.

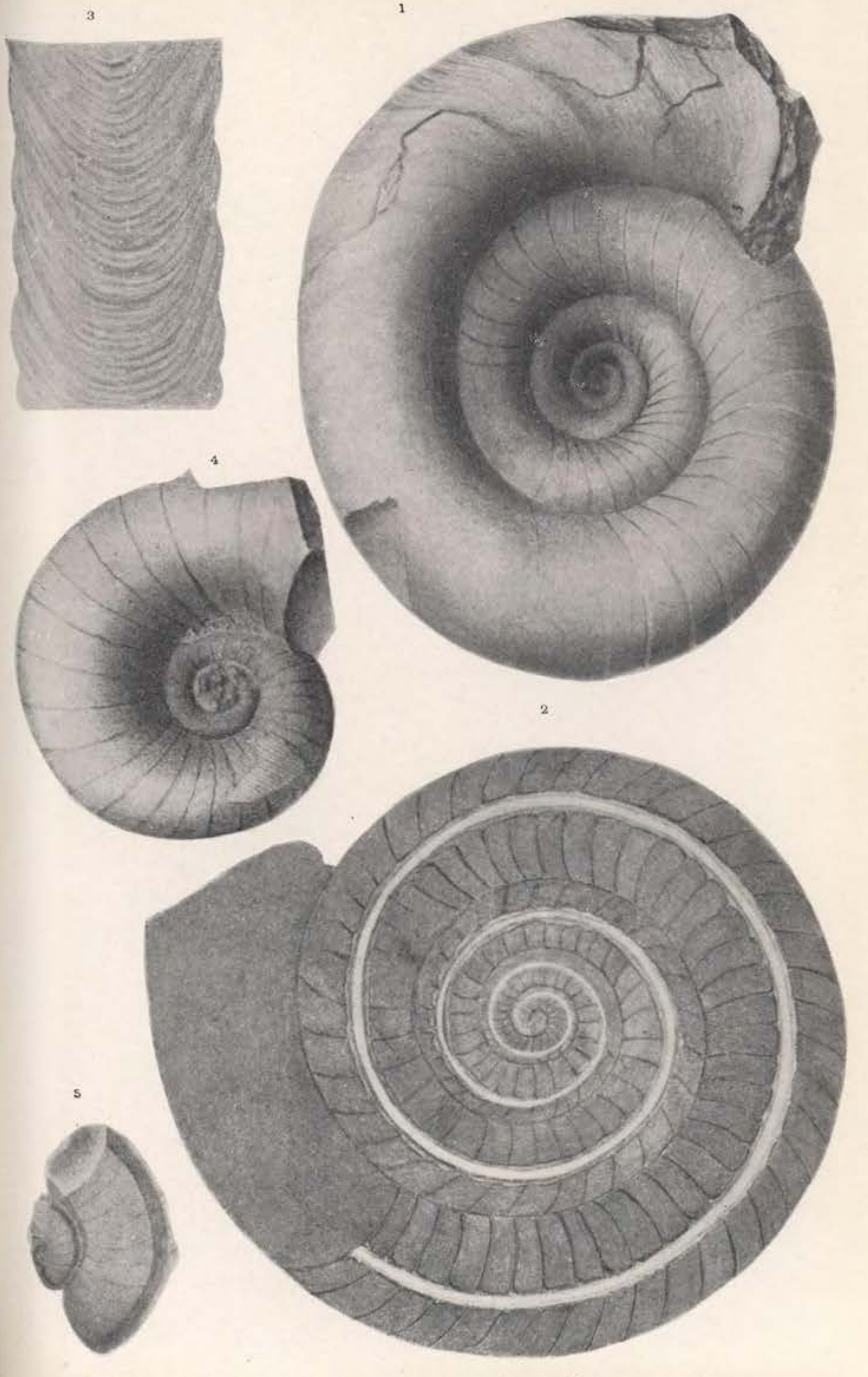


Plate LIV.

PLATE LIV.

1. *Lituites eatoni*, Whitfield.
   Schroederoceras eatoni, Ruedemann.
2. *Lituites eatoni, var. cassinensis*, Whitfield.
   Schroederoceras cassinese, Ruedemann.
3. *Lituites seelyi*, Whitfield.
   Tarphyceras seelyi, Rudedmann.

PLATE LIV.

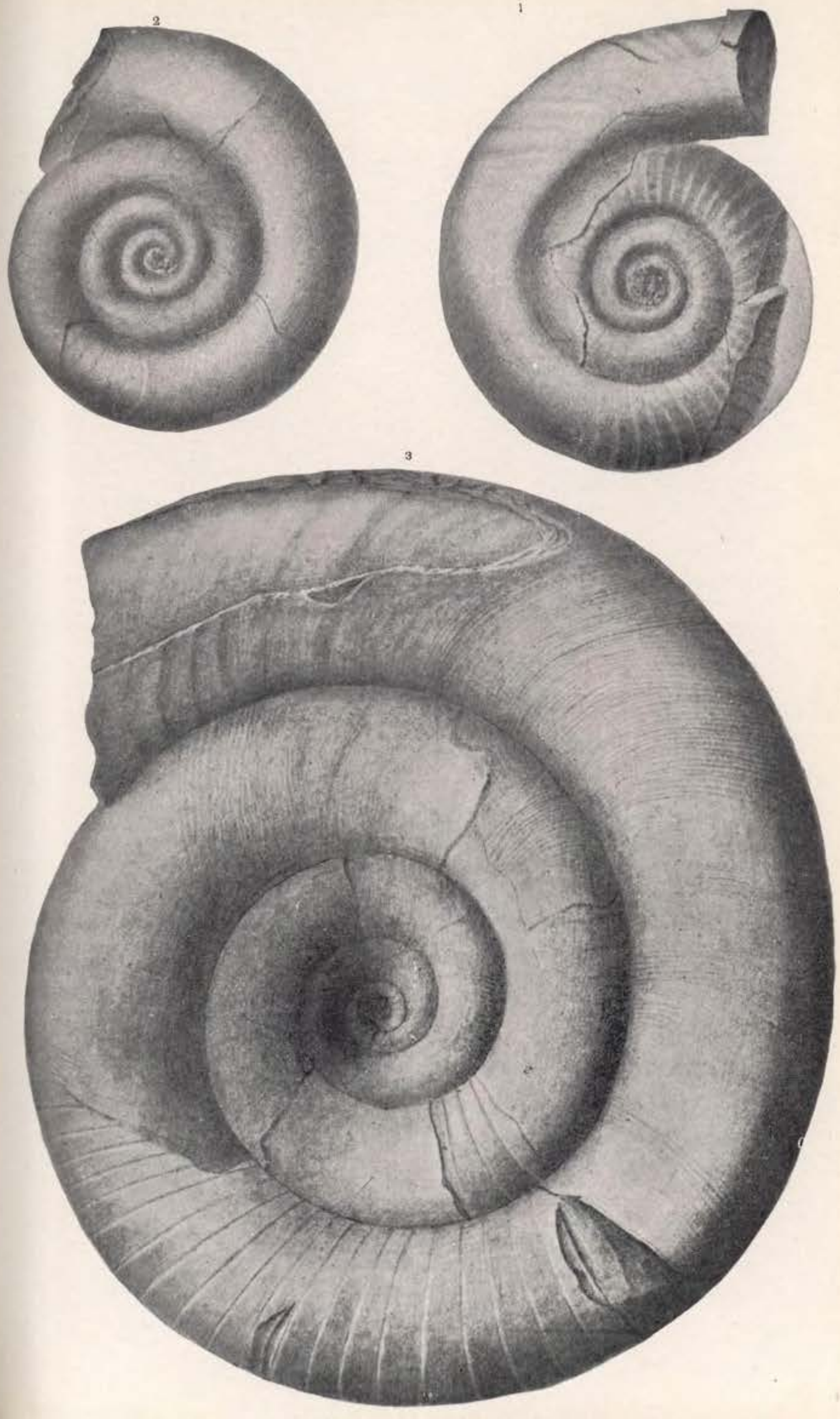


Plate LV.

PLATE LV.

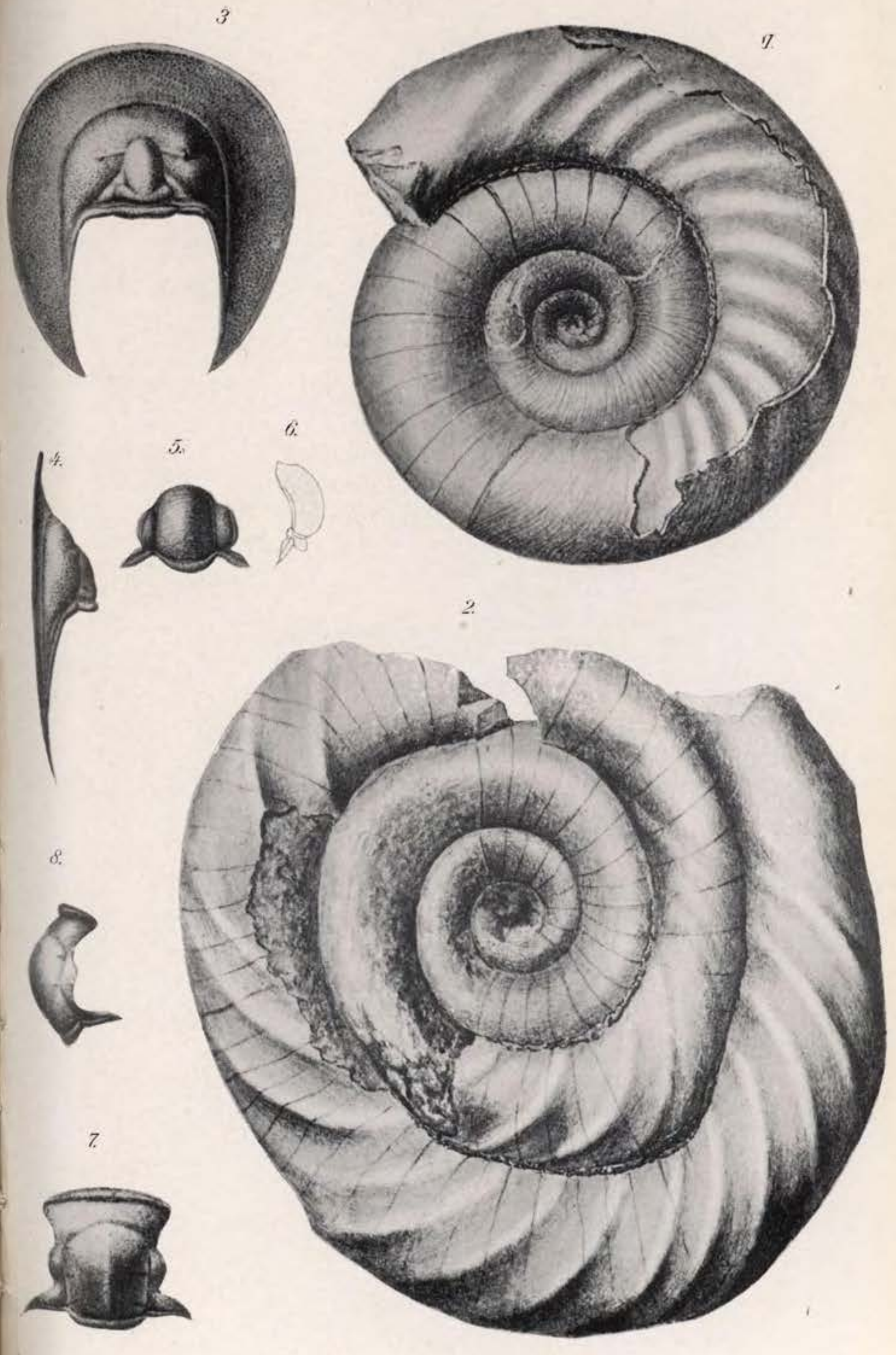
1. *Nautilus perkinsi*, Whitfield.
   Tarphyceras perkinsi, Ruedemann.
2. *Nautilus perkinsi*, Whitfield.
   A large, somewhat crushed specimen, showing well the undulation of the shell.

3, 4. *Harpes cassinensis*, Whitfield. Enlarged twice.

5, 6. *Nileus striatus*, Whitfield. Enlarged three times.

7, 8. *Bathyurus perkinsi*, Whitfield. Enlarged twice.

PLATE LV.



Beekmantown Fossils, Fort Cassin.

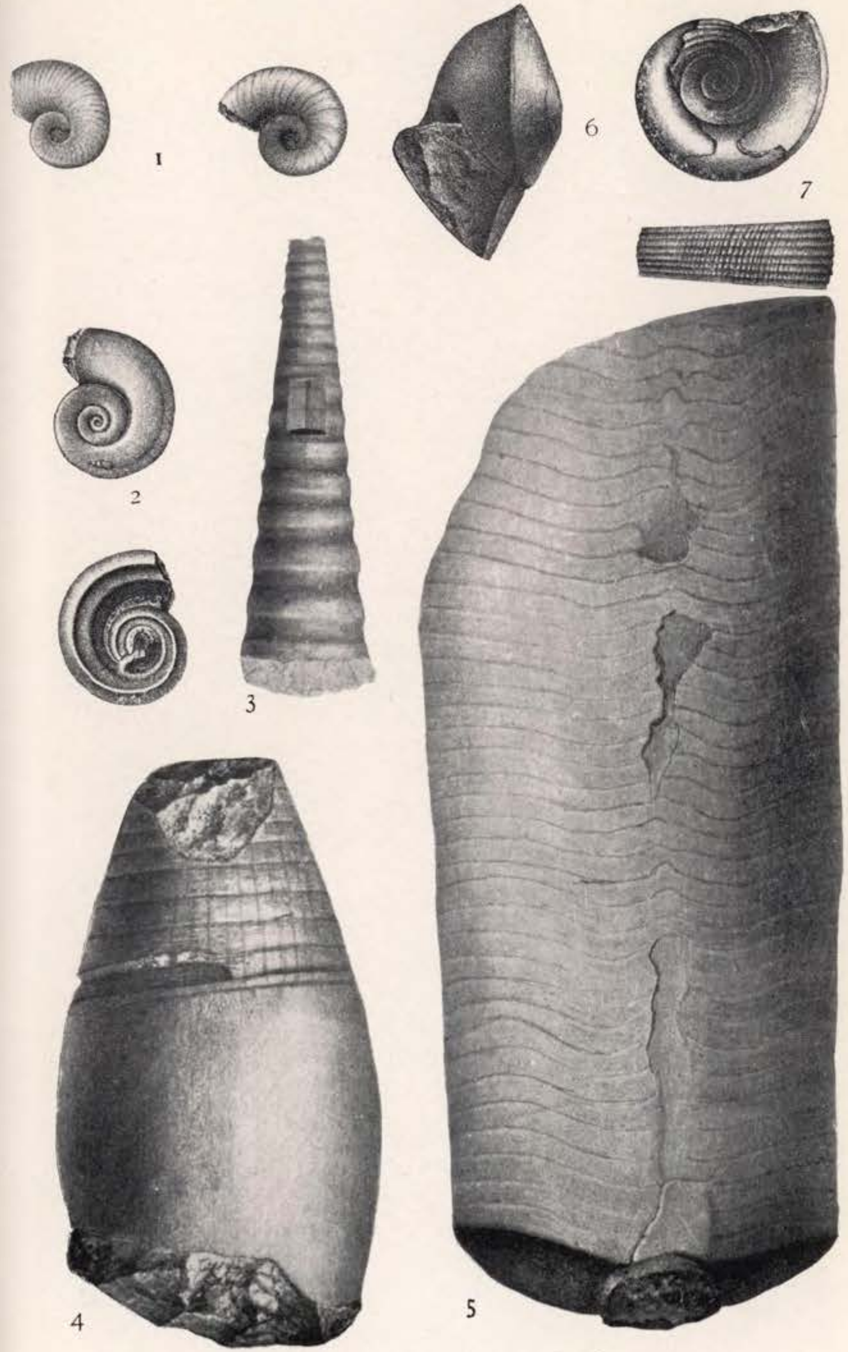
Plate LVI.

PLATE LVI.

1. *Maclurea sordida*, Billings.
2. *Helicotoma similis*, Whitfield.
3. *Orthoceras cornu-oryx*, Whitfield.
   Orygoceras cornu-oryx, Ruedemann.
4. *Gomphoceras cassinensis*, Whitfield.
   Cyclostomiceras cassinense, Ruedemann.
5. *Orthoceras brainerdi*, Whitfield.
   Cameroceras brainerdi, Ruedemann.

6, 7. *Euomphalus perkinsi*, Whitfield.

PLATE LVI.

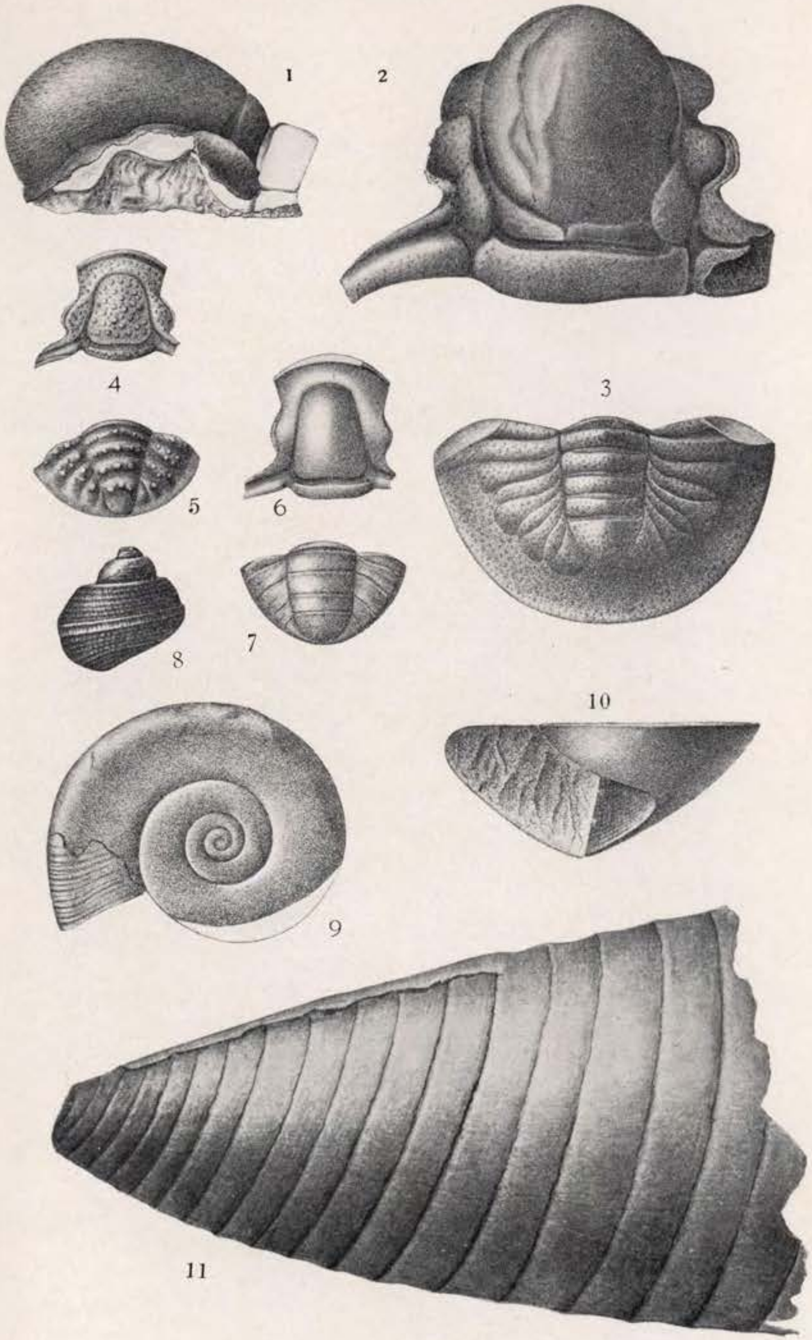


Beekmantown Fossils, Fort Cassin.

Plate LVII.

PLATE LVII.

1, 2, 3. *Bolbocephalus seelyi*, Whitfield.
4, 5. *Bathyurus conicus*, Whitfield.
6, 7. *Bathyurus seeyli*, Whitfield.
8. *Pleurotomaria difficilis*, Whitfield.
9, 10. *Maclurea acuminata*, Whitfield.
11. *Piloceras explanator*, Whitfield.



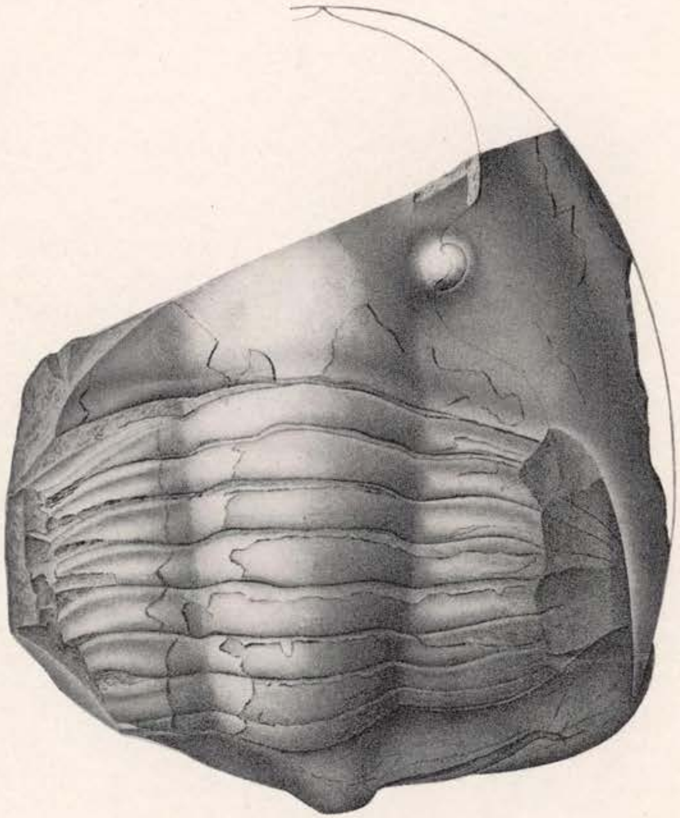
Beekmantown Fossils, Fort Cassin.

Plate LVIII.

PLATE LVIII.

Asaphus canalis, Conrad.

PLATE LVIII.

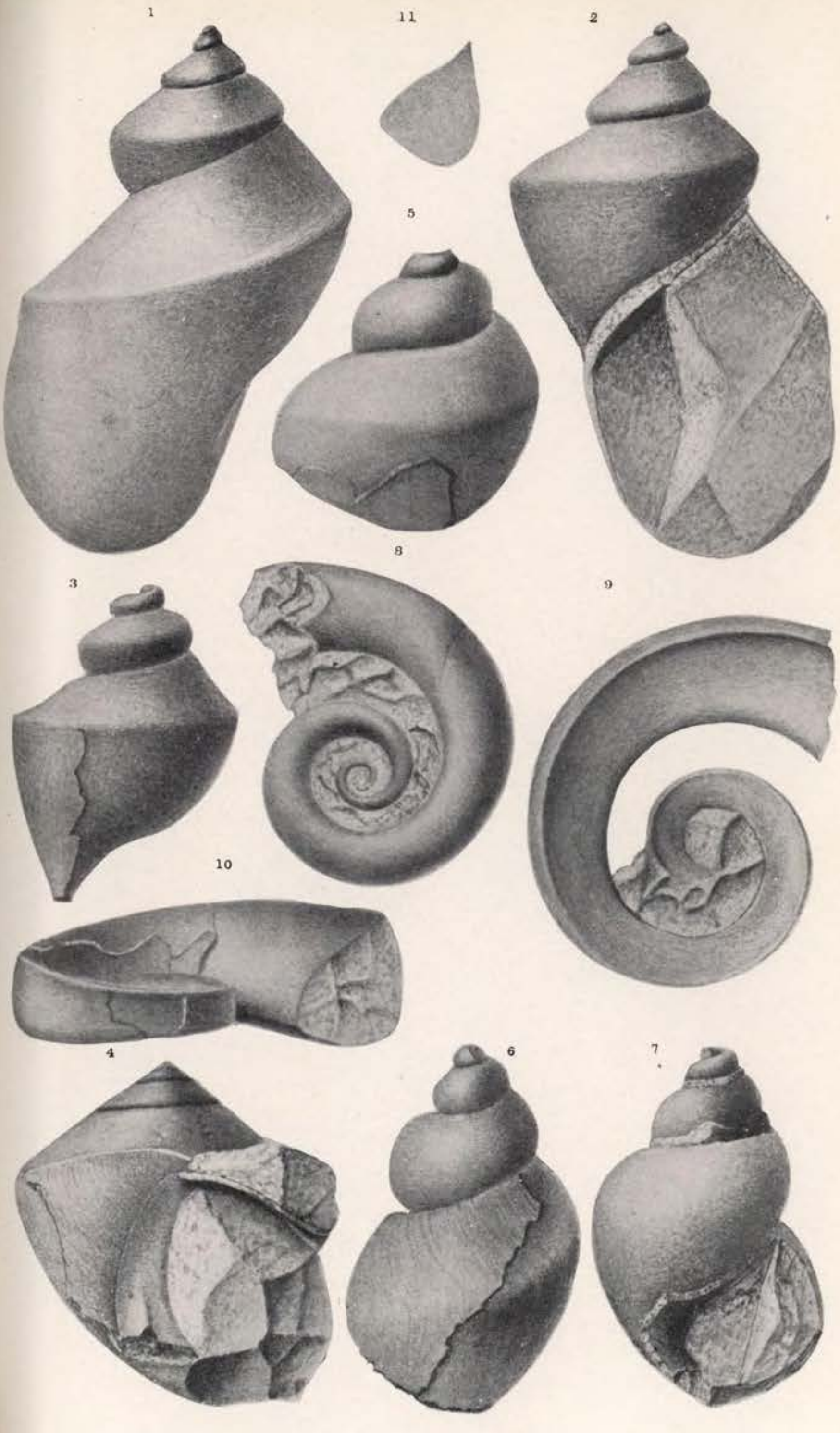


Beekmantown Fossils. Fort Cassin

Plate LIX.

PLATE LIX.

1, 2. *Lophospira cassina*, Whitfield.
3. *Lophospira cassina*, Young.
4. *Lophospira cassina*, Adult, but imperfect.
5. *Holopea arenaria*, Billings.
6, 7. *Holopea cassina*, Whitfield.
8, 9, 10. *Ecculiomphalus volutatus*, Whitfield.



Beekmantown Fossils, Fort Cassin.

Plate LX.

PLATE LX.

1, 2, 3. *Ophileta complanata*, Vanuxem.
4. *Calaurops lituiformis*, Whitfield.
5. *Murchisonia obelisca*, Whitfield.
6, 8. *Murchisonia confusa*, Whitfield.
7. *Bucania tripla*, Whitfield.
9, 10. *Tryblidium conicum*, Whitfield.

PLATE LX.

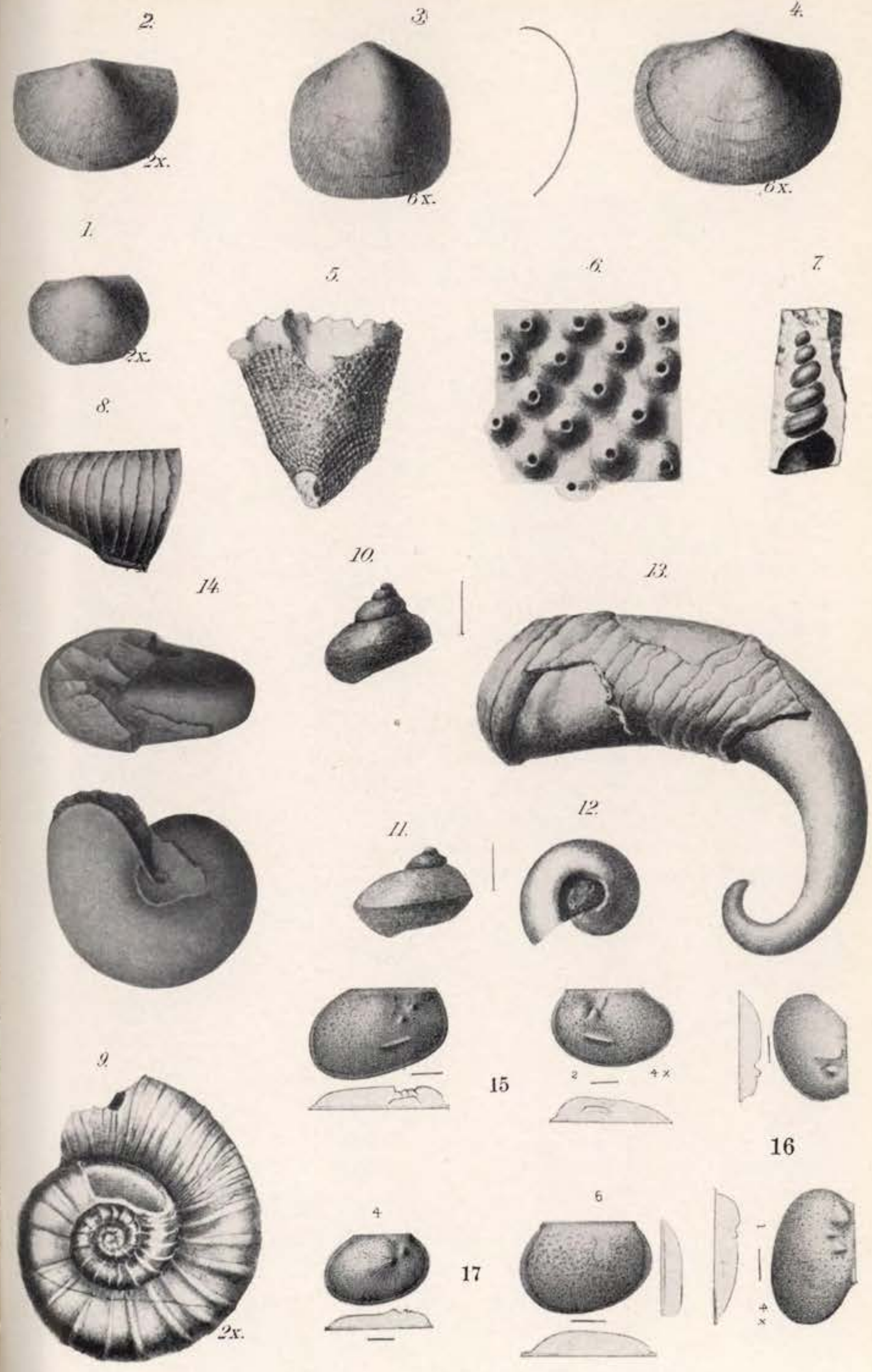
Beekmantown Fossils, Fort Cassin.

Plate LXI.

PLATE LXI.

1, 2. *Protorthis cassinensis*, Whitfield.
3, 4. *Protorthis minima*, Whitfield.
5, 6. *Rhinopora prima*, Whitfield.
7. *Murchisonia cassina*, Whitfield.
8, 9. *Maclurea affinis*, Billings.
10, 11, 12. *Straparolina minima*, Whitfield.
13. *Ecculiomphalus compressus*, Whitfield.
14. *Bellerophon cassinensis*, Whitfield.
15. *Isochilina cristata*, Whitfield.
16. *Isochilina gregaria*, Whitfield.
17. *Isochilina*, large figure, *seelyi*, smaller, *gregaria*, Whitfield.

PLATE LXI.



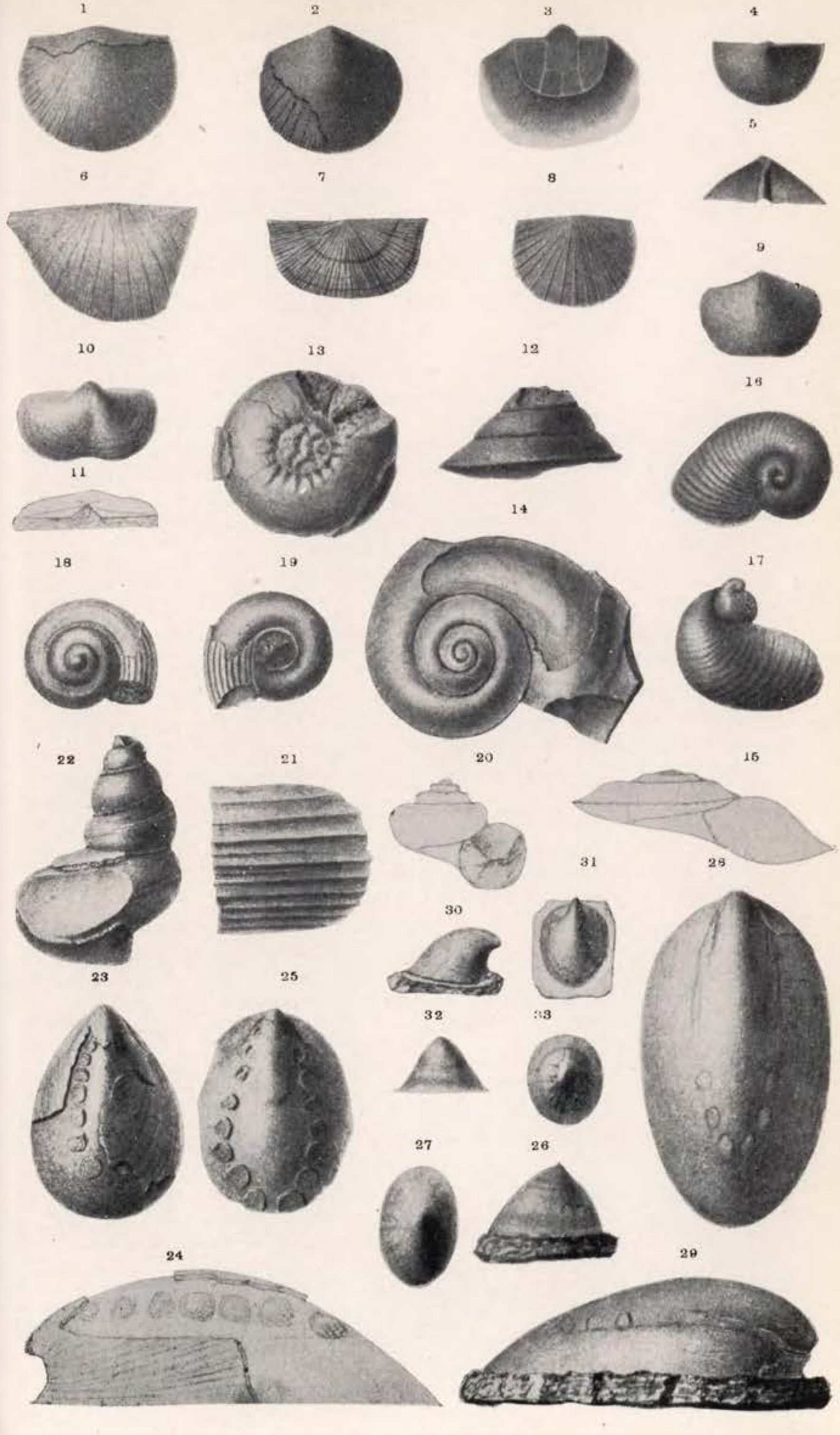
Beekmantown Fossils, Fort Cassin.

Plate LXII.

PLATE LXII.

1–5. *Hemipronites apicalis*, Whitfield.
6. *Leptena*, sp?
7. *Streptorynchus primordalis*, Whitfield
8. *Orthis evadne*, Billings.
9–11. *Triplesia lateralis*, Whitfield.
12, 13. *Pleurotomaria etna*, Whitfield.
14, 15. *Rhaphistoma, compressum*, Whitfield.
16, 17. *Clisiospira lirata*, Whitfield.
18–21. *Euomphalus circumliratus*, Whitfield.
22. *Murchisonia prava*, Whitfield.
23–25 *Tryblidium ovatum*, Whitfield.
26, 27, 32, 33. *Tryblidium conicum*, Whitfield.
28, 29. *Tryblidium ovale*, Whitfield.
30, 31 *Tryblidium simplex*, Whitfield.

PLATE LXII.



Beekmantown Fossils, Fort Cassin.

Asbestos in Vermont.

C. H. Richardson, Syracuse University.

INTRODUCTION.

Under the auspices of the Geological Survey of Vermont, the writer spent a few weeks in the summers of 1909 and 1910 in what is known as the serpentine belt in the northern part of the State in Geological study. The object has been:

1st.—To determine the relation of the sedimentary rocks to each other. Inadequate time for field investigation forbids the accurate mapping and plotting of their relations.

2nd.—To ascertain the relation between these sedimentaries and the various intrusive rocks with which they are associated.

3rd.—To determine the distribution of the serpentine and discover, if possible, new outcrops showing asbestos of commercial value and apply conclusions as to areas where prospecting for asbestos fiber may be wisely and successfully conducted.

To better understand the development and production of this important mineral the author was privileged in the summer of 1907 to spend several days with Professor J. A. Dresser, by the courtesy of the Canadian Geological Survey, in the area of the best development of asbestos at the Black Lake, Thetford and East Broughton districts, northeast of Sherbrooke; and again to enjoy the companionship of and receive many timely suggestions from Professor Dresser in the study of the Vermont area in the summer of 1909. To Professor Dresser, I hereby express my indebtedness.

Note—In Vol. 16, pp. 417-444 Bulletin of the Geological Society and Fifth Report, Vermont Geologist p. 35, Prof. V. F. Marsters discusses the Amphibolites of Belvidere Mt., Vermont. They are practically confined to the uppermost 1000 feet of the mountain and extend as far north as Hazen's Notch. He also cites two small exposures of the same rock at the lower edge of the Serpentine, now worked by the Lowell Lumber and Asbestos Co., at Chrysetile.

The Amphibolites of Marsters seem to be largely confined to the periphery of the Serpentine. They are the rocks that flank the Serpentine on the south-west and north-east sides of Belvidere Mt. These rocks consist essentially of dark green hornblende, which at the contact zone of the Serpentine is highly garnetiferous. His discussion of the Serpentine is practically confined to the single area of Belvidere Mt.

In my own paper the term Peridotite frequently appears. The rock comprises the ultra-basic intrusion that stretches in more or less broken outcrops from Eden and Lowell, Vermont to the Black Lake, Thetford and East Broughton districts north-east of Sherbrooke, Canada. The rock consists in its purer state essentially of Olivene. It is this mineral that metamorphoses to Serpentine and subsequently crystallizes as Chrysotile, the fine silky Asbestos that renders the belt embodied in the discussion of so great commercial importance. The present Author's paper is confined to the larger geological features of the Peridotite in keeping with the work of the Canadian Geological Survey, rather than to the Amphibolite borders of the southern portion of the belt.

Also to William G. Gallager, President of the Lowell Lumber and Asbestos Co., for his many courtesies.*

DRAINAGE.

The drainage of the serpentine belt is, in the main, in a north to north-easterly direction by the Missisquoi River which, in Canadian territory, flows through a transverse valley in the northern extension of the Green Mountains, then turns southwesterly and empties into Lake Champlain. Into this river there flow numerous smaller streams from the crests of the Green Mountains on the west and north-west and the lower range of mountains and hills on the east and south-east. These smaller streams not yet graded furnish numerous water-powers where millions of feet of lumber are sawed each year. The most important water power in the belt is in the Missisquoi Valley, three miles south of North Troy where a sixty-five-feet vertical fall can be secured in the Missisquoi River. This power is not yet utilized. The extreme southern section of the serpentine area is just south of the height of land and the drainage is southerly into the Lamoille River.

TOPOGRAPHY.

The area traversed lies between parallels 44° 45′ and 45° north latitude and longitude 72° 15′ and 72° 30′ west from Greenwich. Its principal valley is the broad, V-shaped Missisquoi with numerous transverse V-shaped valleys, true valleys of incision.

The altitude of the valley ranges from about 700 feet to 900 feet above sea level. The hills and mountains on the east vary from about 1,800 to 2,500 feet in height while those on the west are much higher, reaching a maximum in Jay Peak of 4,018 feet.

GLACIATION.

The area of the serpentine belt in Vermont is mantled with morainic material to such an extent that the geologist may travel many miles without finding a single outcrop of rocks for the study of field relations. This renders conclusions very difficult as to correct geological distribution of the terranes.

There is, however, one important feature in this glaciation, it has eroded the hills of asbestos-bearing serpentine, leaving in many cases the rocks exposed to view, but, of far greater significance, carrying away a portion of the serpentine rock, leaving commercial asbestos fiber at or near the surface. It should hold true that the stoss or struck side of the mountain or hill should be the more deeply eroded and therefore brought nearer the commercial asbestos; but the

*Mineral Deposits of the Serpentine Belt of Southern Quebec, J. A. Dresser.
Jour. Canadian Mining Inst. Vol. XIII, 1909.
Canadian Geol. Survey. Ann. Rep. 1909

asbestos is not always best developed on the north side of the hills. At Chrysotile, the site of the Lowell Lumber and Asbestos Co.'s Mill, the best development is in the north-east side of Belvidere Mountain.

Another feature of the work of the ice in this area is the rounding and polishing of the youngest intrusives, the diabases, until they suggest hay-stacks in some localities and in others, roches moutonnées. These features are best seen in the northern part of Troy and Newport.

GEOLOGY.

The geology of the serpentine belt is intricate and complex. The western range of mountains of which Jay Peak and Belvidere Mountain are the highest, comprise gneisses and schists, folded and faulted, Pre-Cambrian metamorphics. The schists are hornblende, sericite, mica, etc., and dip everywhere at a high angle.

The sedimentaries flanking the serpentine belt on the east are as highly folded and as much metamorphosed as those on the west. They are schists, slates, sandstones and quartzites which may all be Pre-Cambrian, but the writer is inclined to believe that, in part at least, they are Cambrian. It is evident that, in northern Vermont, the Ordovician terranes are not cut by the basic intrusives. The igneous rocks or intrusives in the serpentine belt consist of the ultra-basic rock known as peridotite, pyroxenite, gabbro, gabbro-diorite, diabase and porphyrite are also found; but the nore acid rocks like the granites and aplites, I have not found in Vermont cutting the serpentine, as they do at Thetford, Quebec.

PERIDOTITE.

It is with this rock mass in its numerous phases that this report has to deal, for the peridotite is the source of the serpentine in which the asbestos fiber appears and the magnetite of Troy that was once worked for its iron content.

The term peridotite, as here applied, embraces a series of rocks, sometimes granitoid in texture, occasionally porphyritic, but always dark, heavy and basic. The writer has traced this belt to the north-east through Quebec, Nova Scotia and into Newfoundland where, on the western coast of the Island, most excellent asbestos fiber is developed.

In a south-westerly direction, the belt extends along the Appalachian Mountains to Cuba, for I have received as fine samples of chrysotile asbestos from Cuba as ever came from either Vermont or Canada.

The area covered in this report extends only about 30 miles south of the International boundary up the valley of the Missisquoi River into Eden. The greatest width is in Troy and Jay, reaching a maximum of 3 miles. The general strike is north-easterly, but in Lowell it has a strike of N.

iron, in the process of serpentinization loses a part of the silica and the iron. The olivine is an anhydrous mineral. The serpentine is hydous. In the process of serpentinization the new mineral or rock mass has taken up water to the amount of 12% to 14%. The resulting serpentine is softer than the parent rock. It can easily be distinguished from fresh peridotite. In many localities the alteration is incomplete and therefore all stages of transition exist between the holo-crystalline peridotite and the pure massive serpentine. Even in the same mine, as the Lowell Lumber and Asbestos Co., there are hard masses of rock, essentially olivine now but little changed; and in close proximity to these masses, areas of complete serpentinization.

In this process of alteration, fracturing is necessary. This process is not confined to one cause alone. In the cooling of the original peridotite magma, the normal shrinkage of volume would necessitate fracturing. Along these planes, serpentinization proceeds into the wall rock. In the second place, fractures are produced by expansion due to serpentinization and the greater the fissuring and fracturing the more complete the serpentinization appears to be. A third cause is the dynamic force manifested in mountain building. The greatest amount of fracturing of this kind is found where the serpentine is in contact with sediments, for here would be natural planes of yielding. A fourth cause is found in the casting off of concentric shells from the more or less rectangular blocks formed in the cooling of the magma. Fracturing, therefore, by whatever force, plays the role of both cause and effect.

Water of Crystallization.—In this process of transition from peridotite to serpentine, water is essential; for, as elsewhere noted, the resultant rock contains 12% to 14% of water. The actual source of this water may not be definitely known. There are two sources that appear to play some part in the process: 1st, the meteoric waters that circulate so freely amongst the rocks; for where springs and brooklets appear in the serpentine belt, the serpentinization is greater and the rock more fully fractured. 2nd, the introduction of either basic or acid intrusives would bring in magmatic waters. In the presence of the basic intrusive, diabase, in Troy, the original pyroxenite is completely metamorphosed into steatite, while in Canadian territory, where the acid intrusive, granite, cuts the serpentine, it is looked upon by Professor Dresser as a favorable indication of the occurrence of asbestos.

According to Dr. F. W. Clarke, chief chemist of the United States Geological Survey, serpentine may be formed from any silicate which happens to be rich in magnesia; such as, olivine, pyroxene, amphibole, garnet or chondrodite.*

*Data of Geochemistry, F. W. Clarke, Bulletin 330, U. S. G. S.

Peridotites, pyroxenites, gabbros and amphibolites may undergo serpentinization, but the pyroxenites in the serpentine belt in northern Vermont seem to metamorphose into massive talc or steatite and the peridotites into serpentine. The gabbros and diabases are here of later origin.

According to Dr. Clarke, again, when distinctively magnesium silicates undergo hydrous metamorphism, which happens chiefly in the belt of weathering, the product is likely to be talc or serpentine. A typical production of serpentine from rock containing olivine may be represented by the following equation:—$2\ Mg._2 Si\ O_4$ plus $2\ H_2O$ plus CO_2 equals $Mg_3\ H_4\ Si_2 O_9$ plus $Mg\ CO_3$. Peridotites are especially liable to this sort of alteration.

ASBESTOS.

The term asbestos has been applied commercially to two distinct and widely varying classes of minerals whose value in the marts of trade is based upon flexibility, toughness, incombustibility and non-conductivity of heat.

In the first class falls the amphibole asbestos, with the minerals actinolite and tremolite the most delicately fibrous; in luster, dull to vitreous; in color, green to white; in tenacity, flexible to extremely brittle; with 1% to 2% of water common in the older crystalline rocks of the Appalachian belt and present as actinolite at the New England mine in Eden and the Broughton district in Canada.

In the second class falls the true asbestos serpentine, variety chrysotile, whose luster is silky or silky metallic; whose color ranges from greenish white through green, olive green and yellow to white. In structure it is delicately fibrous, flexible and easily separating into threads so fine, so flexible, so tenacious, that it can be easily spun or woven into fabrics.

Into the above class falls also picrolite whose fibers or columns are not easily flexible and often not easily separable; splintery in fracture, and in color, varying shades of green, gray and brown. The composition of the second class, the varieties of serpentine may be represented by the formula, $3\ MgO,\ 2\ SiO_2,\ 2\ H_2O$.

Kinds of Fiber.—There are several different kinds of asbestos fiber determined by the composition of the mineral or rock mass producing the material. The cross-fiber is of the greatest commercial importance. It occurs in distinct veins and extends directly across from wall to wall of the serpentine. The center of the fiber is often marked by a film of magnetite or chromite from which the chrysotile grows exogenously into the walls of serpentine. Tape measuring of several samples has proven $\frac{2}{3}$ serpentine and $\frac{1}{3}$ fiber. These fibers vary in length from a small fraction of an inch to 2 inches. Cross-fiber is best developed in Vermont at the property of the Lowell Lumber and Asbestos Co., at Chrysotile.

The slip-fiber occurs parallel with the fracture planes produced by the crushing and shearing of the rocks in the process of mountain building. Such sheared or shaly serpentine may carry a larger percentage of fiber than the cross-fiber bearing rock, but it is not of so great commercial significance. This is best developed in Vermont at the property of the New England Asbestos Co., in Eden.

The third form of fiber to distinguish it from the others is called mass-fiber. Unlike the other two it does not occur in veins but in masses, with the absence or rare presence of the other forms of fiber in the rock. Some small aggregations of fiber have been reported from the village of Lowell, on the property of Mr. J. H. Sillsby. A fourth type of fiber has been found at Chrysotile. For the want of a better term the author would catalog it shear-fiber. The rocks have been sheared after the development of the cross-fiber. It lies parallel with the fracture planes, but orientation occurred after the growth of the fiber. Such shear-fiber is of equal fineness, strength and flexibility with the best cross-fiber. Samples have been found at Chrysotile 6 inches in length, but most of this type is of the same length as the cross-fiber.

According to Professor W. F. Masters, both kinds of fiber, slip and cross, amphibole and chrysotile occur in both Eden and Lowell, and are best developed in the immediate vicinity of faults or near the upper and lower contacts of the serpentine with intrusives.*

Origin.—Chrysotile represents the molecular rearrangement or crystallization of the serpentine, in form most delicately fibrous. The fracturing of the original peridotite, by cooling, by expansion due to serpentinization, by the process of mountain building, by throwing off concentric shells of rectangular blocks or by whatsoever cause the parent rock may be broken, is necessary that serpentinization may ensue. The crystallization of the serpentine in silky fibers gives rise to chrysotile. It is the amorphous serpentine of the side walls that suffers this change. The presence of the film of magnetite now marks the line of fracture. The growth is outward from the film of magnetite or chromite into the wall of serpentine. Its growth is exogenous, outward, rather than endogenous, inward growing, as is manifested by the filling of fissure, from the walls inward.

A single hand sample collected at Chrysotile shows the film of magnetite in the center of the asbestos vein; the asbestos one-half inch in width, the serpentine band 1½ inches wide on either side of the asbestos vein. Each band

*Serpentine Belt of Lamoille and Orleans Counties, W. F. Marster's Fourth Report Vermont State Geologist, 1903-04.

is distinctly marked as the vein itself, and beyond these bands of serpentine the peridotite, essentially olivine.

Replacement or crystalization is always proportionate to serpentinization and the vein of chrysotile is about $\frac{1}{3}$ the width of each band of serpentine A well serpentinized peridotite should yield 15% of asbestos fiber. The process demands moisture, derived either from meteoric or magmatic waters, or from both It demands heat from overlying sediments, regional disturbance or the introduction of intrusives.

Geographical Distribution.—There are four distinct asbestos properties in northern Vermont. One of these is situated in the eastern belt of the peridotite and three in the western. The first of these in the eastern belt is situated 2 miles northeast of Lowell, on the farm now owned by C. F. Kelley. The mineral right is owned by Judge M. E. Tucker of Hyde Park. The property has long been known as the Charles Perkins farm. Five openings have been made upon the property, three on the west side, one on the north-east side and one on the east. It is upon the east to north-east side that the best asbestos will be found. The fiber here is essentially the cross-fiber and the veins vary from a mere fraction of an inch to 1½ inches in length. One block 2 feet in diameter showed 20 veins of cross-fiber, netting 6 inches of fiber. Another block 21 inches in diameter gave 17 seams of cross-fiber, netting 5 inches of fiber. Still another 12 inches in length shows seams, netting 4 inches of fiber. In these samples the rock is all serpentinized. They are exceptionally fine fragments or blocks thrown out in the small amount of work done on the property. The rock is not equally serpentinized. On the western side it consists largely of olivine and by its superior hardness would be difficult to work.

The southern-most of the openings on the west side shows good slip-fiber and some cross-fiber. If all the development work done on this property had been executed on the east or northeast side of the outcrop a far better showing would be available and much commercial asbestos obtained. It is the author's opinion that sufficient fiber exists to warrant the immediate development of the property and the construction of a mill that can manufacture a car-load of asbestos per day. The strike of the outcrop is N. and S. Its length, practically unbroken, has been traced for 25 miles. Its width at this point is ½ mile provided it is not connected with the Round Mountain area. If so, it is over 2 miles in width. The character of the out-crop and the working of the steam drill on the east side can be seen in Plate LXIII.

The second possibility of asbestos fiber of commercial significance is situated on the north-east side of the Round

Mountain area in Lowell and Westfield. The belt is several miles in length and one in width. On the southern end of the Mountain no asbestos fiber of importance seems to appear, but on the north and north-east sides both slip-fiber and cross-fiber were apparent in considerable quantity, enough to warrant the carrying on of development work to a considerable extent. The surface rock is soft, easily worked and well serpentinized. The property is now under option which soon expires. The property is owned by Thomas Gilbert of Westfield. Two samples from this quarry were measured. Each was 1 foot in length. One showed 17 veins of fiber, and the other 12; each would give 3 inches of fiber. These may be exceptional samples, but if obtained from the surface, the condition is favorable for merchantable asbestos in considerable quantity.

Erosion has carried away the sedimentaries on the east so that the Mountain rises hundreds of feet above the Missisquoi Valley. This makes the development of the property easy, for the serpentine is cut at a low level on the side where fracturing has been the greatest, serpentinization the most complete, and therefore the point where commercial asbestos is most likely to be found.

The third of these belts is situated on the south-west side of Belvidere Mountain in Eden, Lamoille County. The New England Asbestos Co. has leased for 198 years, 90 acres of land thus located. The asbestos bearing rock crops out over a considerable portion of this area. It is well serpentinized, crushed and easily worked.

A considerable amount of open cut work has been done which shows good asbestos in the direction of the strike N. E. and S. W. A shaft has been sunk some 40 feet which is reported to be in fine asbestos. The present working breast is about 200 feet north of the mill and 30 feet higher in altitude. Gravity, therefore, can handle the mineral, and several hundred tons of good milling rock are on the dump on either side of the trestle leading to the mill which is a three-story structure and designed on the basis of 30 tons of finished product per day. A boarding house and stables have also been constructed. A considerable quantity of machinery lies about the mine. It is a matter of deep regret that after spending $90,000 in development work upon this property the company should not have become a large producer of asbestos. That it is through some mismanagement that the plant now lies idle is practically proven by the results of the treatment of both asbestos bearing rock and tailings, by the fine mill of the Lowell Lumber and Asbestos Co. at Chrysotile, June 3, 1908, as given below.

Sample No. 1 was taken from the milling rock by the side of the trestle. Weight, 2,150 pounds.

No. 1 fiber	7.5 lbs.
No. 2 fiber	30 "
No. 3 fiber	50 "
No. 4 fiber	254 "
Total	341.5 lbs.

Sample No. 2 was taken from the tailings of the mill. Weight, 1,752 pounds.

No. 1 fiber	2.5 lbs.
No. 2 fiber	11.5 "
No. 3 fiber	27 "
No. 4 fiber	196 "
Total	237 lbs.

When the tailings allow 15% of waste some error is very apparent. By conservative management this property may yet become a producer of considerable asbestos.

On the Eden side of Belvidere Mountain are situated the properties of six companies. Their arrangement from west to east would be, Brown Asbestos Co., New England Asbestos Co., United States Asbestos Co., Lamoille Asbestos Co., Blake and Lewis Asbestos Co., Stearns and Farrington Asbestos Co. The strike of the vein on the New England Asbestos Company's property would lead to the conclusion that commercial asbestos might be found upon the Brown and United States Companies' property. The writer has examined ten openings upon the property of the Lamoille Asbestos Co., but no commercial asbestos was found.

The fourth field, which is the first in importance for the production of asbestos in Vermont, is located at Chrysotile. It is situated on the north-east side of Belvidere Mountain in the township of Lowell. The name Chrysotile for the growing hamlet stamps the locality as the great producer of chrysotile asbestos in the United States. The property is owned by the Lowell Lumber and Asbestos Co., whose president and general manager is William G. Gallager. Plate LXIV.

Discovery.—A French-Canadian lumberman in the employ of Judge M. E. Tucker, some 16 or 17 years ago, discovered, while felling trees on the eastern side of Belvidere Mountain, a vein of chrysotile. This was immediately recognized by its similarity to the Canadian product. Mr. Tucker at once began search for merchantable asbestos and did considerable development work before the purchase of the property by the Lowell Lumber and Asbestos Company.

According to Professor J. F. Kemp of Columbia University,* the serpentine area is here bounded on the south, east and west by gulches, so that it forms a sort of protecting

*The occurrence of Asbestos in Lamoille and Orleans Counties, Vt., J. F. Kemp, Min. Resources U. S. 1900, pp. 6-12.

PLATE LXIV.

Asbestos Opening. Lowell Lumber and Asbestos Company, Chrysotile, Vermont.

buttress extending outward from the mountain. As the mountain is approached, a great shoulder is found projecting to the south from the main peak which rises some 2,000 feet above the serpentine. To the north of the serpentine there rises above it a precipitous wall of hornblende schist, dipping to the east. A fault with strike north 15° west brings the hornblende schist, sometimes altered to chlorite schist, abruptly against the serpentine and forbids the extension of the latter farther to the west.

At the exposures of the Lowell Lumber and Asbestos Company's property, Plate LXV, the serpentine forms a precipitous cliff and the excavations are made on the face of this escarpment. It now rises 75 feet above the lower workings. Therefore the rock can be blasted out in open cuts for a considerable period of time.

Advantages of mining asbestos at Chrysotile:

1. A sufficient supply of water flows down the sides of the escarpment to allow washing off all soil and waste rock from the surface to be mined.

2. The altitude of the open cuts is more than 100 feet above the valley below, which permits of the disposal of grout into the valley by short trestles.

3. A 75-foot working face that can be carried back permanently without hoisting machinery.

4. A maximum of 140 feet vertical face with 2,000 feet on the horizontal.

5. The possibility of working under ground in winter time in short adits.

6. The mill is so situated on the side of the valley below the escarpment that it will take all the mineral that can be mined above this altitude direct to the storage bins without the necessary expense incurred in hoisting.

7. Close proximity to water for the manufacture of heat and electricity for light and power.

8. An adequate supply of timber for all purposes of mine and mill construction, together with dwelling houses for the workmen.

9. The construction of these homes enables Mr. Gallager to secure the better and more permanent class of laborers.

10. Marketing the best manufactured products without the payment of duty, as a 25% duty exists on the importation of Canadian asbestos manufactures.

11. The ratio of well serpentinized, easy milling rock to the hard, unserpentinized, olivine bearing rock.

12. Reasonably close proximity to market, allowing low freight rates to both Boston and New York. Therefore it enters easily into competition with the Canadian chrysotile.

The Type of Fiber.—The asbestos occurs in three distinct and contrasted varieties. 1st. The cross-fiber extending plates accompanying this article. One advantage the mill has over many others is the saving of a large percentage of fiber as soon as it is separated. The mill is clean and in every way efficient.

The company has recently purchased a traction engine, capable of hauling 25 tons to or from Hyde Park. This will reduce the cost of transportation of materials both to or from the nearest railway station. The engine, when the new road is finished, can easily make the round trip in a day. The company is also about to erect a hydro-electric power plant, and is constructing buildings and installing machinery for the manufacture of asbestos shingles, lumber and related products.

Grades.—There are 6 grades of asbestos known as numbers 1, 2, 3, 4, 5, and 6.

1. Crude asbestos, per short ton, ranges in value from $250–$350.
2. Crude asbestos, $150–$250.
3. Asbestos fiber, according to grading, $50–$150.
4. Asbestos fiber, according to grading, $25–$50.
5. Fines, according to grading, $10–$25.
6. Fines, according to grading, $1–$10.

About 21 hundred tons of all grades were produced by this plant in 1909. More chrysotile asbestos may be expected from this mine in 1910 than ever before.

Conclusions based upon the study of the Geological Formations at Chrysotile:

1. The quantity of merchantable asbestos available. This depends upon several factors.

a. The percentage of olivine in the original peridotite, as determined by the degree of differentiation in cooling as influenced by basicity and gravity.

b. The amount of fracturing that has taken place under the contraction of the cooling magma, producing joint planes, regional compression in mountain building, the throwing off of concentric shells from jointed blocks, expansion due to serpentinization and possibly to flow structure in the periphery of batholitic intrusions.

c. The presence of intrusives. These, wherever present, aid in the fracturing of the original peridotite, thereby producing both a cause and an effect of serpentinization. They also introduce magmatic waters that aid in serpentinization and possibly in crystallization.

2. The most favorable places to exploit for asbestos are:

a. On the north or northeast sides of the serpentine-bearing hills. Erosion has been deeper and therefore productive zones more liable to be encountered.

b. If the structure be a sill the asbestos is more liable to appear at its base. If a batholith, at or near its center.

c. In the immediate vicinity of faults or near the upper and lower contacts of the serpentine with intrusives.

3. *a.* Olivine magmas serpentinize and crystalize as chrysotile.

b. Olivine and pyroxene magmas give rise to serpentine and steatite, or chysotile and talc.

c. Pyroxene magmas metamorphose into massive talc or steatite.

4. A residual product, through chemical changes, is a silicious magnesite as found at the Red Rocks in Troy.

5. The Lowell Lumber and Asbestos Company has an adequate amount of chrysotile-bearing serpentine rock to warrant the output of 100 tons, or 5 car-loads, of asbestos per day.

The pulverized tailings of the present mill, when mixed with some chemical binder, can be utilized as insulators for chemical work, paving and roofing materials. Even the by-product of dust serves as a filler rather than a hardening ingredient in paint which never flakes and remains light gray in color.

USES.

According to J. S. Diller of the United States Geological Survey,* the fundamental property of asbestos upon which its use depends, is its flexible, fibrous structure, coupled with which are the scarcely less important qualities of incombustibility and slow conduction of heat and electricity when the mass is fiberized and porous, which makes it valuable, not only for fire-proofing, but for insulating against heat and electricity.

1. Asbestos fiber or cotton rock was known to the ancient Greeks and Romans. Its earliest use was for spinning and weaving to make incombustible thread, yarn, rope and clothing. Newer uses are for gloves, boots, etc., for firemen, theatrical curtains, and paper for mortgages, deeds and marriage certificates.

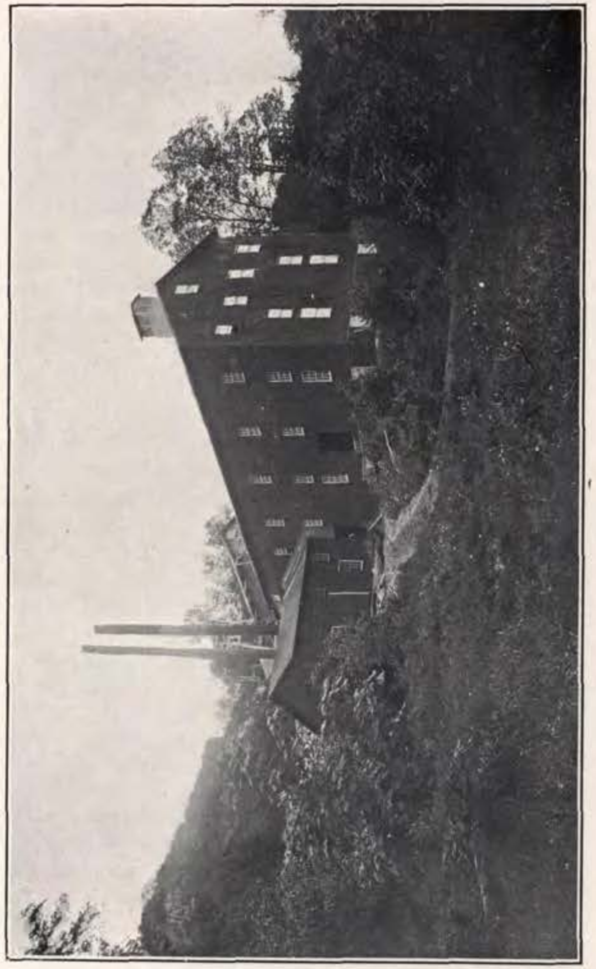
Therefore the most important uses are those based upon this property of incombustibility. Crude asbestos is best suited for this purpose, but Nos. 1 and 2 from the mills are also used. The fiber is so delicately fine that a single pound will connect two points more than 6 miles apart.

2 Its slow conduction of heat and electricity has given rise to a large number of uses as a basis of insulation. Its fiber is of a refractory nature and an insulator of high order. It may be added as a fibrous binder or used on account of its resistance to the active chemical agents so likely to attack electrical insulators.

3. In structural materials, when influenced by heat and electricity or for decorative effect. Asbestos roofing

*Min. Resources, U. S. 1907, pp. 766-781, 1908, pp. 697-706.

PLATE LXVI.



Mill, Lowell Lumber and Asbestos Company, Chrysotile, Vermont.

slate which makes a permanent fire-proof roofing of uniform color. This slate can be nailed whether perforated at the time of manufacture or using.

In shingle for roofing or sides of houses for decoration. In asbestos boards that can be nailed or screwed to walls of wood or iron.

In asbestos lumber that can be planed or sawed like wood. This ever increasing use is thoroughly practical, for there is no shrinkage and no expansion, will not absorb moisture and is fire-proof. It can be applied both to the interior and exterior of buildings. It is especially valuable near the sea-shore where saline waters disintegrate wood or destroy pigments. In decorative interior work it can be finished in quartered oak, mahogany, black walnut or like any other wood. In the construction of garages of steel frame, asbestos boards can be fastened to the walls and shingles to the roof and the structure will be fire-proof. The building will not rust and will require no painting. Stucco and plaster are forms used in decoration. Houses made of asbestos are not only fire-proof but also warmer in winter and cooler in summer.

4. In various minor uses, as the manufacture of fire-proof safes and vaults, refrigerator linings, cistern and cold storage structures.

5. As a pigment under the name of asbestine. Its value depends upon its power to hold up other pigments in the paint. It gives tooth and feel under the brush and imparts strength and life to the coating. With lead and zinc, it imparts properties given by no other pigment in the marts of trade.

6. Asbestic is a wall plaster that is without either hair or sand. The asbestos fiber furnishes a substitute for the former and the pulverized rock for the latter. It is used for plastering walls and ceilings and for fire-proofing columns, beams, etc. It is not affected by frost nor extreme climatic changes.

7. Vitribestos is a vitrified and indurated asbestos. Its value depends upon its great strength, solidity, fire-proof and water-proof qualities; also its lightness and high insulating properties.

8. Domestic uses. In table cloths, stove mats, stove linings, iron holders, iron rests and gas heaters.

In short, the uses of asbestos and its variousm anufactured products are too numerous to catalog, but the above will give a general idea of the fields in which it is most widely utilized.

MAGNETITE.

In the last report of the State Geologist, 1907–1908, the writer called attention to the lenses of magnetite that occur in the serpentine belt in Troy, about 2 miles north-east of the village. The ore, as already noted, was at one time worked in a foundry situated on the banks of the Missisquoi River, while a part was shipped to St. Johnsbury some 50 miles distant.

The analysis of the ore is given below:

Magnetic iron, Fe_3O_4	70.44%
Chromic oxide, Cr_2O_3	.41 "
Manganese oxide, MnO	3.15 "
Titanium oxide, TiO_2	2.10 "
Sulphur, S	.17 "
Phosphorus, P	none
Serpentine by difference	23.73 %
	100.00%

The freedom of this ore from phosphoric acid and sulphur is especially interesting.

LUMBER.

Perhaps this appended note has no place in a report upon the asbestos industry in Vermont, but the hills flanking the serpentine belt both upon the east and the west are heavily freighted with valuable lumber. By careful consultation with the owners of some of the mills manufacturing various forms of lumber in the Missisquoi valley and others interested in the industry, it was ascertained that 25,000,000 feet of lumber was produced each year in this serpentine area.

This output, together with 5 car-loads of asbestos per day from Chrysotile from the Lowell Lumber and Asbestos Co., as assured by Mr. Gallager, 2 car-loads per day from the New England Asbestos Co., as assured by Mr. B. B. Blake of Eden, and a possible car-load per day from the M. E. Tucker property, ought to be inviting to some railroad to extend its line through the productive Missisquoi valley.

Mineral Resources.

G. H. PERKINS.

The flourishing condition of the stone industry in Vermont which has been noticed in previous Reports, has continued throughout the two years included in the present volume.

It is quite certain that, while as heretofore, there will be fluctuations in the demand for building material of all sorts and, of course, a corresponding fluctuation in the demand for structural stone, notwithstanding this, the increased demand for stone, especially marble and granite, to be used in building, is permanent. As is obvious to everyone who notices the buildings that have been erected within the past ten years, stone is much more commonly used in most large buildings than formerly. As the country grows older and money in considerable sums is more available for building, wood gives place to the more costly, but far more durable and elegant material.

We may therefore safely assume that not only has the greater demand for stone come to stay,but that for the same reasons the demand must increase.

As Vermont is so fortunate as to possess a practically unlimited supply of building material, slate, granite and marble, of a quality that is nowhere surpassed, the above facts are of no little importance. However it may chance to be with other industries, however the market may change as to such other materials or commodities as are produced and sold in Vermont, it is, I think, quite certain that the sales from the quarries will continue for many years to bring large revenue to the State. Other states may supply a larger amount of stone if all kinds are considered, because in other states there are larger beds of slate, limestone, sandstone, trap, etc., than we possess, but there are nowhere else in this country and probably nowhere else in the world, such deposits of marble and granite, and in these two most important kinds of stone, Vermont leads all other states and will continue to do so.

It is not certain that any other state, vastly greater as is the area of many, will ever lead this in the stone business as a whole. In 1908, Vermont produced more stone of all sorts than any state in the Union. This is the first time that we have held the lead in the stone business and it seems probable that we may keep it. Should the production of those varieties of stone used in building which we do not supply, or only in limited quantity, so increase in other states that we lose our present position, there yet remains to us the practical assurance that we shall always lead in granite and marble.

I suppose that no state is wholly destitute of some sort of useful stone and some can furnish the market with many more varieties than can Vermont, as would be expected, when the comparative area is considered, but very few, if any, can supply the two kinds most necessary in fine building in such quantity and quality as can this State.

Nor have we reason to be silent as to our production of slate. While Vermont cannot hope to equal Pennsylvania in the amount of slate produced and sold, it does exceed all other states, and in the variety and quality of this material which it can produce, there is reason for great satisfaction.

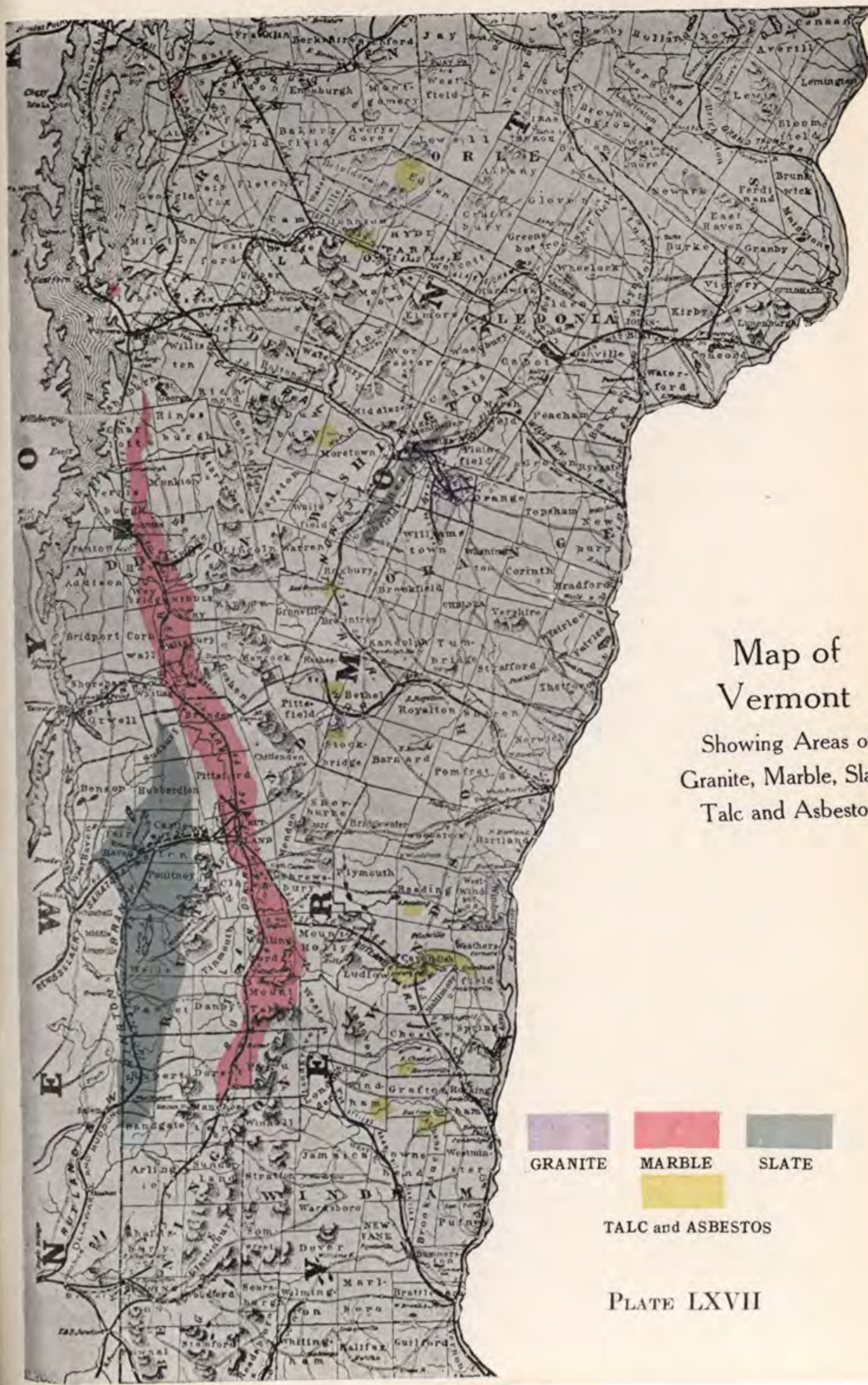
The accompanying map, Plate LXVII, is prepared in order that the relative distribution and extent of the deposits of granite, marble, slate, talc and soapstone may be seen at a glance.

The very limited distribution of marble and slate and much more general distribution of granite, tho the areas are much smaller, is well shown. It is possible that there may yet be discovered a few small areas in which granite can be quarried that are not now recognized and not shown on the map, but these cannot be very important.

Considering now in some detail, the principal kinds of stone quarried and sold in Vermont, we first look more closely at our marble industry.

MARBLE.

As is well known, Vermont produces a far greater amount of the finer grades of marble sold in this country than any other state or than all together. This is the more remarkable, not only because of the small area of the entire State as compared with most others, but also because within this small area the territory from which marble can be obtained is very small. This may be well seen by reference to the map, Plate LXVII, on which that portion of the State in which marble can be quarried is colored red. Nearly all is found within the narrow strip extending from Charlotte on the north to the southern part of Dorset. Far north of this area, not far south of the Canada line, is shown the location of the quarries of the Champlain marbles. This area might properly have been extended south into the northern portion of Burlington, for the same stone occurs at intervals near the Lake shore as far as this, even within the Burlington



Map of Vermont
Showing Areas of Granite, Marble, Slate Talc and Asbestos

PLATE LXVII

city limits, and it has been quarried at several points along this narrow strip, but none of these quarries have been recently in operation. The very small area in Roxbury from which the Verde Antique is taken is too limited to show on a map of such a scale as this. It may be noticed in passing that neither the Champlain marbles nor that from Roxbury are true marbles, tho none the less valuable on that account. All the true marbles are included in the narrow belt shown. Almost all the marble companies doing business in the State report not only good, but increasing sales.

There has been especially a notable increase in the sale of building material. Formerly by far the larger part of the Vermont marble was sold in the form of monuments and interior finish, while the sales of building marble for exterior work were quite insignificant, but during the last few years there has been a great change and now nearly as much marble goes into the outside of buildings of various sorts as is used for any other purpose. This change is best shown by a few figures. In 1900 and 1908 the reported sales were as follows:

	Monumental.	Building.	Interior.
1900	$ 1,570,980	$ 574,623	$ 202,956
1908	1,848,444	1,558,954	1,184,250

	Ornamental.	Other Purposes.
1900	$ 6,000	$66,989
1908	18,000	70,107

Nearly all of the marble sold in this State is finished on the ground. Of the total sales in 1908, amounting to nearly $5,000,000, only $290,000 worth was sold in the rough. I have given the figures for 1908 because they are the latest exact amounts that can be furnished. There is every reason to believe that those for 1910 will be somewhat larger. The gain in sales for interior work is not only great, but the financial gain is much greater than appears, since many blocks that have lain for years about some of the quarries, because not sufficiently sound for monumental work, have been sawed into slabs which are perfectly serviceable when used as wainscotting or in other inside positions. As stated in the last, Sixth Report, there are not less than a hundred varieties of marble which can be furnished from the quarries of Vermont. Probably not more more than fifty of these are usually on the market, as these are more commonly found, easily worked or more generally demanded, but others can be supplied if called for.

As will be noted later, there have been some changes in the organization and working of some of the marble companies, but on the whole the business has gone on much as heretofore, tho with increased success and increased facilities for large production.

The following companies are now active in this State:

Barney Marble Company, Swanton. This Company, tho doing business under its former name, has for some years been a part of the Vermont Marble Company and has been carried on by that company.

The quarries and mills of this company at Swanton work almost exclusively the red mottled Champlain and the green and white Roxbury Verde Antique marbles. For descriptions of these and the varieties of marble named beyond, the reader is referred to the Sixth Report.

Brandon-Italian Marble Company. This company has ceased to do business in its own name and is carried on by the Vermont Marble Company for the present.

The Clarendon Marble Company. This company, organized a year or two ago, is working a large quarry near Clarendon Springs which, tho operated fifty years ago, has since then been idle. This company has been getting out marble for about a year. The stone is unusually sound from the very top and of good quality.

A branch line connects the quarry with the Delaware and Hudson railroad. The marble is mostly of the lighter veined varieties, but there is also dark stone in the quarry. At present, 1910, the chief product of the quarry is used in the new Educational Building in Albany, N. Y. For this 150,000 cubic feet will be needed.

Only stone in the rough is sold as the Company has no mill.

Columbian Marble Company. This company has passed thru some vicissitudes during the last few years. The old Columbian Marble Company was reorganized a few years ago into the Columbian Marble Quarrying Company.

After a not long time it passed into the hands of a receiver and for a year or two its property was leased by the Vermont Marble Company and operated by them. That lease has now ended and a new company having the former name has been organized.

During the last year the company has been at work in the old quarry in Proctor to some extent, but especially in developing a new quarry in Proctor some distance south of the old quarry.

The Eastman Marble Company. This company operates an excellent quarry of light marble in West Rutland, selling the stone in blocks.

Manchester Marble Company. This company has taken the place of the long known Freedly Marble Company, having bought the entire plant of the older concern.

The quarries are on the east side of Dorset Mountain and the mill at the foot of the mountain near the track of the Rutland Railroad.

Norcross-West Marble Company. This company has quarries in Danby and Dorset and a large mill in Manchester. This mill is connected with the Dorset quarries by a railroad six miles long. During the past year the mill has been considerably enlarged.

The marble is all of the lighter varieties and harder than most of the stone quarried farther north. It is used mainly for buildings and some of the largest and finest public buildings erected during the last ten years have been constructed of marble from these quarries. Much stone has also been used for interior work, wainscotting and the like, as in the new Hampden County Court House in Springfield, Mass.

Orvillo Marble Company. This company has operated a quarry in Clarendon which is now idle.

Raleigh Marble Company. This is a company formed to work the old Raleigh quarry in Pittsford and, as I understand, intends to get out stone in the near future, but at present is doing nothing.

Rutland-Florence Marble Company. The quarries of this company are in Fowler and Pittsford and their excellently equipped mill is in Fowler, views of which were given in the Sixth Report. The business of this company is steadily increasing and their quarries have been enlarged and developed during the year.

Vermont Marble Company. This company, with its numerous quarries in Proctor, Pittsford, West Rutland, Danby, Monkton, etc., and mills at Proctor, Rutland, Center Rutland, Brandon, Middlebury, Beldens, East Dorset, and Swanton, is carrying on an enormous business and alone supplies a large part of the marble used in this country. To the already very extensive plant the large quarry at Brandon and mills at Middlebury of the old Brandon-Italian Company have been added since the last Report was published this company having leased the whole plant. A constantly growing business is reported, especially in building marble for both exterior and interior work. The change already mentioned in the varieties of marble sold is well shown in the history of this company.

Not many years ago, by far the greater part of the stone sold was in the form of monuments and mausoleums. During the past ten years the demand for building marble has rapidly increased until now it almost equals that for monumental work.

At present, the largest piece of work that is under way at any of the mills of this firm is a series of sixteen monolithic columns for the Curtis Publishing Company's buildings in Philadelphia.

These columns are each thirty feet long, three feet, eight inches in diameter and weigh from forty-five to fifty tons, Several new quarries have been opened in West Rutland, and to supply the Pacific Coast, marble-producing land has been bought in Alaska, quarries opened and from six hundred to eight hundred tons are sent out each month. This is sawed and cut at Seattle and sold on the west coast.

SLATE.

During the past two years the slate industry has been somewhat irregular. Altho on the whole the sales of slate of all kinds have been larger than at any previous time, there have been some checks to the continuous advance which granite and marble sales have shown.

The slate mills of Fair Haven, Castleton and the vicinity continue to suffer from the effects of the strike mentioned in the last Report. Much of the trade in what is known as "Mill Stock," that is, manufactured slate such as billiard table tops, stair treads, electrical switch-boards, etc., etc., which, during the strike, left Vermont and went to Pennsylvania and in less amount to Maine, has not come back since the settlement of the strike and apparently it will not be recovered. On this account most of the mills have been running either on partial time or, at best, have not been crowded by orders.

The southern part of the slate belt, from which the product is mainly roofing slate, has not suffered as much as it was not greatly affected by the strike and because the demand for roofing slate has, with some fluctuation, continued good. Indeed, at some times the dealers report an abundance of orders and at times more than could be promptly filled. The map, Plate LXVII, shows in the region colored blue the location of the slate of this State. As will be noticed, the main area is in western Vermont, in Rutland County. A small area will also be seen in Washington County. On the whole, taking all kinds of slate into account, larger sales, or at least sales amounting to a larger sum, are reported for the last two years than ever before. This is not wholly due to increased quantity of slate sold, but in part to higher prices received. The total sales in Vermont now amount to nearly $2,000,000 annually.

While those of Pennsylvania are more than twice as great, no other state at all equals our own in this respect, Maine, which is next, only producing one-eighth as much. About eighty-five per cent. of the total production of this State is in the form of roofing slate, this being by far the more important part of the industry.

In the volume of *Mineral Resources* for 1908, in the article on slate, Miss A. T. Coons makes the following statements which are of such practical value that they are quoted here.

"The greater part of the slate quarried in the United States is for roofing purposes and is put on the market and sold by "squares," a square meaning a sufficient number of pieces of slate of any size to cover 100 square feet of roof, allowing a three inch lap. The sizes of slate in a square vary from 24 by 16 inches to 9 by 7 inches and the number of pieces necessary for a square varies from 85 to 686, according to the size of the pieces. The ordinary thickness of a piece is from one-eighth to three-sixteenths of an inch. The approximate weight per square of ordinary roofing slate is 650 pounds, and it is generally shipped in carload lots of from 50 to 100 squares per carload, according to the size of the pieces.

The ordinary price varies from about $3.50 to $10.00 per square f. o. b. at the quarries and depends on the quality, color, size, thickness, smoothness, straightness, and uniformity of the pieces. Some of the inferior slate, which is mottled or ribboned, sells as low as $2.50 a square, but specially prepared slate, with pieces carefully selected with regard to color, extra thickness and size and extra cutting, sells as high as $30.00 per square."

An account of the methods of working slate was given, with illustrations of machinery, in the Fifth Report of this series.

Professor T. N. Dale, with the assistance of several others, has prepared a Bulletin, 275, published by the U. S. Geological Survey on the *Slate Deposits* and *Slate Industry of the United States.* Those who are especially interested in this subject will find much of value in this Bulletin. A brief quotation from this work as to the geological relations of the Vermont slate will not be out of place here. "The broader geographical and geological relations of the western Vermont slate belt are shown in the map. The Ordovician (Hudson) schist of the Taconic range is bordered on the west, except along a stretch of six miles in Pawlet and Rupert, by a belt of Lower Cambrian rocks estimated as at least 1,400 feet in thickness, which include about 240 feet of greenish and purplish roofing slates. This boundary between the Ordovician and Lower Cambrian has been shown to represent not only an unconformity but a folded overlap. In Pawlet and Rupert the schists of the Taconic range merge at the west through decrease of metamorphism into an irregular area of shales and grits of the same age, (Hudson), not less than 1,200 feet thick, which include about fifty feet of reddish and greenish commercial slate. These have long been quarried in Granville and Hampton, N. Y., and are decribed in detail on page 70. In places the Lower Cambrian slate protrudes through the Ordovician slate areas, in others, lenticular remnants of Ordovician slate overlie the Lower Cambrian slate. The relations of these two formations are more intricate in the New York than in the Vermont part of the slate belt.

The Lower Cambrian slates of western Vermont are greenish gray, purplish and variegated, *i. e.*, greenish gray and purplish mixed. These occur in alternations. The quarry diagrams show that there is little regularity in these alternations. In the main, however, this horizon seems to consist of from 100 to 140 feet of greenish and purplish slates, the greenish ones predominating, with from 40 to 50 feet of variegated or mottled overlying, but possibly replacing the purple in places. On the west side of Lake Bomoseen nearly 100 feet of purple are exposed. The purple sometimes contains a few inches of dark reddish slate not unlike the red of the Ordovician.

There is some difference in the shade of the different beds of green in the same quarry, some being more greenish, others more grayish. There are also differences in the amount of discoloration produced by weathering in beds of the same locality. Although some quarries produce only the so-called 'unfading green' and others only the 'sea green', these differences appear not to belong to strata of different ages, but to occur at different points in strata of the same age.

Interbedded with the slates are beds of calcareous quartzite of very different areas, ranging in thickness from, a few inches up to five feet. This quartzite contains a few grains of plagioclase and more muscovite scales, and is veined with quartz, which crystallizes in cavities. Associated with the slate are also beds of limestone conglomerate or breccia ranging from a foot to forty feet in thickness, carrying the trilobite *Olenellus* and other fossils characterisic of the Lower Cambrian. One of these beds of limestone breccia is of frequent occurrence in the quarries overlying the slate.

The slate bed surfaces are generally covered with annelid trails or impressions of algae or both. The purple slates are often ribboned or banded with light green slate beds an inch or more in thickness or have oval or roundish light green spots, frequently in rows. Similarly the sea-green slates have grayish ribbons crossing them.'

LIST OF VERMONT SLATE COMPANIES.

CASTLETON.

Criterion Slate Company, Hydeville.
Hayes Slate Company, Hydeville.
Hinchey Brothers, Hydeville.
Hinchey, O. & Company, Castleton.
Hydeville Slate Works, Hydeville.
John J. Jones Slate Company, Castleton.
Minogue Brothers & Quinn, Hydeville.
Metalo Slate Company, Hydeville.
Penryn Slate Company, Hydeville.

FAIRHAVEN.

Allen's, S. Sons, Fairhaven.
Bedford & Ryan Slate Co., Fairhaven.
Bonville Brothers, Fairhaven.
Bonville, E., Fairhaven.
Coleman & Westcott, Fairhaven.
Durick & Flannagan, Fairhaven.
Durick & Keenan, Fairhaven.

Durick, Keenan & Flannagan, Fairhaven.
Fairhaven Marbleized Slate Company, Fairhaven.
Jones & Owens, Fairhaven.
Jones & Francis, Fairhaven.
Maley Brothers, Fairhaven.
McNamara Brothers, Fairhaven.
Mahar Brothers, Fairhaven.
Pelkey Brothers, Fairhaven.
Valley Slate Company, Fairhaven.
Vermont Unfading Green Slate Company, Fairhaven.
Victor Slate Company, Fairhaven.
Young, A. B., Fairhaven.

POULTNEY.

Auld & Conger, Poultney.
Eastern Slate Company, Poultney.
Edwards Slate Company, Poultney and Wells.
Eureka Slate Co., North Poultney.
Green Mountain Slate Co., Poultney.
Griffith & Nathanael, Poultney.
Hughes-Snyder Slate Co., Poultney.
Johnson, E. S. Slate Co., Poultney.
Jones, Roberts & Rowland, Poultney.
Matthews Slate Company, Poultney.
Nathanael William, Poultney.
New York Consolidated Slate Company, Poultney.
Parry, Jones & Owens, Poultney.
Rice Brothers, South Poultney.
Rutland County Slate Co., Poultney.

PAWLET AND WELLS.

Layden & Burdick, West Pawlet.
Hughes, W. H. Slate Company, West Pawlet.
Nelson Bros. & Morow, West Pawlet.
O'Brien Brothers, Wells.
Rising & Nelson, West Pawlet.
Roberts, G. T., West Pawlet.

GRANVILLE, NEW YORK, QUARRIES IN VERMONT.

Norton Brothers, Granville, N. Y.
Owens, O. W. Sons, Granville, N. Y.
Sheldon, F. C., Granville, N. Y.
Vermont Slate Co., Granville, N. Y.

NORTHFIELD.

Vermont Black Slate Company, Northfield.

GRANITE.

In common with many other industries during the past few years, that concerned with granite has suffered more or less hindrance from strikes altho, I believe arbitration has been applied more often in this than in other business troubles in this State.

On account of these checks, the granite industry in Vermont has not gone on increasing as it would have done if there had been no set-back. Since the settlement of the last strike, which occurred early in the present year, nearly all firms report not only good, but unusually good business, so that for the year it is pretty certain that the amount of sales and output will be up to the average for the past five years. It may exceed this, for some companies report a larger volume of business than ever before at this season, that is, during the summer and fall.

Vermont is likely to maintain its position as first among granite producing states. When it is understood that not less than forty states produce granite and that six of these states each produce over $1,000,000 worth annually, this precedence is most creditable and satisfactory. The amount of granite used in the United States is enormous and is constantly increasing.

As the writer has already stated, the full Report of

Dr. T. N. Dale is given in this volume because of its inherent worth and especially because of its great and permanent value to all Vermont granite workers. As the map, Plate LXVII, shows better than words alone, the granite areas, while less in extent when taken singly, are much more widely distributed over the State than those of either marble or slate. Moreover, the map shows only those localities in which granite is now, or in all probability soon will be, actually quarried and there are other places where this stone is found and where in time it will be taken out.

The importance of the granite industry to Vermont is indicated plainly by the following figures taken from a copy of the Barre Times of some months ago. "The number of men employed in the industry in Barre at present is 3,358. Of this number, 1,825 are granite cutters at $3.00 per day, minimum; 137 polishers at $3.00 per day, minimum; 150 sharpeners at $3.00 per day, minimum; 986 quarrymen at $2.08 per day, average; 229 lumpers, boxers and derrickmen at $2.25 per day, average; 31 engineers at $2.50 per day, average." If we could add to these figures those for Hardwick, Woodbury, Bethel and the other places where this work is going on, they would, of course, be much larger.

Some of the larger companies do a business that runs up into the hundreds of thousands or even millions.

One of the largest Barre firms, Jones Brothers Co., is reported to turn out and ship on the average one mausoleum a week during the year. When it is considered that a finished mausoleum costs from $10,000 to $20,000 the value of such a business is more fully understood. But this is only a part of the business of one firm. Another Barre Company report the amount of granite quarried during one year as 1,418,559 cubic feet, or 202,651 tons, and this does not include paving stone, material for road making, etc. A number of the companies have made substantial additions to buildings, equippment, etc., to meet the demands of larger business. The Barre granite has been always most extensively sold in finished work, tho a large quantity is sold to retail dealers and small workers in the rough, but mostly for monumental purposes, while the Hardwick firms, as well as those at Bethel, have sold far more for building, tho these, especially the former, have sold some fine and costly monuments.

In many of the Vermont quarries the stone lies in an exceptionally favorable manner for quarrying and this, it goes without saying, is a very important matter, economically. It also occurs in great sheets or masses from which very large and sound pieces can be moved out. So far as I know, there have been larger pieces of granite moved in some of our Vermont quarries than anywhere else. The largest piece was moved at one of the quarries of E. L. Smith & Company, which was 200 feet long, 80 feet wide and 24 feet thick. Its estimated weight was 69,120,000 lbs., as it contained 384,000 cubic feet. A mass of this size is, of course, not moved from the quarry nor very far in it, but it was broken entirely away from the main mass.

Such a block would, when broken up, fill 1,728 cars, giving each a 40,000 lbs. load. In a quarry carried on by the Boutwell-Milne-Varnum Company a mass was moved which contained 190,000 cubic feet, and the Woodbury Granite Company moved a piece 200 feet long, 20 feet thick and the same in width, containing 80,000 cubic feet and weighing 12,000,000 lbs.

Next to Barre, Hardwick and Woodbury have been most active in the granite business. The quarries are mostly in Woodbury, while the cutting plants are mainly in Hardwick. Not only for monuments has Vermont granite been largely used all over the country during the last few years, but as a building stone it is used much more extensively than marble, large as have been the sales of the latter stone for building purposes. As has been noted previously, the use of stone as a most satisfactory and elegant building material has been steadily and rather rapidly increasing for some time all over the country. The granite from Robeson Mountain in Woodbury has been used in a large number of costly buildings and is in constant demand for this purpose. I suppose that few, if any, stone producing companies in the country have supplied as large an amount of building stone as has the Woodbury Granite Gompany. Within a few years this company has furnished granite for the whole or a part of five state capitols, as well as many other large buildings, and during the last five months they have furnished the stone for nine postoffices, a score of bank and office buildings, two large court houses, the Chicago city hall, various office buildings, etc. Not all these buildings are made of the Woodbury granite, for the white granite quarried by the same company at Bethel has been largely in demand.

This Company have installed electric motors in nearly all departments of their work, both at Hardwick and Bethel. They use water power for the generators. A new economy, which in this and other granite works seems likely to prove very valuable, is indicated by the instalment of a large crusher with 23 tons capacity per hour by which the always troublesome waste fragments or grout is not only saved from being a nuisance and expense, but is turned to profitable account. "A constantly increasing market is being created for this crushed granite, which is in demand for road and sidewalk construction and as a base for concrete work. Large quantities are also being shipped for railroad ballast."

The quarries on Robeson Mountain are operated by ten heavy derricks with all necessary accessory machinery.

The remarkable growth of the granite business in Bethel within a few years was noted in a former report and little additional statement is needed.

Since the E. B. Ellis Company closed their contract for the Washington Union station, the demand for this singularly hard and white stone has been large. The six huge statues of Bethel granite mentioned in detail in the Sixth Report are still under the hammer, only two, I believe, having been completed. These weigh nearly eighty tons each and they are to stand about the central pavilion of the station. Besides this work, the company have contracts for several large buildings in various parts of the United States and Canada. This company quarry their stone in Bethel and finish it at their large plant in Northfield. The Woodbury Granite Company also quarry granite in Bethel and have a large cutting plant near the Central Vermont tracks at the same place. Both the Bethel quarries named are several miles from Bethel village and are connected with the main line of the Central Vermont by a branch line. The Woodbury Company has recently increased its cutting plant at this place by the addition of a building 300 feet by 150, fitted with three overhead cranes, large lathes for turning columns, etc.

The following ist of granite companies is designed, as are the other lists of stone workers, to give the correct address of all wholesale firms doing business in the State.

It is quite probable that some are included which should not be and others omitted which should be included. The writer will be greatly obliged to anyone noticing errors in the list if he will send him any corrections which should be made.

The writer is glad to acknowledge his indebtedness for assistance in preparing the list to Mr. D. Barclay and Mr. Charles Withers, Barre, Mr. Geo, James, Hardwick, Mr. R. Farquharson, South Ryegate.

In the list, C. stands for cutting plant, Q. for quarry.

LIST OF GRANITE COMPANIES IN VERMONT.

BARRE AND VICINITY.

Adie & Milne, Barre, C.
Aimetti & Co., Williamstown, Q.
Anderson & Sons, Barre, Q. C.
Barclay Brothers, Barre, Q. C.
Barclay, Andrew & Co., Barre, C.
Barre Blue Granite Co., Barre, Q.
Barre Granite Co., Barre, Q. C.
Barre Granite Turning Works, Barre.
Barre Medium Granite Co., C.
Barre White Granite Co., Barre, Q.
Barre Granite Quarry Co., Barre, Q.
Barton Hayes & Bancroft, Barre, C.
Beck & Beck, Barre, C.
Bessey Granite Co., Barre, C.
Bianchi, Charles & Son, Barre, C.
Bond, C. E. & Co., Barre, Q. C.
Boutwell-Milne-Varnum Co., Barre, Q. C.
Brown, Carroll & Co., Barre.
Brown, John & Co., Barre, C.
Brusa Brothers, Barre, C.
Bugbee, E. A. & Co., Barre, C.
Burke Brothers, Barre, C.
Canton Brothers, Barre, Q. C.
Carle, E. W., Barre, C.

Carroll & McNulty, Barre, C.
Carswell-Wetmore Co., Barre,
Carusi, E. A., Barre, C.
Central Granite Co., Barre, C.
Chiold Brothers, Barre, C.
Coburn & Harper, Barre.
Cole, W. & Sons, Barre, C.
Comolli & Co., Barre, C.
Consolidated Quarry Co., Barre, Q. C.
Corskie, J. B. & Son, Barre, C.
Cutler, Stover & Fay, Barre, C.
Davis Brothers, West Berlin, C.
D. B. L. Granite Co., East Barre, C.
Densmore, C. D., East Barre, C.
Dessureau & Co., East Barre, C.
Dewey, Col. Cutting Works, Barre, C.
Dineen & Co., Barre, C.
Eclat Granite Co., Barre, C.
Eclipse Granite Co., Barre, C.
Excelsior Granite Co., Barre, C.
Freeman & Wasgatt, Barre, C.
Gasparello Brothers, Barre, C.
Gallagher, L. B., Barre, C.
Goodwin & Milne, Barre, C.
Glysson, E., Barre, C.
Grapponi Brothers, Barre, C.
Grearson & Lane, Barre, C.
Grearson-Beckett Co., Williamstown, Q.
Guidici Brothers & Co., Barre, C.
Hadden & Co., Barre, C.
Hall, W. A., Barre, C.
Harper, Gallagher Co., Barre, C.
Harrison Granite Co., Barre, C.
Hebert & Ladrie, Barre, C.
Hoyt & Lebourveau, Barre, C.
Johnson & Peterson, Barre, C.
Johnson & Gustafson, Barre, C.
Jones Brothers' Co., Barre, Q. C.
Jones, A. S., Barre, C.
LaClair & McNulty, Barre, C.
Leland Company, Barre, C.
Libersont, George, Websterville, C.
Littlejohn, Odgers & Milne, Barre, C.
Lucia Granite Co., East Barre, C.
McCall, John, Barre, C.
McIver, Mattheson & Co., Barre, Q. C.
McMillan, C. & Son, Barre, C.
McMinn, J. & Sons, Barre, C.
Macchi, Z., Barre, C.
Manufacturers' Quarrying Co., Barre, Q.
Marciasi, O. N., Barre, C.
Marr & Gordon, Barre, C.
Marrion & O'Leary, Barre, C.
Martinson Estate Co., Barre, C.
Melcher & Hadley, Barre, C.
Milne, Alex, Barre, C.
Milne, Geo., Barre, C.
Milne & Robertson, Barre, C.
Moore, Chas. H. & Co., Barre, C.
Moore Brothers, Barre, C.
Murray, J. F., Barre, C.
Mutch & Calder Granite Co., Barre, C.
Newcombe, T. J., Barre, C.
North Barre Granite Co., Barre, C.
Novelli & Calcagni, Barre, C.
Oliver & Co., Barre, C.
O'Herrin, Robert & Co., Websterville, C.
Palaora Brothers, Barre.
Parry & Jones, Barre, C.
Parnigoni Bros., Barre, C.
Passera Bros., Williamstown.
Peterson, Isaac, Barre.
Phillips, Findlater & Co., Barre, C.
Pirie, J. K., Graniteville, Q.
Presbrey-Coykendall Co., Barre, C.
Provost & Boussiere, Gouldsville, Q.
Provost, S., West Berlin, C.
Pruneau, John, Websterville, Q.
Rae, James & Son, Barre, C.
Restelli & Cruickshank, Barre, C.
Rizzi Brothers, Barre, C.
Rizzi. L. G., Barre, C.
Robertson, J. C., Barre, C.
Robins Brothers, Barre, C.
Ross & Ralph, Barre, C.
Ross & Cassellini, Barre, C.
Rust & Brown, Barre, C.
Sanguinetti, A. & C., Barre, C.
Saporiti, J. P., Barre, C.
Sassi & Co., Barre.
Scandia Granite Co., Barre, C.
Scott Brothers, Barre, C.
Sector, James & Co., Barre, C.
Smith, E. L. & Co., Barre, Q. C.
Smith Brothers Granite Co., Barre, C.
Standard Granite Co., Barre, Q.
Star Granite Co., Barre, C.
Stephen & Gerrard, Barre, Q.
Stevens, H. D., Barre, C.
Straiton, George, Barre, C.
Sunnyside Granite Co., Barre, Q.
Sullivan Eugene, Barre, C.
Sullivan, J. J. & Co., East Barre, C.
Thom, Clark & Co., Barre, C.
Tost, E. & Co., Barre, C.
Valz Granite Co., Barre, C.
Walker, Geo. & Sons, Barre, Q. C.
Wells-Lamson Quarry Co., Barre, Q.
Wells & Barney, Websterville, C.
Woodcock Bros., Barre, C.
World Granite Co., East Barre, C.
Young Brothers, Barre, C.

MONTPELIER.

Aja Granite Co., Montpelier, C.
American Granite Co., Montpelier, C.
Bertoli, H. J., Montpelier, C.
Bianchi Granite Co., Montpelier, C.
Bonazzi, Bonazzi & Co., Montpelier, C.
Bowers, R. C. Granite Co., Montpelier.
Caslani, Montpelier.
Columbian Granite Co., Montpelier, C.
DeCalaines, R. J. & Co., Montpelier, C.
Dillon & Haley, Montpelier, C.
Doucette Brothers, Montpelier, C.

Excelsior Granite Co., Montpelier, C.
Fernandez, P., Montpelier, C.
Fraser, R. M., Montpelier, C.
Gasparello Bros., Montpelier, C.
Gill, C. P. & Co., Montpelier, C.
Gillander & Keough, Montpelier, C.
Globe Granite Co., Montpelier, C.
Hill, Felix A., Montpelier, C.
Jellyman & Jones, Montpelier, C.
Jurras, J. & Co., Montpelier, C.
Lillie, D. K. Montpelier, C.
McGoverin Granite Co., Montpelier, C.
Mills & Co., Montpelier, C.
National Granite Co., Montpelier, C.
Patch & Co., Montpelier, Quarry at
Pecu Brothers, Montpelier, C.
Pioneer Granite Co., Montpelier, C.
Poulin, J. Granite Co., Montpelier, C.
Robar, F. J. & C., Montpelier, C.
Ryle & McCormick Co., Montpelier, C.
Sibley, Clark E. Montpelier, Q.
Sweeney Brothers, Montpelier, C.
Wetmore & Morse Granite Co., Montpelier, Q.

NORTHFIELD AND BETHEL.

Brusa Granite Co., Northfield.
Brusa & Giffin, Northfield, C.
Brusa, P. & Co., Northfield, C.
Burns, J. J., Northfield, C.
Cannon & Slack Co., Northfield, C.
Cross Brothers, Northfield, C.
Devine & Burns, Northfield, C.
Ellis, E. B. Granite Co.,Quarry at Bethel, Cutting works at Northfield, Q. C.
Empire Granite & Quarry Co., Northfield, C.
Kittridge & Sons, Northfield.
Osgood Granite Co., Northfield.
Pelaggi, N. & C., Northfield, C.
Phillips & Slack, Northfield, C.
Woodbury Granite Co., Bethel, Q. C.

WATERBURY.

Drew Daniels Granite Co., Q. C. Quarry at Adamant.
Oclair & Anair, Waterbury, C.
Perry Granite Co., Waterbury.
Sutherland Granite Co., Waterbury.

HARDWICK AND WOODBURY.

Ainsworth & Ainsworth, Woodbury, Q.
Albertini & Co., Hardwick, C.
American Granite Co., Hardwick, C.
Bardelli, G. & Co., Hardwick, C.
Blackhall & Hay, Hardwick, C.
Calderwood & Merriam, Hardwick, C.
Crystal Brook Granite Co., Hardwick, C.
Donald, Wm. B., Hardwick, C.
Emerson & Bond, Hardwick, C.
Eureka Granite Co., Hardwick, C.
Fletcher, E. R., Woodbury, Q. C.
Hannigan, John, Woodbury, Q.
Hardwick Granite Co., quarry at East Hardwick, C.
Hardwick Polishing Co., Hardwick.
Haskins & Stevens, Hardwick, C.
Howard & Martin, Hardwick, C.
Jackson & Mack, Hardwick, C.
James Granite Co., Hardwick, C.
McGovern, Jas., Hardwick, C.
Murch, E. R., Hardwick, C.
Pinera, Ramon, Hardwick, C.
Purdy, H. A., Hardwick, C.
Robie, L. S., Woodbury, Q.
Smith & Barter, Hardwick, C.
Stewart Granite Works, Hardwick, C.
Sullivan, J. E., Hardwick, C.
Union Granite Co., Hardwick, C.
Vermont Quarries Co., Hardwick.
Woodbury Granite Co., Hardwick.
Quarries at Woodbury and Bethel.
Works at Hardwick and Bethel.
Quarries at Woodbury.
Woodbury Monumental Quarries Co., Woodbury, Q.

GROTON AND RYEGATE.

Anderson, Axel, South Ryegate, C.
Beaton, James, Ryegate, C.
Beaton, A. T., Ryegate, C.
Benzie & Company, Groton, C.
Blue Mountain Granite Works, Ryegate, C.
Cerutti, J. C.
Courtney, T. C.
Craigie, James, Ryegate, C.
Eliason, C. E., S. Ryegate, C.
Gray, T. S., S. Ryegate, C.
Harty, L., S. Ryegate, C.
Hendry & Weber, Groton, C.
Hosmer Brothers, Groton, C.
Osgood Granite Company, S. Ryegate, Q. C.
Leonard, G., S. Ryegate, C.
McDonald, M. F., Ryegate, C.
Metcalf, H. E., Ryegate, C.
Morrison, D.A. & Co., Ryegate, C.
Osgood Granite Co., Q. C.
Rosa Brothers, Ryegate, Q. C.
Ryegate Granite Works, Ryegate, Q. C.
Samuelson, H., S. Ryegate, C.
Zambelli, S. Ryegate, C.
Zambion, Peter, S. Ryegate, C.

OTHER PARTS OF THE STATE.

Ayer, E. S., West Danville, C.
Calais Granite Co., Calais, Q.
Chapman, W. J., West Concord, C.
Clark, James, West Dummerston.
Daniels, J. C., West Concord, C.

Goss, A. J., West Danville, C.
Grant, C. H. Granite Co., Dummerston, Q. C.
Grout Granite Quarry, West Concord, Q.
Haselton, Charles, Beebe Plain, Q.
Kearney Hill Granite Co., West Concord, Q.
Lake Shore Granite Quarry, Adamant, Q.
Newport Granite Co., Albany, N. Y. Quarry at Derby.
Norton, S. B., Beebe Plain, Q.
Stanstead Granite Quarries Co., Beebe Plain, Q.
Tillcrop Granite Co., West Concord, C.
Union Granite Co., Calais, Q.
Welch, Joseph, West Concord, C.
Williamson, Harry W., Concord, C.

SOAPSTONE AND TALC.

These minerals may well be considered together since soapstone is merely a massive form of talc.

Still, there are many uses to which each is put for which the other is not adapted. Both of these substances occur widely over the State and at one time or another many of the beds have been more or less worked. Often, as would be expected, both are found in the same locality, but sometimes a mass of rock is entirely made up of talc and elsewhere of soapstone. Many of the outcrops of these minerals are too small to attract much notice and could not be profitably worked and the number of such as have promised well is very small. There is little to add to what was stated as to talc and soapstone in the last report.

During the last few years these minerals have been mined in the following places, viz: Moretown, East Granville, Rochester, Johnson, Cavendish, Grafton, Athens, Chester, Weathersfield, Windham and Hammondsville, but some of these beds have not been worked for some time, and some but little at any time. At some, mills have been operated for some time and considerable material put on the market.

In the Vermont Geological Report of 1861, Volume I, pages 783–791, there is a detailed account of the beds of soapstone or steatite in this State. This is to some extent a repetition of a similar account in Volume I, pp. 534–542, but is presumably later, and a larger number of localities are mentioned. In most of these places there are no deposits that have been worked. Some are too impure, some too small, some, for other reasons, are untouched, but some have been operated for many years. Perhaps none of these has been worked continuously so long as the beds at Chester and Weathersfield, (Perkinsville). At Chester there are two quarries from which a large amount of stone has been taken. These are described in the preceeding report. They are worked by the Union Soapstone Company. Some of the stone is talc rather than soapstone and this is ground by the American Soapstone Finish Company, of Chester, and sold in powder for various purposes.

At Perkinsville, a village in the town of Weathersfield, a new mill built to replace the one formerly used, which was destroyed by ice and flood a few years ago, is in operation.

There is here a quarry which is producing excellent stone, and an older one long worked, but now abandoned for the other, which is near. These are carried on by the Vermont Soapstone Company.

More than eighty years ago soapstone was quarried in Grafton and the Report of 1861 says of this that, "The quarries of Grafton or, rather, Grafton and Athens, for the soapstone extends into the latter town, have been longer worked with more profit and have produced more stone than any other soapstone quarry in Vermont." More than forty years ago they were successfully worked and furnished window caps and sills, fireplaces, pipes for aqueducts, etc. The quarry in Grafton was called Smith Quarry and that in Athens, the Goodrich Quarry. After the death of the former owners and on account of delay in settling the estates, these quarries both lay idle for many years. The Smith quarry has, within a year or two, been taken in hand by a new company who intend to put men at work there. The new company have bought a large and apparently very satisfactory building in Saxtons River for a mill where they intend to saw and work the stone.

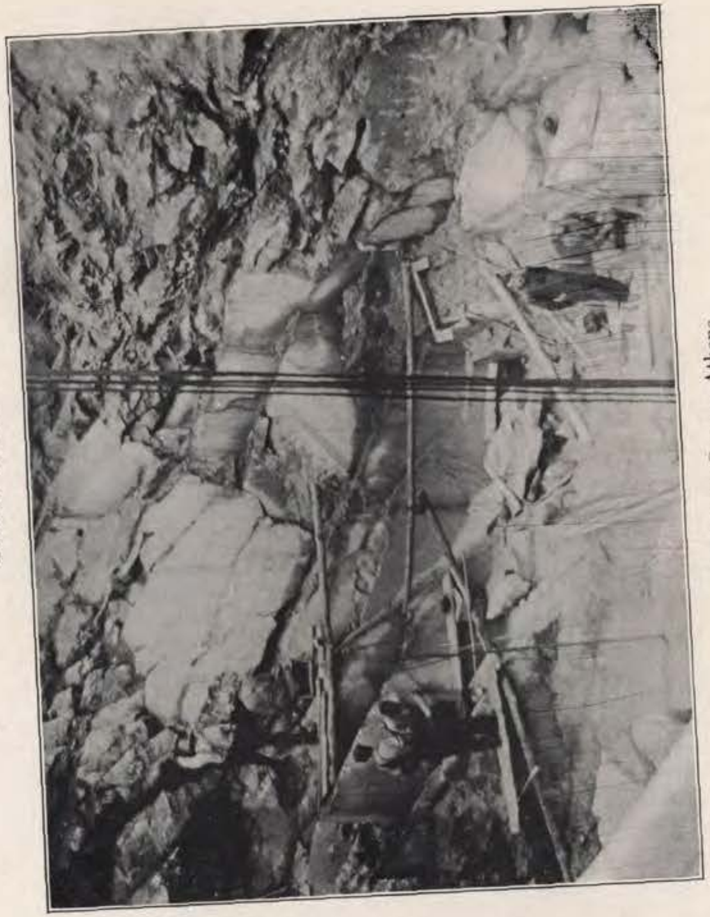
In the fall of 1909, I visited these two quarries and examined them. While it was not wholly certain what further working might develop, it seemed probable that a large amount of most excellent soapstone could easily be obtained. As is usually true in soapstone quarries, the stone is not in a continouous belt, but in lenses, that is, masses of long oval or similar form and of varying size. Sometimes these lenses are more or ess separated, sometimes they are so closely placed that they form a practically continuous layer.

From appearances, this latter is true of the soapstone in these quarries. Those familiar with the conditions when the Smith quarry was in active operation dec are that the stone was considered to be of unusua ly good quality. It is also stated in the 1861 Vermont Report that at one time this quarry was producing four hundred tons annually. The rock immediately above the soapstone is a black mica schist and a schistose talc in which is some actinolite. Above this is a bed of hornblende of varying thickness up to six feet. This impenetrable layer has so protected the beds of soapstone below that it has not been injured by surface water.

Usually, above the hornblende is the common gneiss rock of the region. Fifty or sixty rods south-west of the Smith Quarry is the Goodrich, being just across the line in Athens.

Here the conditions are similar to those just noticed. At different times several openings have been made in this place and there seems to be opportunity to start new quarries at some of these points. Plate LXVIII shows the appearance of the quarry as now worked. The quarry is

PLATE LXVIII.



Soapstone Quarry, Athens.

operated by the Union Soapstone Company of Chester and the blocks of stone are drawn by team to Chester, thirteen miles north. The drift is quite thick in places over the ledges, which consist of gneiss, hornblende, talc, talcose slate, actinolite, etc. In the old days, the stone from this quarry was drawn to a mill at Saxtons River to be worked. That from the Smith quarry was much of it taken to a mill at Cambridgeport, only three miles distant. There is a mill in Windham which has been in operation, more or less, during the past few years.

Talc is ground in Chester, as already stated, and at several other places. The Eastern Talc Company, at East Granville, have built a mill since the last report was published and grind a large amount of stone. Considerable work has been done by the American Mineral Company at Johnson.

The Reading Talc and Asbestos Company have done some work on a talc deposit in Hammondsville, a hamlet in Reading.

There had been a shaft sunk to the depth of 60 feet at the time of my visit, July, 1909. This shaft was wholly in the talc and did not go thru it. On the surface, the talc cropped out in many places and thru a distance of ten or twelve rods and perhaps more. The beds are on the westerly side of a hill which forms part of the east side of a narrow valley.

Mr. Harvey Dana, who showed me the deposit, said that talc also cropped out on the opposite side of the valley and also at a place a mile or so north-west. Therefore there seems to be no question as to the great amount of talc to be found at this locality. As to quality, I have seen no analysis. So far as could be ascertained from such examination as could be given the talc, it appears to be of quite uniform quality and in general very good, tho not of the best. Its color is not very white in most specimens. Distance from railroad is a great drawback. A mill of considerable size was partly built at the time I was there. This is to be supplied with machinery. Unfortunately, the talc deposits, of which, as has been stated, there are many in this State, are often rendered of little or no value by the contained impurities, but some of the talc appears to be very pure.

According to Mineral Resources, soapstone and talc are found in ten states and Vermont is third in production.

According to Mr. J. S. Diller in Mineral Resources, 1908, talc and soapstone are found only along "The belt of ancient crystalline rocks which form the axis of the Appalachian Mountain system from Canada to Alabama."

Vermont produces, annually, about 10,000 tons of these materials.

ASBESTOS.

There is only one producing asbestos plant in the State, tho there are several outcrops upon which more or less development work has been done. The Lowell Lumber and Asbestos Company are carrying on and developing their business, which was mentioned in some detail in the Sixth Report, and in this volume Professor Richardson has a full account of the rocks of the immediate region of the Asbestos mine and also of the mill, and on this account it will not be further considered here. In his article will also be found a description of the region and the mill and openings of this company.

LIME.

Limestone does not occur in such extensive areas nor in such thick beds as it does in some states, but there are, scattered over the State, ledges of limestone, some of no inconsiderable size from which very much lime has been obtained.

By far the most available beds of limestone are in the western border of the State, tho there are more or less extensive outcroppings east of the Green Mountains, and some of these are utilized in manufacturing lime. While limestone is now much more extensively burned to make lime than formerly, yet in the olden time the kilns, tho small, were far more numerous and it is not uncommon to come upon long since abandoned and ruined kilns as one wanders about the State in regions where any small, or it may be large, outcrop of limestone appears. Naturally, these earlier kilns, most of them home made, were very rude and simple and incapable of producing very much lime as compared with the modern steel, perpetual kilns. There are now rather fewer producers of lime than two years ago and two years ago the amount produced was less than for some time previously, but during the last year the production has increased somewhat and it is probable that during the present year as much lime has been made and sold as at any past time. While the lime industry is not likely to rank as one of the great industries of the State, it is certainly worth considering and encouraging in every possible manner. The increasing use of lime for agricultural purposes bids fair to make a greater demand for it than heretofore. One of the largest producers of lime in the State writes that he thinks the increase in the demand for lime for agricultural purposes is not less than 200 per cent. The total sales annually amount to from \$200,000 to \$250,000. The quarries and kilns of Mr. L. E. Felton at *Highgate*, John P. Rich at *Swanton* and W. E. Fonda at *St. Albans*, are well known and are all actively at work. Illustrations

PLATE LXIX.

Quarry of the Brandon Lime and Marble Company, Leicester Junction.

and descriptions of these quarries and kilns have been given in earlier reports.

At the kilns in *Colchester*, now carried on by Mr. G. B. Catlin, less lime is burned than ten years ago, but the kilns are in operation and considerable lime is made and sold.

Farther south, in Addison County, there are several quite large lime kilns. The latest formed company is called *The Green Mountain Lime Company* with office in Middlebury and quarry and kilns in New Haven. This company is operating three kilns capable of producing three hundred and fifty barrels daily.

Strong testimonials as to the superior quality of the lime produced by this company are numerous.

At *Leicester Junction* there are two quarries now worked, each of them burning lime. On the west of Otter Creek, the Brandon Lime and Marble Company, managed by Mr. Huntley, has long worked a quarry in a large upthrust of lime rock. It is a large, open quarry, the excavation running in a general north and south direction. The rock is much upheaved and varies from a rather hard, gray stone to a light buff or more often pinkish and softer marble-like stone. The strata are sharply tilted, the dip being to the east, in some places the rather thin layers lie at an angle of 50°–60° or even more. The quarry is long and narrow, cut right thru the mass and the walls are, where highest, some 40–50 feet. The annual output at this place is about 40,000 barrels. Plate LXIX is from a photograph of this quarry.

About a mile south and east of this quarry, on the opposite side of Otter Creek is the quarry of the Leicester Marble-Lime Company. Soon after crossing the covered bridge over the Otter, upthrusts of light colored limestone appear. And there are several abandoned quarries, two of them of considerable dimensions, showing that formerly a large amount of stone has been taken out. Beyond these is the quarry which is at present worked. The stone here differs somewhat from that in the first named quarry. Here all the limestone is hard, dark gray with, in places more or less numerous, veins of satin spar. In this quarry are seen some very peculiar examples of folding. In all parts of the ledges exposed on each side of the north and south opening, are abundant evidences of sharp upthrusting, fracture and great disturbance. Like the quarry of the Brandon Lime and Marble Company, this has been worked from north to south until it extends for quite a distance, as a sort of canon, the walls being a few hundred feet apart. But aside from the frequently seen fractures and tilted beds there are some remarkably crumpled layers, in some places crushed into narrow folds, more like those seen in some gneisses and schists than any that I have seen elsewhere in limestone. Plate LXX shows some of this folding. But the most re-in a series of, approximately, north and south folds which crop out in a series of rather sharp ridges.

In none of several older quarries near was there any approach to these rolls, altho there is everywhere in the region much folding and upthrusting. This is also shown in the Huntley Quarry, Plate LXIX.

The limestone from the quarries at Leicester Junction makes a very white and strong lime.

The Leicester Marble-Lime Company, managed by Mr. Swinington, puts out about 25,000 barrels of lime annually, considerably farther south and on the east of the Green Mountains.

At *Amsden* there is an outcrop of a hard and somewhat peculiar limestone, often with narrow seams of micaceous iron, which sometimes occurs in masses of several pounds weight and there are also bands of biotite mica. There are four quarries from which a large amount of stone has been taken. The older of these quarries have not been operated for some years, all that has been used for burning into lime of late has come from the newer openings. The oldest quarry is of considerable size and is said to have been worked nearly or quite a hundred years ago. This quarry is geologically interesting because of two dikes that have cut thru it. Each of these dikes is several feet across and extends completely across the quarry and the limestone has been considerably disturbed and broken by the intrusion.

The stone is now burned in two stone perpetual kilns, but a new steel kiln was at the time of my visit in process of construction.

The stone appears different in some respects from any other that I have seen in this State at the various lime kilns. It must be managed more carefully while burning than other stone and when burned it is not white, but a moderately dark brown, not very unlike the shade of Rosendale cement. It makes a very strong mortar and needs no reinforcing by addition of cement. Blocks, like those of cement, can be made from it, but it is not hydraulic. The lime is drawn by teams to Cavendish for shipment. As may be seen by comparison of analyses, and as its color indicates, this limestone contains more iron than other stone that is burned and also somewhat more magnesia.

Mr. Luke C. White, the manager of the Amsden Lime Works, has given me the following analyses of the stone used.

ANALYSES OF AMSDEN LIMESTONE.

Samples:—	No. 1	No. 2.	No. 3.
H_2O	.04	.085	.10
P	.087	.013	.065
Fe_2O_3	1.43	.83	.77
MnO	.60	.84	.61
Al_2O	1.35	.42	.37
CaO	38.94	52.78	50.00
MgO	11.32	1.60	1.66
SiO_2	3.33	.49	5.98
CO_2	42.74	42.74	40.09

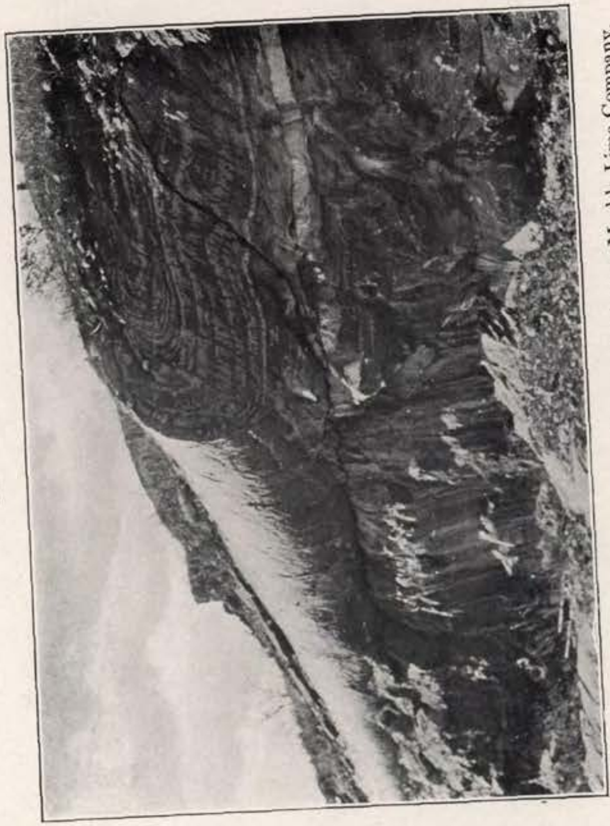
CLAYS.

Only two companies are working clays, except, of course, the common brick clay.

The Rutland Fire Clay Company continue to do a large business and plan further increase. This plant is fully described with illustrations in the Sixth Report.

Horn, Crockett & Company, of Brandon, produce from the white kaolin dug near the works at Forestdale a fine white clay used in the manufacture of china, plaster, paper, etc. They have sunk a new shaft, increased their output 50 per cent., and improved the methods of preparing the clay.

PLATE LXXI.



Differential Folding of Limestone. Quarry of Leicester Marble-Lime Company, Leicester Junction.