Report of State Geologist

ON THE

MINERAL RESOURCES OF VERMONT

1899-1900

REPORT

OF THE

STATE GEOLOGIST

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Mineral Industries of Vermont.

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BURLINGTON:
FREE PRESS ASSOCIATION,
PUBLISHERS, PRINTERS AND BOOKBINDERS.
1900.

STATE OF VERMONT.

OFFICE OF STATE GEOLOGIST.

BURLINGTON, VT., July 25th, 1900.

To His Excellency, Edward C. Smith, Governor of Vermont:

SIR :—In accordance with the provisions of Section 2, Act No. 7, 1896, I have the honor to present herewith my report as State Geologist for the years 1899 and 1900.

So far as was practicable with the very limited appropriation at my disposal, I have sought to perform the duties which the several Acts of the Legislature impose upon the Geologist.

I am glad to acknowledge the hearty encouragement and assistance which I have constantly received from you.

As Curator of the State Cabinet I have almost wholly rearranged the specimens and added many new species not previously represented. It is my hope that the changes made in the cabinet will make it more attractive and instructive to the many visitors who come to it. For a more detailed account of the work accomplished, I would respectfully refer to the following pages.

I may, however, add to what is given in the report that, in accordance with your suggestion, I have in course of my investigations of the rock formations of the State, been on the lookout for deposits that could furnish suitable material for macadamizing, or otherwise improving, the roads. I am not at present able to make a definite report upon this part of my work, but I hope to do so at a future time. In the meantime, I shall be glad to be of such assistance as may be within my power to any who wish advice in this matter. I am, sir,

Very respectfully,

GEORGE H. PERKINS,
State Geologist.

REPORT.

INTRODUCTION.

Soon after his appointment as State Geologist in 1898, the writer published a Report on the Marble, Slate and Granite Industries of Vermont. This report was much less full and comprehensive than it would have been had there been more time for its preparation.

At that time it was hoped that in the report for the years 1899 and 1900, it might be possible to present a full and well illustrated account of the quarrying and mining interests of the State. The necessary funds, however, were not provided by the Legislature, and all that can be done in the present report will be to give such a statement as is possible under the circumstances, leaving the more satisfactory treatment of the topics considered until it may be practicable to present them without too narrow limitations. For the same reason much of the more strictly scientific material which is available is omitted as the publication of this would involve expense which can not now be incurred.

The present report is intended in some measure to supplement the previous one, since the same great industries, marble, slate and granite, are again considered and more recent facts given, but also the other mineral interests of the state are more or less fully discussed.

It has seemed necessary to devote this report to these subjects because during the past two years many letters have been received from almost every state in the union asking for information as to one or another of our mineral deposits, their extent, value,location, availability, etc. It is impossible to find answers to such questions in any published work and the demand has appeared to be so great that I have left aside other material to make room for such an enumeration of our mineral products as should serve in some measure to provide information

for those interested in these subjects, though very imperfectly because of the extreme brevity with which each topic must be treated.

I have therefore mentioned in course of the following pages, all of the various useful minerals and rocks which are found in this state, giving such facts as have been obtainable as to localities, present condition of deposits and whatever other items appeared to be desirable. While it is hoped that in the main these statements are accurate, yet it is scarcely to be expected that no errors have crept in. It has not been possible to examine all of the localities named, personally, and, although several hundred letters of inquiry have been sent to owners or managers of mines and quarries, from many no reply has been received, and only very partial ones from others, so that much desirable information can not be given. It may be proper to remark at this point that if in the following pages certain firms are more fully mentioned and a better statement of their business given than others receive, this is in no wise because it is designed to give any one interest any advantage over others, but because it inevitably follows that if one firm furnish more complete statements than do others in response to inquiries, this firm will be more fully represented in any such report as this. It has been the intention to afford the same opportunities for furnishing information to all.

As has been noticed, there is a demand for information as to the natural resources of Vermont and a demand which is by no means local, but which comes from all parts of the country. This demand arises partly because some of the older mineral industries, such for instance as copper mining, have been greatly stirred to new and larger activity on account of new uses for their products and partly because wholly new industries have arisen and created new demands for material employed in their processes. Hence many old deposits, formerly worked at a loss, are now reopened and found profitable under the new conditions while heretofore useless materials are now become of value.

In what was said above I do not at all intend to intimate that consumers of mineral products are looking to Vermont alone for a possible supply, but only that they are looking this way as they are looking in every direction, and that state which can most promptly and satisfactorily answer their inquiries will secure the business which may arise. For this reason, the Geologist has considered it not the least important part of the work of his office to correspond with those who might be purchasers of our products. This correspondence has grown to large proportions.

For the same reason, there is great need of a thorough and systematic exploration of the state in order that its mineral resources may be better known than they are at present. It will take both time and money to accomplish this, but both would be well spent and would unquestionably bring very material returns in increase of business, not to mention the scientific value of the facts which would be thus gained.

In proportion to her population Vermont has greater wealth in quarries than any other state and it is only common business wisdom to ascertain all that can be known of these quarries and the deposits in which they are located and, having gathered the facts, to publish them so that anyone interested may have access to them.

Vermonters may reasonably be proud of the marble, granite and slate beds which are their possession, but something more practical than pride is necessary in order that these already great interests may be developed as fully as possible, for the increased prosperity of these means the increased prosperity of the state.

While here and there quarries have been given up temporarily or permanently, I believe it to be true that on the whole, there is greater activity in these industries than ever before. That is, there is at present a larger amount of capital invested, a larger number of workmen employed and a larger and more valuable output than at any time heretofore. Of course this is not true in all cases, but as a general statement I think that it is.

During the past year there have been at least two hundred quarries of various sorts operated in the State. In these and in the mills connected with them there are employed eight thousand men. The capital invested amounts to over $6,000,000. The stone quarried is valued at $6,500,000. The annual cost of working these quarries and mills is $4,000,000. While some firms report a decrease in business, most report an increase, some a very considerable increase.

I have spoken only of quarries for two reasons. First, Vermont never has been and never can be a very important mining state. I do not mean by this that there are no good mines. I think that in a few localities copper mining may be profitably carried on as will appear later, but these localities are limited and the work carried on in them can never approach that which is going forward in the great quarry regions.

METALLIC PRODUCTS.

COPPER.

The only mining in this state which has ever been carried on to any large extent is that of copper. As will be noticed later, other metals have been found in the rocks of Vermont and at times iron has been obtained in considerable quantity, but far more extensive than other mining operations have been those for copper. The unusual demand for copper which during the last few years has been produced by its use in electrical equipments and the consequently increased price of the metal has aroused new interest in all deposits from which it could be obtained.

There is no native copper, like that found in the Lake Superior region, in Vermont. Our copper ore is nearly all of it chalcopyrite, or copper pyrites, a sulphide of copper, which may be, and usually is, largely mixed with pyrrhotite, or iron sulphide. There is in one locality another ore, bornite, or copper and iron sulphide. In the Report on the Geology of Vermont 1861, p. 850 there is a very good account of the earlier efforts at copper mining in this state It appears from this account that copper

has been to some extent mined in Vermont for at least eighty years, though at times there have been intervals of entire inactivity.

At present copper is being mined at the old Ely mine in Vershire, at the Elizabeth mine in South Strafford, at the Reynolds mine in Strafford, and at the mine of the Vermont and Boston Mining Company in Berkshire. There are other localities in which some little prospecting has recently been done, but I know of no real attempt at mining at other places than those named. Formerly there were two mines in Corinth which were quite extensively worked, but without very much profit, so far as I can ascertain. The statistics of copper production in this state for the past fifty years show very great and often sudden fluctuations in the amount of ore raised and of metal extracted. In 1860 about 1500 tons of ore were mined, in 1870 1000 tons, in 1880, 28,000 tons from which 2,647,900 lbs. of metallic copper were smelted. In 1883 this large quantity had shrunk to 400,000 lbs. of copper and then during the next ten years the amount was very small or nothing, in 1890 the amount was only 72,000 lbs. During the past year, 1899–1900, the Elizabeth mine has produced not far from 2,000 tons of ore and during the past ten years this mine has produced 50,000 tons most of which has been shipped to other states for smelting.

As has been stated, two mines were formerly worked with some energy in Corinth. A few words as to these may not be without interest as history. For many of the facts given I am indebted to a paper by Gov. Farnham in the Report of the Board of Agriculture, 1872.

At one time these two mines, the "Corinth" and the "Union" employed two hundred men. The "Corinth" produced about 150 tons of ore monthly, all of which was shipped elsewhere for smelting. But these times of activity seem to have been of no long duration. The closing of these mines does not appear to have been caused by diminished quantity of ore, but rather because the methods employed in getting out the ore and reducing it to copper was such as to cost more than the copper obtained was worth.

The most famous mine in Vermont has been the Ely at Copperfield, Vershire. This mine has been more extensively worked than any other in the state and for several years paid dividends and in 1872 it was producing metal at the rate of $300,000 worth a year and employing three hundred men and boys. "The dip of the vein is towards the east and for the first three or four hundred feet from the surface is about 30°, but for the last few hundred feet that have been worked it is only 23°. Since 1854, the main shaft has been pushed down on the vein until now it has reached the depth of nearly nine hundred feet from the surface and a new adit has been driven in until it reaches the main shaft, a horizontal distance of nearly eight hundred feet." This was in 1872. The draining of this mine was unique. So little water entered through the compact rock and the ore body itself was so far above the valley that drainage, which is often the most costly and difficult part of mining, is here very easily accomplished. All the machinery needed was a tank which was drawn into the mine and the water which had accumulated in a reservoir blasted out for that purpose was dipped into it and drawn out. It is said that only a few daily trips were needed to drain the whole mine. The best ore, the pure chalcopyrite, affords on the average some twenty-five to thirty per cent of copper, but most of the ore is largely mixed with iron sulphide so that the average of the ore as mined is very much less, not more than three per cent. or in better portions, four per cent.

After years of mingled prosperity and adversity, this mine was closed and for some years nothing was done there. The mine filled with water, the machinery rusted, the imposing row of smelting furnaces stood dismally silent and empty and everything about the place wore an air of desolation and ruin. Within a few months, however, the property has been bonded to Mr. George Westinghouse, of the Westinghouse Air Brake Company, and about $60,000 I am told has already been expended in repairing the dilapidated buildings and machinery and putting in new. The mine is being pumped out and the

old ore dumps are being worked over, ore is mined from the upper part of the deposit, exploration is going forward, a hundred and fifty men are at work, ore is crushed and reduced to matte in a reverberatory stack roaster. The Superintendent writes that the mine following the vein, which, as noticed above, dips 23°, is 3,300 feet in from the surface and the vertical depth is 1,500 feet.

The oldest mining locality in the State is that at South Strafford, the property of The Elizabeth Mining Company. Only a few rods from the present mine there is an enormous trench from which as long ago as 1793 pyrite, iron sulphide, was mined for the manufacture of copperas. For many years this was carried on, indeed, mining of some sort appears to have been going on at this place with little, if any, interruption ever since the above date. For a long time, however, copperas, not copper, was the object of the miners. After a time the copperas mine was abandoned and shafts were sunk north of the old trench and now the ore sought was that which would produce metallic copper. For a considerable number of years the Messrs. Tyson have carried on the mine and have expended much money and labor in developing the ore body.

The Elizabeth Mine is in many respects very favorably located. Although the nearest railroad station is at a distance of over eight miles, that at Sharon on the Central Vermont, and the station of the Passumpsic at Pompanoosuc is ten miles, yet the roads to these stations are well kept and the grade from the mine is mostly descending.

What is of more importance, the mine being situated in a side hill at a considerable height above the valley lying to the east, drainage is readily secured.

The rock in which the ore is found is mainly mica schist and the ore is substantially the same as at Copperfield, chalcopyrite, associated with a large proportion of pyrrhotite. It is probable that the mass of ore here is larger than anywhere else in the state. At any rate it is enormous. As at present, 1900, developed, the ore body is a mass 1,000 feet long, 240

feet high and 35 feet wide, but it is evident to anyone who examines the mine that the full dimensions of the whole body have never been disclosed.

The ore is most of it low grade, from two per cent to six per cent only being copper, but some of it contains much more, ten to fifteen per cent, and at times ore is found which affords from twenty five to thirty per cent. The ore body is in the form of a "chimney" or "lens" which pitches towards the north. It is reached chiefly by an adit 1,400 feet long which has been worked in through the hillside. This adit, or tunnel, inclines 20° as it goes in. Higher up on the hillside are three shafts, the deepest of which reaches down 150 feet. There are three levels on which the ore has been worked or "stoped." The deepest of these is 300 feet below the surface. Everywhere the excavation shows the presence of ore and the deeper stopes give the best. In September, 1899, about 50,000 tons in all had been taken out. The crushers, furnace, etc., are all below the entrance to the adit so that loaded cars carry the ore from the mine by gravity. Until within a few months, the best ore has been shipped to New Jersey where it was smelted, while the rest was piled in quadrangular heaps, each being about 40x23x8 feet and containing some three hundred tons of ore. Each pile is built on a layer of dry wood which is set on fire and the heat soon frees sulphur enough to supply fuel for the remainder of the process which lasts about two months. The residue is a black mass of iron and copper from which the copper must be separated. Mr. Tyson writes that there are now, September, 1900, twelve thousand tons on the roasting beds. Last November a reducing furnace was completed and since then ten thousand tons of ore have been reduced to "matte" which contains some thirty to forty per cent of copper. "During the past year we have been sinking below the adit level and find a superior quality of ore and the whole north end shows a 4.6 per cent ore."

The furnace mentioned above is now smelting about 125 tons of ore daily and in and about the mine 140 men are employed.

As has been stated, the ore at the Elizabeth mine is chalcopyrite, copper sulphide, mixed with a greater or less amount of pyrrhotite or iron sulphide. The relative proportions of these minerals vary very greatly. Usually the copper sulphide forms only a very small part of the ore brought out, but in some parts of the ore mass the copper sulphide exists as a much larger part of the whole. The average of the ore used is stated as being five to six per cent. A complete analysis of average ore furnished by the company, is as follows:

Copper	5.01 per cent.
Alumina	8.97 "
Iron	30.99 "
Silica	27.95 "
Sulphur	21.77 "
Lime	1.68 "
Magnesia	2.36 "
	98.73 per cent.

The metallic copper from this mine is said to be of very excellent quality, much above the average.

Besides copper, the ore sometimes contains in small quantity both gold and silver. "About 2 ounces of silver and 0.8 pennyweight of gold per ton." Hitherto these metals have not been taken into account as the methods used for the extraction of copper were not such as favored getting the other metals and it would cost more to get them than they would be worth. Different processes, however, might make it possible to save even so small an amount of the precious metals. And, though the value in each ton is so small, yet when it is multiplied by the total number of tons annually produced the sum becomes eminently respectable, perhaps not less than $40,000 for a year.

From South Strafford on north through Strafford to Vershire, there are outcrops of copper bearing ore, but none of these are worked except at what is known as the Reynolds mine in Strafford. This is at present in the "prospect" stage, but the indications are promising. It is located about a mile

north of the village and was worked somewhat about thirty years ago and some very good looking ore taken out, but the work was for some reason soon given up. By the present working, the shaft has been carried down about a hundred feet where a cross cut is being made. A vein of good ore ten feet wide has been found.

The only other mine now working in the state, is that of the Vermont and Boston Copper Mining Company at Berkshire. About a year and a half ago, this mine was opened and now the shaft is a hundred feet down and from it there is a drift eighty-five feet long. The superintendent reports that "Large bodies of chalcopyrite and bornite have been opened up. Assays from 5 per cent. to 60 per cent."

GOLD.

In many places in the state gold has been found, but nowhere in paying quantities. Most commonly it occurs in the sand of streams, but in some places, as at Plymouth and Bridgewater, gold bearing rock has been found and mined. So far as I can ascertain, in all of the localities the cost of getting the metal has been more than it was worth. There is no probability that it will ever be otherwise in this state. It is therefore useless to spend time and money in trying to find a fortune in gold mining in Vermont. Considerable money has been lost because it was invested in such mining, but I have yet to hear of much that was made in this way in this state. Occasionally a little "pay dirt" has been found, but in a short time the promising mine has been left unworked.

In 1865 there was, if we may judge by reports, a stir of excitement over the golden sands of White River near Gaysville and Bethel, and for a time it really seemed as if something might come of it all. So much interest was excited that, first and last, a considerable sum of money was invested in labor and machinery. After a short season of apparent prosperity, however, the enterprise was abandoned. Several hundred dollars worth of gold was obtained from this locality, if reports are

true, and in all quite a little amount must have been taken out in Plymouth, but it is not possible to get any very definite statements as to the amount.

What is true of all mining is especially true of gold mining. It is exceedingly uncertain business. If anywhere in nature lawlessness rules, it is in the arrangement of mineral veins. They may pass from rich to poor, or wide to narrow, very suddenly and apparently without any reason whatever. About all that is sure in a vein of ore is that part which is actually in sight. Hence whoever goes into mining should distinctly understand that he is engaging in a very risky business, though a perfectly legitimate business. Much money has been made in mining, but much has also been lost.

It is well for those who think that they have found gold bearing rock to know that locating such ore does not by any means insure a fortune or any part of it. It is always necessary to take account of the cost of getting the metal out of the rock or ore. It is quite possible to find a vein of gold bearing quartz, for instance, which is of little or no value to its owner because the expense of getting the stone out of the ground and then getting the gold out of the stone would be more than the gold would be worth. The process of separating gold from quartz is complex and involves the use of expensive machinery and nothing of importance can be done with even a rich vein until such machinery is provided.

Another important fact is that a quartz vein is not always, nor usually, gold bearing. The world is full of quartz veins and masses which are quartz and only quartz. These remarks will undoubtedly seem quite unnecessary to many who may read these pages, but more than once, indeed not seldom have I found persons in this state trying to start a gold mine with evidently no conception of what was before them if they carried out their plans to any completion, the sole foundation for their hopes being that they had found a mass of quartz that had a little gold in it, or, even less promising, quartz that looked like that from some western locality in which gold had been found.

Much time, labor and money have been wasted from failure to attend to facts like those noticed above.

In this connection I wish to correct an error which has stood uncorrected for a long time. In the Vermont Agricultural Report for 1874, there is an article on Gold Mining in Vermont, in which it is stated that with the gold taken from an island in White River there had been found the rare metal iridium. The statement was undoubtedly made in good faith and what were supposed to be specimens of iridium were exhibited.

It seemed, however, so extremely improbable that iridium has ever been found in Vermont that I have been at some pains to investigate the above statements and it appears to be certain that no such metal was ever found in the locality named, or anywhere else in the state, but that those who supposed that they had found it mistook grains of specular iron or some similar metal common in the White River sand, for the rare iridium.

LEAD.

Galenite, the common ore of lead, is found in small masses in many parts of the state, but nowhere has it ever been successfully mined. Some of the veins which I have examined are of excellent quality, but do not afford a sufficient quantity of ore to make development worth while. I do not find that there has ever been any very serious attempt to mine lead anywhere in the state. Some attempt, however, has at different times been made to work lead mines in Thetford, Norwich, Morristown, Bridgewater, Brandon, Chittenden and perhaps at a few other localities, but without important results.

IRON.

Many towns in the state possess some sort of a deposit of iron, but for many years no iron of any value has been produced in Vermont. So far as I can ascertain, no ore beds are now worked in the state.

Iron occurs in the state in a variety of ores. The bog ore, limonite, is most commonly found. Beds of this have been

worked near Brandon, Monkton, Bennington and other localities, mostly in the southern part of the state. The Brandon beds were at one time of considerable importance to the state. "Iron ore was first discovered in Brandon in 1810, and soon after a forge was built and bar iron of superior quality was manufactured for several years. In 1820 a furnace was built by John Conant." In 1850 this furnace was bought by the Brandon Iron and Car Wheel Company and in course of a few years a capital of $175,000 was paid in. But ill fortune came upon this promising enterprise and it was finally given up. Associated with the iron were ochre, clays, kaolin, etc.

Magnetite in small amount occurs at Bethel, Rochester, Bridgewater and is the most common ore found in the black sand of many streams.

Specular and titaniferous iron are found in a few localities. A bed of carbonate of iron, siderite, was worked for some time at Tyson furnace. Chromite, or chromic iron has been found in the northern part of the state, at Jay, Westfield, and Troy and to a small extent in the southern part, as at Newfane. At the Jay locality several tons of this ore were taken out in 1871. About the same time over 100 tons were mined and shipped in Westfield, but the work ceased in a year or two.

According to the U. S. Census Report for 1880, Vermont produced in that year 250 tons of metallic iron, but after that date little, if any, was produced.

MANGANESE.

Bog manganese is found here and there all over the state, but is of no great value. The manganese ore found at Brandon is psilomelane and is of much more value. Another ore of manganese is braunite, which is found in Brandon, Plymouth, Bennington and a few other places. Pyrolusite is also found in the same localities. I can not ascertain that manganese at present is mined anywhere in the state, but until recently more or less was obtained and sold. In 1888 not less than 1,000 tons were sold, but in 1891 only 49 tons were mined and since then none of any consequence.

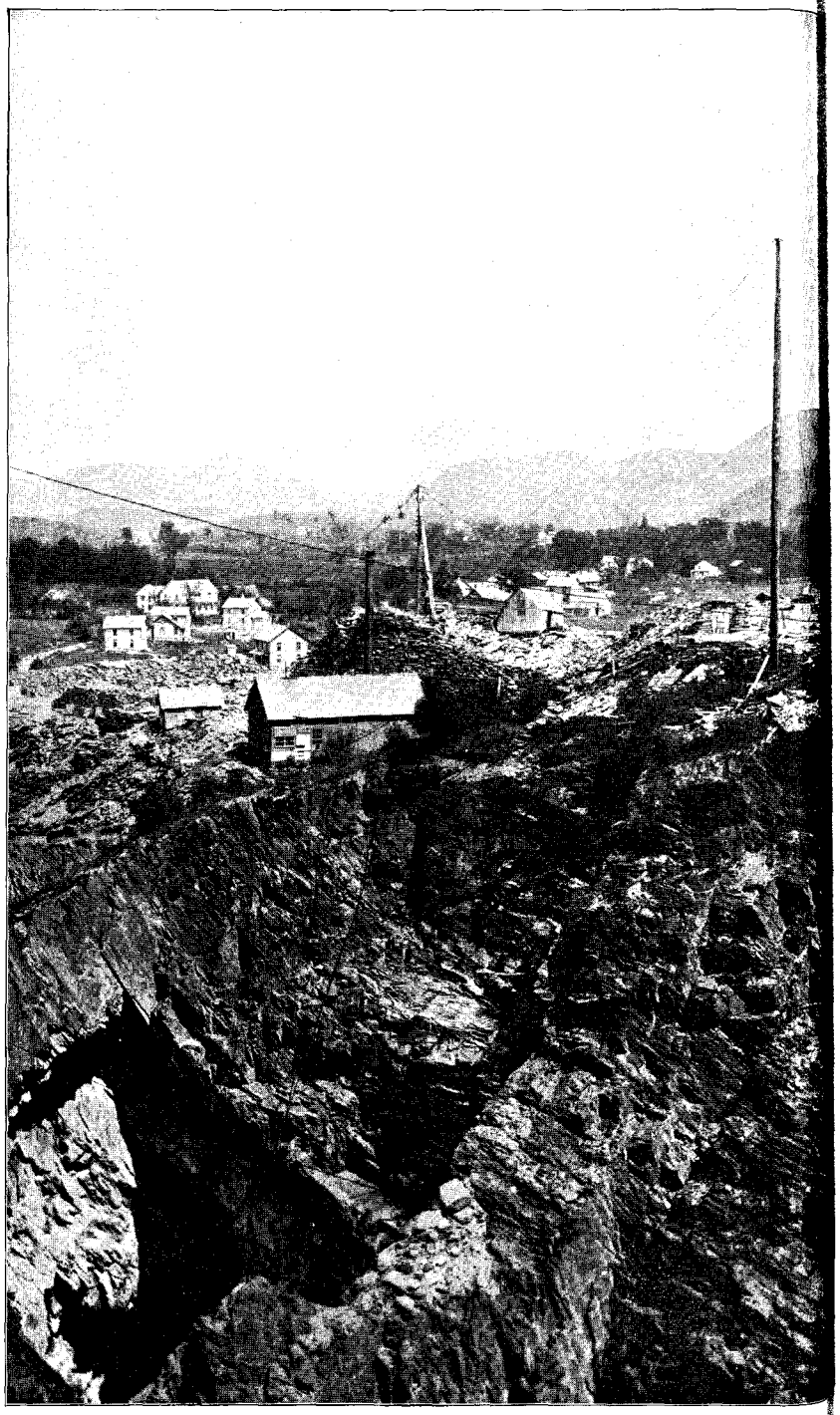

FIGURE 1. SLATE QUARRIES AT WEST PAWLET, LOOKING NORTHEAST. The hills in the background are a portion of the Taconic Range and are chiefly composed of schist. From the U. S. G. S.

SLATE.

The slate business in Vermont has on the whole changed but little during the last two years. A number of new quarries have been opened, some old ones abandoned. I think that a larger number of quarries are now in operation than two years ago. Most of the firms engaged in this business report increased sales during the past year. This is especially true of those quarries that produce the variety of slate called unfading green, for which the foreign demand continues brisk. Other varieties of slate are exported, but none is in great demand abroad except the unfading green. The foreign trade has saved more than one company from serious trouble. The extent of this export trade may be seen from the following extract from a recent letter which I have received from one of the large quarries. "We are loading today, two cars for Durban, S. Africa, twelve for London, six for Bristol and Newcastle." Most of the quarries which are not so fortunate as to possess the unfading green, report little or no increase, and some a decrease, in their business.

While nearly all the productive quarries are in western Vermont, slate has been quarried in past years in many parts of the state, to a greater or less extent. Most of these quarries have been abandoned for many years, though some were worked considerably for a time. At present no quarries are worked outside of Rutland county, except one or two at Northfield.

The great slate belt of Western Vermont begins on the north near Glen Lake at West Castleton, though the first bed which is worked is that at Cedar Point on Lake Bomoseen, six miles north of Fair Haven. It extends southwards on each side of Lake Bomoseen, especially on the west side, through Scotch Hill, where some of the first quarries in this region were opened in 1839, and something has been done at this place ever since that time. From Scotch Hill the belt may be followed through New Haven on to Blissville, Poultney, South Poultney, Wells, Pawlet, to West Pawlet, south of which place there are no Vermont quarries now worked, though formerly there were quarries as far south as West Rupert. The adjacent New York quarries in

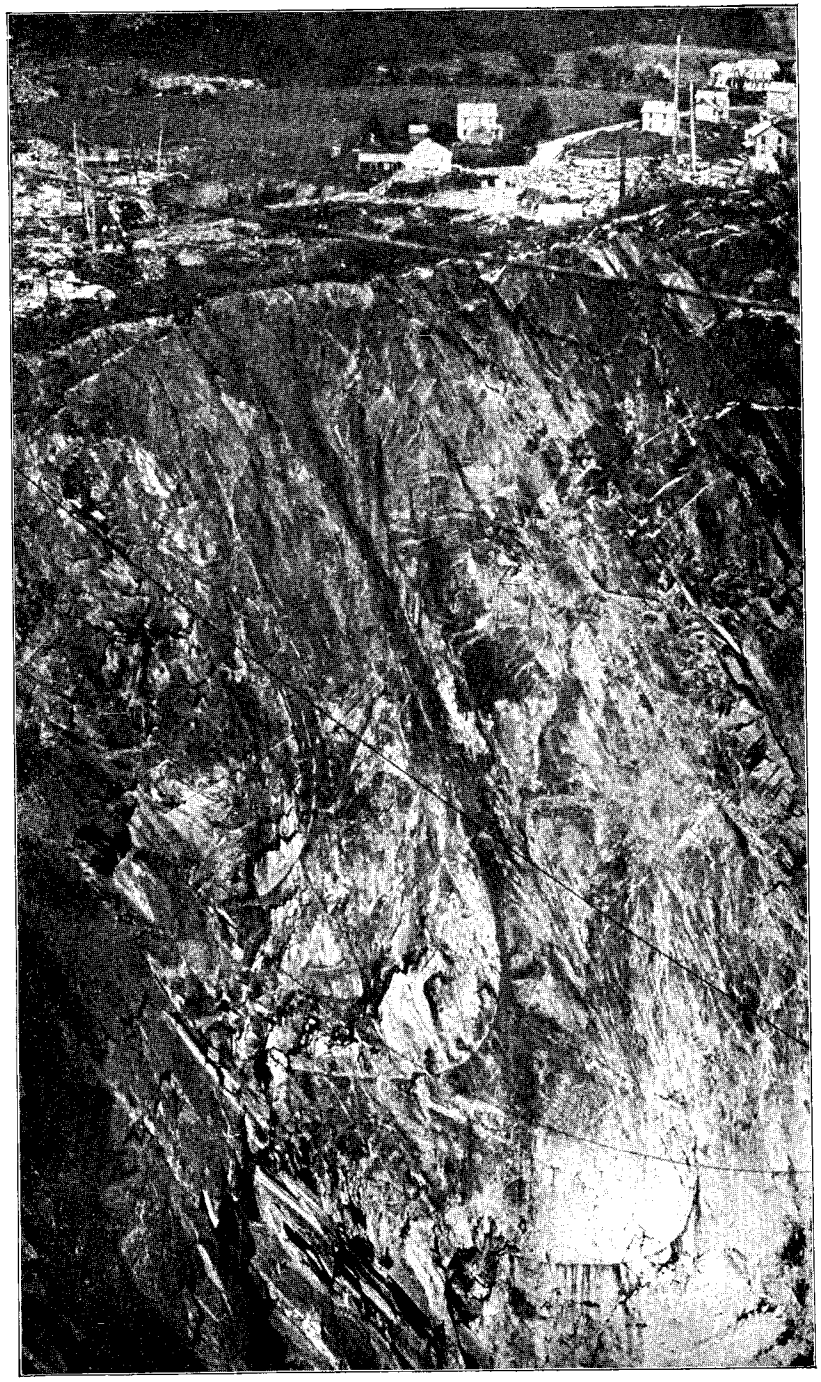

FIGURE 2. INTERIOR OF ONE OF THE DEEP SLATE QUARRIES AT WEST PAWLET. In the lower left-hand side of the figure, between the cables, is seen a synclinal fold in the slate. From the U. S. G. S.

Washington county reach considerably farther south than those in Vermont. The Vermont slate region is, as indicated, about thirty miles in length from north to south. In width the area is nowhere over eight or ten miles, and for the most part not more than five or six miles. From a little south of New Haven the quarries, with some rather long interruptions, are very closely located, being at some points contiguous, and the forest of derricks forms a conspicuous feature in the landscape as one approaches the place. The dump heaps, which are sometimes enormous, are also very conspicuous. Most of the quarries are deep pits which begin on the top of a high ridge as rectangular openings of greater or less dimensions from which the stone is removed downwards. It is not easy to get a good view of any of them. Figures 1, 2 and 3 show the interior of the West Pawlet

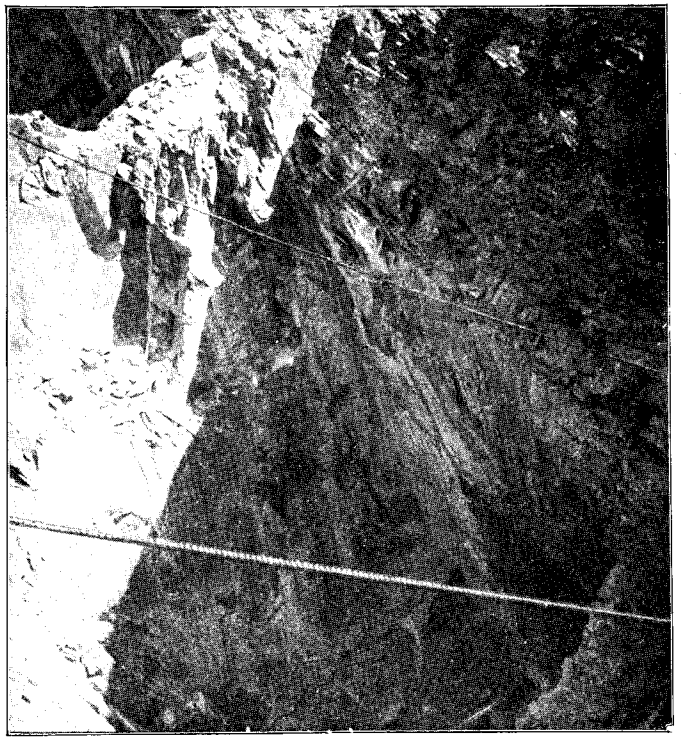

FIGURE 3. SLATE QUARRY OF RISING AND NELSON, NO. 3, WEST PAWLET, LOOKING DOWN AND NORTH. This shows the interior of a deep quarry. From U. S. G. S.

quarries. These may be two hundred feet or more in depth. Figures 4 and 5 show the quarry at Cedar Point which, unlike most, is a side-hill quarry.

Within the Vermont slate area there are worked and abandoned, permanently or temporarily, about a hundred and fifty quarries. These quarries produce a number of varieties of slate which have quite different market value. No black slate is found in this belt. The varieties are, unfading green, sea green, purple, variegated and in one quarry, Griffiths and Nathaniels at Poultney, there is a vein of a dark gray called Poultney Gray. In many of the beds the color of the slate is very uniform and free from spots, but that from other beds is often spotted and this of course greatly damages the stone as it makes it unfit for market. In purple or red slate, the spots are green, or at least of a greenish hue. The spots may occur throughout a bed, or only in a part of it. The spots appear to contain less iron oxide and more lime carbonate and also more of the carbonates of iron and manganese than the rest of the rock. There is also more silica, for which reason the spots are harder than the rest. The less quantity of iron oxide $Fe_2 O_3$ is supposed to be due to the decomposition of organic matter, fossils, and the increase in carbonates is caused in the same way. "In view of all these facts and indications, the spots may safely be regarded as probably produced by chemical changes in the sediments consequent upon the decay of organisms."*

The increase of quartz is supposed to be due to infiltration from the surrounding rock.

Anyone visiting the slate quarries of Rutland county, Vt., and Washington county, N. Y., would naturally regard them as parts of the same formation, but as will be seen later, they do not belong to the same age. Most of the New York quarries are later in age than those in Vermont, though some of them are within a stone's throw of each other. Both areas together extend about fifty miles from north to south and are, as estimated by Mr. Dale, seven miles in average width, and nowhere is the combined area over ten miles in width. In this area there are in all some two hundred and fifty quarries of which, as has been stated, a hundred and fifty are in Vermont.

* Slate Belt of Eastern New York and Western Vermont, page 258. T. N. Dale.

In my report of last year the erroneous statement occurs that both areas are geologically the same. I regret that this mistake should have been made, for it is some time since Mr. Walcott, by a careful examination of fossils, showed that the Vermont slate was of a different age from that of New York. By most diligent exploration he found fossils in one hundred and fifty-four localities and later came the extremely thorough and important survey of the region by Mr. Dale, who has added to Mr. Walcott's fossil localities no less than one hundred and eighty-nine. As a result of the above investigations, it is settled beyond doubt that the slate of Rutland county is Cambrian, while that of Washington county is Ordovician (Lower Silurian.) As to this Mr. Dale remarks, "The Cambrian roofing slates are, therefore, regarded as occurring not far from the top of the Lower Cambrian series as exposed in this region and very near the overlying Ordovician. As the Cambrian beds are made up of numerous folds, generally close and overturned, the slates also occur toward the center of the belts, but their stratigraphical position is the same. The first place to look for the Cambrian roofing slates is near the Cambro-Ordovician boundary. Where the red slate occurs in close proximity to, and on the west side of, the Cambrian roofing green and purple slates, and the dip is easterly, as it usually is, the red slate may be found underlying the sea green, unfading green, or purple slates and vice versa; on the eastern side of the Cambrian areas, the green and purple slates of the Cambrian may be found underlying the red of the Ordovician when both dip easterly. At several points (Blissville, Eureka, etc.) away from the Ordovician boundary, the rock which appears to immediately underlie the Cambrian slates is the olive grit, one of the so called "wild rocks" of the quarrymen. The rock which overlies the Cambrian slate is either the "Black Patch grit," or the Cambrian black shale, or

the Ferruginous quartzite and sandstone. Most generally, there is a bed of limestone conglomerate or breccia, followed by black shales or slates. These vertical relations are pretty well established.''*

It is a very interesting fact that all the red slate is Ordovician while all the purple and green is Cambrian and it is most probable that the black slate of Benson is Ordovician, as is pretty well established in case of the black slate of Northfield,

FIGURE 4. VIEW IN THE SLATE QUARRY AT CEDAR POINT ON LAKE BOMOSEEN. The ladder, about 13 feet long, is placed against the synclinal fold of the slate. The fold has been overturned and lies on one side. The syncline strikes N. 10° W. From U. S. G. S.

* Dale l. c. p. 265.

as was shown in the last report. In the slate belt, these two areas, the Cambrian and the Ordovician, are curiously intermingled. The Cambrian occupies a greater area, but its territory is invaded in a very complicated manner by tongues, promontories and islands of Ordovician. To the eastward of the slate belt in Vermont the rocks are Ordovician. In the slate region, the rocks are quartzite, which is perhaps most abundant of all, limestone, schist and shale. The whole is covered to a considerable depth by glacial drift. The higher portions of the Taconic range, which runs north and south, east of the slate, are mainly schist. Some of these are seen in the background in Figure 1. According to Mr. Dale, the lower hills are mainly quartzite. The slate does not always form a mass by itself, but not infrequently it is intermixed with quartzite, which may be calcareous. These quartzite beds may be only a few inches thick, or they may be several feet and, as would be supposed, they may greatly interfere with the value of a slate deposit. Above the slate, beds of calcareous conglomerate often occur, and in these fossils, Olenellus, and other Cambrian species are found.

The slate beds are quite differently situated in different quarries. In some the slate beds are nearly horizontal while in others and most, the beds are inclined or folded. In the quarry at Cedar Point, on Lake Bomoseen, the purple slate is folded and the folded mass turned over so that it is like a letter v, laid on the side, that is, it is what is called an overturned syncline. Figures 4 and 5 show this structure as does Figure 2 which shows the same synclinal arrangement in one of the quarries at Pawlet. In the Eureka quarry at Poultney, Mr. Dale reports the following layers. Beginning at the top, there are : Purple slate, 20 feet ; not named, about 30 feet ; variegated slate, 20 feet, followed by a second bed of the same about 2 feet ; green slate, 30 feet ; light green slate, 20 feet ; gray green slate, 11 feet ; gray green, 18 feet; quartzite, 4 feet; gray slate with black patches, 20 feet. This is more complex than is usual in the quarries. At the Lake Bomoseen quarry, shown in Figure 4 there are 127

feet of purple slate above which are 50 feet of green. At one of the Fair Haven quarries the order of beds is, below the surface rock, 18 feet of variegated slate, then a thin layer of quartzite, then 13 feet of green slate, followed by a thin bed of quartzite, below which are 20 feet of green slate.

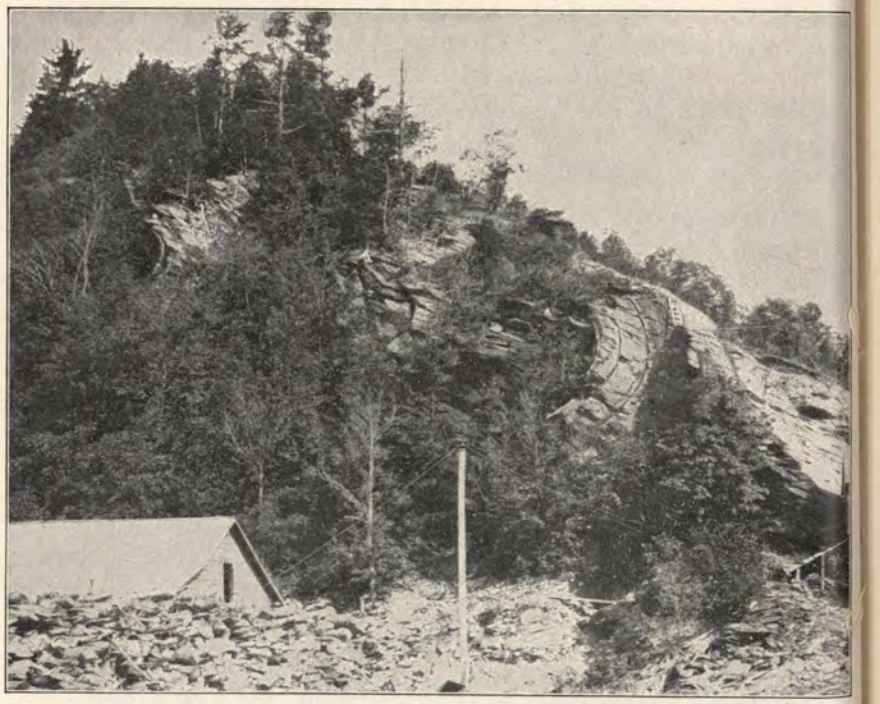

FIGURE 5. VIEW AT THE SLATE QUARRY AT CEDAR POINT. The same syncline seen in figure 5 is shown at the right. From the U. S. G. S.

The total area as previonsly outlined, is about two hundred and fifty square miles. To this should be added, for the entire slate area of the state, about eight square miles of black slate in Benson and a small area in Northfield. The larger part of the quarries produce only roofing slate, but a few, as that at Cedar Point, and one or two at Scotch Hill, produce what is known as mill stock which is a somewhat more compact stone having a

less perfect cleavage. This is sawed into slabs for billiard table tops, tiles, blackboards, etc.

The color of the slate varies in different localities. In some quarries all the slate is purple, in others both purple and green, in others it is all green. And, as the section given above shows, there may be several layers of each color in a single quarry.

The difference in color is due to difference in composition.

In Mr. Dale's Report, analyses by Dr. W. F. Hillebrand are given and from these I quote the following :

ANALYSES OF ROOFING SLATE, MADE BY DR. W. F. HILLEBRAND, U. S. G. S.

Constituents.	Sea Green.	Unfading Green.	Variegated.	Purple.	Benson Black.	Red. New York.
SiO_2 Silica	63.33	59.37	60.24	61.29	59.70	63.89
TiO_2, Titanium oxide	.73	1.00	.92	.77	.79	.52
Al_2O_3, Alumina	14.86	11.93	18.46	16.24	16.98	11.80
Fe_2O_3 Ferric oxide	1.12	1.18	2.56	4.53	.52	4.56
Fe O Ferrous oxide	4.93	6.69	5.18	2.62	4.88	1.33
Ca O Lime	1.20	.49	.33	.60	1.27	2.25
Mg O Magnesia	2.98	2.36	2.33	2.99	3.23	4.57
K_2O Potash	4.06	3.78	4.09	5.27	3.77	3.95
Na_2O Soda	1.22	1.71	1.57	1.38	1.35	.50
CO_2 Carbon dioxide	1.41	.30	.08	.54	1.40	3.15
FeS_2 Pyrite	.11	.14	.16	.04	1.18	.92
H_2O Water above 110C	3.37	4.91	3.81	3.16	3.82	2.82
C Carbon	Trace				.46	
Sundry and Water below 110,c	.69	.51	.39	.56	.70	.77
Totals	100.01	100.05	100.12	100.09	100.05	100.13
Specific gravity	2.776	2.795	2.805	2.806	2.774	2.796

A careful study of the above table gives us a clue to the cause of the different colors seen in the slate of different beds. It also shows that slate is quite complex in its constitution. We see that the green slates contain less iron oxide, ferric oxide, than the purple or red. Thus we find that the purple and red slates contain four times as much ferric oxide as the green. Mr.

belt we have been studying. All the slate here is black and some of it appears to be of very good quality but none of the deposits are now worked.

East of the Green Mountains at Northfield there are a number of quarries of black slate, only one or two of them now worked. The reason usually given by those who may be supposed to know, for the closing of these quarries, is that they are owned by people living outside the state who do not care to put their money into their development.

It is said that slate was formerly quarried at Thetford and that at one time quite a large amount was obtained. In Guilford two beds of slate were worked for a time. One of these was worked by the New England Slate Co. as early as 1812, and is, therefore, one of the first slate quarries opened in the state. There were also quarries at Fairlee, Waterford and elsewhere.

Pennsylvania leads the country by a long way in the production of slate, but Vermont comes next, though not producing nearly so much, the total amount being only about a third of that furnished by the larger state. In 1898 Vermont produced slate to the value of $732,684, which was a considerable increase over 1897, and there is every reason to believe that a still larger quantity was sold in 1899, and that yet further increase will be noted in 1900. The largest sales of slate made in this state were in 1892, when they amounted to $1,014,000. In 1893 the sales declined to little more than one-half those of the previous year, and then a slow increase followed and this has continued until the present, when the sales are larger than in any previous year since 1892. It has not been possible to collect full and accurate statistics of the slate industry in Vermont for the past two years, but from the reports which have been sent in, and from such inquiries as I have been able to make, I think that it is quite within the limits of truth to say that there are at present twelve to fifteen hundred men employed in the mills and quarries, over half a million dollars invested in the business, over $700,000 paid in wages, and an output valued at nearly a million dollars, and this is increasing.

In concluding what I wish to say of the slate of Vermont, I am sure that I can do no better than quote once more from Mr. Dale's report, condensing his statements.

After noticing that the geological history of the slate belt cannot be wholly made out as yet, he says: "Some of the main outlines, however, as generally received, are as follows:

First. A land surface chiefly of granites and gneisses.

Second. The advance of the sea in the earliest Cambrian. The nearest land masses then were the Adirondacks and adjacent pre-Cambrian masses on the northwest and portions of the Green Mountain range on the east.

Third. The deposition of the lower Cambrian sediments from the products of erosion of these land masses. These sediments were mainly sandy and clayey, but sometime calcareous and then largely of organic origin. The frequent alternation of fine and coarse sediments and of these with calcareous ones, and the recurrence of conglomerates, indicate changing conditions. There was deep and shallow water, quiet water and rapid currents, occasional exposure of the sea bottom to wave action and then its submergence, owing to minor oscillations of the earth's crust. Slates and their interbedded quartzites correspond to extremely fine argtillaceous sediments from the waste of granites and gneisses, and to coarse sandy ones representing coarser material.

Fifth. The lower Cambrian sediments are followed by the grits, black, red and green shales and slates of the Ordovician. The Ordovician grits contain not only fragments from the granitic and gneissic masses, but also from sedimentary beds, limestones, slates and quartzites, which must have been somewhere above water. The black Ordovician shales abound in graptolites and owe their origin to organic matter. The red slates and shales, with their high percentage of ferri coxide, and their proximity to the black shales, suggest the possible agency of decomposing organisms in their formations, and that either on land or in the sea.

Sixth. Probably at the close of the Ordovician time the accumulated sediments gradually emerged in gentle folds. Under increasing pressure new mineral combinations were formed in the sediments; cleavage, foliation and grain were superinduced in the finer sediments.

Seventh. At some later time another movement occurred, resulting in various secondary structures, diagonal joints, slip cleavage, superinduced on slaty cleavage, quartz veins, minor faults and shear zones.

Eighth. The Cambro-Ordovician area between the Adirondacks and the Green Mountain highlands was then exposed to a long period of erosion from atmospheric agencies. Large areas of the Cambrian thus became denuded of their Ordovician sediments.

Ninth. Direct atmospheric erosion was interrupted, however, by the southward extension of the north polar ice cap which rounded, polished, furrowed and scratched the surface of every exposed slate ledge in the region.

Tenth. The retreat of the glacier left the surface covered with boulders and morainal material, which was redistributed by the great streams from the thawing ice.

Eleventh. A later depression of the Lake Champlain region, amounting to from 300–400 feet, let in the sea from the north which formed a bay extending as far south as Albany, and left sea beaches with marine shells above the lake.

Twelfth. The re-elevation of the region brought in the present conditions.''*

BUILDING AND ORNAMENTAL STONE.

LIMESTONE.

Naturally, the first quarries opened in the state were those in which building stone was sought. As soon as stone is quarried and drawn to the spot where it is to be used in building, there is need for mortar and this must be obtained from limestone. Hence the first quarries in any new country must be

* Dale l. c. p. 299.

those of the most conveniently located building stone, and of limestone if any is to be found. In this state nearly all the limestone is located in the western part and not far from Lake Champlain. To the eastward of this narrow strip the rocks of the state are mostly, though not exclusively, schist, granite, gneiss, quartzite, and other metamorphic rocks. This being the case, while building stone is found in all parts of Vermont, lime can be burned in few places except in the western portion of the state. East of the Green Mountains, lime has been burned at Whitingham, Plymouth, Townshend, Weathersfield, Cavendish, and other places. West of the mountains, it has been obtained at Highgate, Swanton, Colchester, Grand Isle, Brandon, Leicester Junction and elsewhere, and, of course, throughout the marble border.

Probably as old a quarry as any in Vermont, if not the oldest, is that at Fisk's on the southern end of Isle La Motte. This is in an almost black limestone containing few fossils, but sufficient to fix the age of the rock. Stromatocerium lamottense, Seely and Maclurea magna, Hall are most characteristic, though other species occur, and place the quarry in the lower Chazy. For more than a century stone has been taken out at this point. The quarry is nowhere much below the level of the neighboring carriage road, which is only a little above the level of the lake. By the aid of a tramway the quarried blocks are easily taken to the dock on the shore of the lake. In addition to what was said of this quarry in the last report a few points may be noticed. The walls of the quarry are nowhere very high, not more than twenty or at most, thirty feet. The area from which stone has been removed is large, I should think not far from twenty acres.

Fleury's quarry, a short distance southeast of Fisk's, is the only other quarry now worked on Isle La Motte, though there are several which are not worked. Until recently there have been no quarries of much importance on Grand Isle, but now there are two on Phelps' Point which have been opened and are worked by the Rutland Canadian railroad, the stone being all

used in the construction of the road. Both of these quarries furnish an abundance of good stone. The quarry which is located farthest to the east is remarkably thick bedded. Some of the blocks which had been thrown out of place by blasts were 15 or 16 feet thick. The beds are black, or dark gray, and very sparsely fossiliferous, but a few Maclureas and Brachiopods and fragments of Asaphus were found. At the other quarry, which is just northeast of the north end of Providence Island, from which Grand Isle is separated at this point by only a very narrow bit of water, the bedding is thinner and the stone better for many purposes. At the time I visited the place blocks were being quarried and dressed for piers and abutments of bridges, etc. The stone at this quarry is much more fossiliferous than that at the larger one farther east. Some of the layers here were well filled with Maclurea and other Chazy species.

Probably the limestone quarries at Highgate and Swanton are among the oldest in the state. They have, at any rate, been worked since the early part of the century. Aside from certain minor quarries, those of importance are that at Highgate carried on by Mr. L. E. Felton and those of Messrs. J. P. Rich and W.P. Fonda at Swanton. All of these furnish the stone for extensive kilns in which lime is made. The limestone is what is generally known as the "dove." It is a hard, compact and very pure stone as the following analysis shows.

Analysis of Limestone from Swanton *:

Calcium oxide, CaO	55.83
Magnesium oxide, MgO	Trace
Iron and Aluminum oxides	.10
Silica, SiO	.40
Carbon Dioxide, CO	43.65
Total	99.98

The quarries are not deep, but as the illustrations show, the ledge of stone has been quarried away over a large surface without going down very far. Figure 6 shows a small part of the quarry carried on by Mr. Rich.

*Mineral Resources of the U. S. 1898, p. 456.

FIGURE 6. LIMESTONE QUARRY OF J. P. RICH, SWANTON.

The dove limestone makes a very delicately shaded marble and for a time in the early part of the century it was one of the most highly valued marbles in use in the state. In some of the best of the old houses especially in Northern Vermont, there are not only hearths, but finely wrought mantels of this marble and very elegant they are. It takes a good polish and finishes well in every respect. The Barney Company still use it in their trade and it produces a very pleasing effect when used in mosaic tiling with the colored marbles. There is, however, difficulty in getting large slabs which are free from flaws to which the stone seems to be very liable. For this reascn it is not used as marble as extensively as it otherwise would be.

The dove limestone, though occurring in thick beds is remarkably wanting in fossils. Some of the exposures have been long and carefully examined with no results. On this account it is difficult to assign it to a definite geological period. I think, however, that they will, most of them at any rate, be finally placed in the Calciferous, probably the lower. What I believe to be of the same age as the Swanton dove limestone is found in what is locally known as the "Lime Kilns," a couple of miles or so northeast of Burlington. At this place a great deal of limestone has been quarried and burned to lime. Diligent search has revealed no fossils at this quarry, but on the farm of Mr. D. B. Griffin where the same formation crops out, perhaps a mile north of the quarry, well defined fossils have been found. The most clearly distinguishable of these are remarkably well preserved specimens of Billings' Pleurotomaria (Raphistoma) Canadenses Stromatocerium and other Calciferous species. It immediately overlies the Red Sandrock, which is Middle Cambrian, and as a rule lies to the east of this rock, though at Swanton there are considerable beds of the Winooski or Champlain Marble east of the limestone. The principal quarries of the Barney Company, from which the Champlain Marble which is worked up in their mill is obtained, are in these beds and they are of the same age as the Red Sandrock.

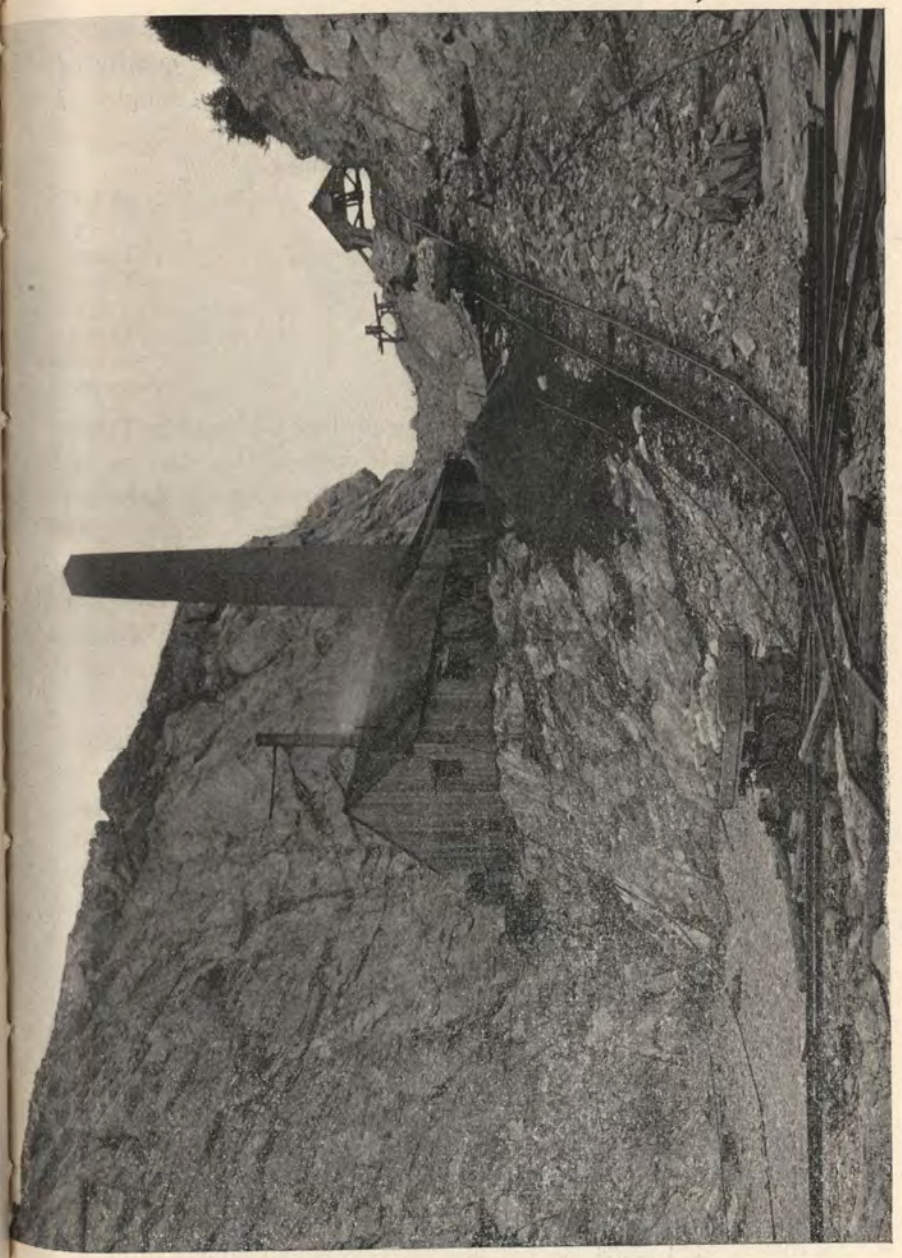

FIGURE 7. VIEW OF THE LIMESTONE QUARRY OF W. B. FONDA, SWANTON.

The dove limestone produces a most excellent quality of lime. The following average of the analyses of four samples of the Swanton lime show its quality.

Average of four analyses of Swanton lime:

Calcium oxide, CaO	98.96
Magnesium oxide	.43
Ferric oxide, Fe_2O_3	Trace
Ferrous oxide, FeO	Trace
Carbon dioxide, CO_2	.37
Silica, SiO_2	Trace
Total	99.76

At Winooski Park, Colchester, some lime is burned by Tobey and Catlin, but not so much business is done at this place as formerly. There are two companies which burn lime at Leicester Junction and several smaller kilns in other places. According to the report in *Mineral Industries of the U. S.*, Vermont, in 1898, produced lime to the value of $178,750, but this must be an under estimate for, not taking into account several large firms which have not sent in any report, those that did report in 1899 produced over $225,000 worth of lime.

This industry appears to be subject to considerable fluctuations. In 1893 the production amounted to $400,000; in 1894 to $151,000; in 1896 to $147,000, while during the past year it has been probably, in all the kilns, not less than $300,000. The Plymouth limestone is a very peculiar brecciated stone which was formerly sawed and polished for marble, but in late years, the marble business not proving successful, it has been burned for lime. This stone is said to be strongly magnesian and to make a strong, durable, but not very white lime. The kilns used in the larger lime works are perpetual, that is, they can be used continuously, the fire not being directly beneath the stone as in the old kilns, but in a separate chamber at one side, from which the flame passes up into the mass of limestone. By this arrangement the lime can be removed as formed without disturbing the fire and conversely, the fire can be replenished without interfering with the charge of stone. A row of such kilns is seen in Figure 8, which shows kilns at Fonda's quarry.

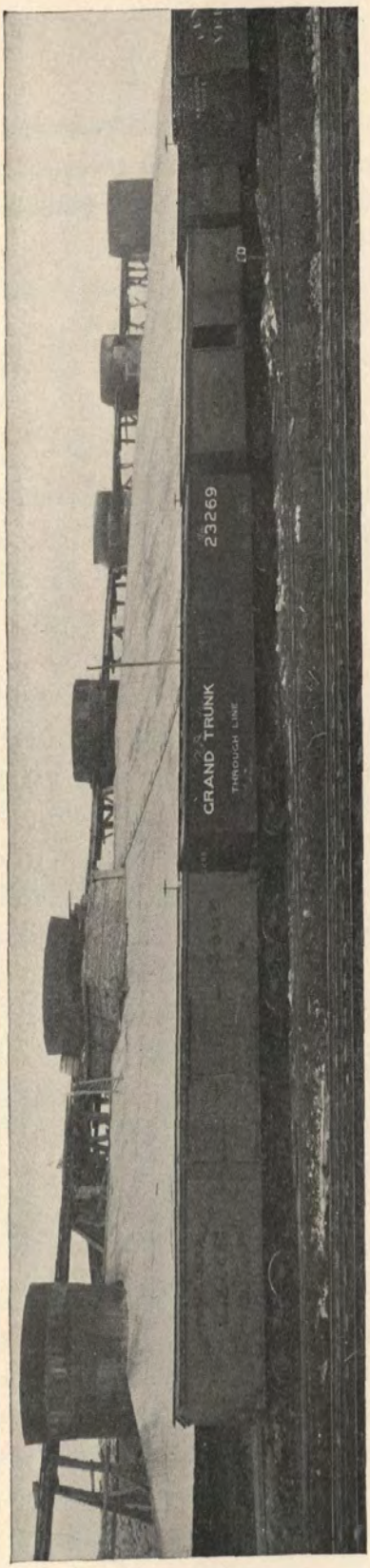

FIGURE 8. PERPETUAL KILNS AT THE WORKS OF W. B. FONDA, SWANTON.

The stone broken to a suitable size is thrown in at the top of the cylinder and renewed as often as necessary. The lime as formed drops below, where it can be removed from time to time.

MARBLE.

Since the country was sufficiently settled to need marble for ornamental or building purposes, Vermont has supplied the need more largely than any other state, or all others combined. Vermont marble is not only valued above other sorts in this country, but it is to some extent exported to foreign countries, even as far as India, China, Japan and Australia.

While the marble industry in this state has never had any such remarkable and rapid development as has the granite business, yet it has for nearly a hundred years been steadily growing and is so established that it seems quite improbable that anything can permanently or seriously check its growth.

It is indeed true that in some parts of the marble belt of the state, there seems to be a bad showing for the business. There are abandoned quarries, tumble down mills, rusting machinery in some localities, and the sight of such things is not encouraging, but this is by no means the universal condition of the business. Like all industries, this has had its ups and downs. The use of marble increases or decreases with the prosperity of the country. When money is abundant, much marble is used in the adornment of buildings, while in stringent times, plainer and cheaper materials are used.

According to the Report of the United States Geological Survey, Vermont, in 1898, produced marble valued at $2,067,938, which is nearly two-thirds of all produced in the United States. The largest sales on record were made in 1872, when they amounted to $2,275,000. During the years immediately following 1872, the sales fell quite perceptibly, until 1896 they were only $1,101,000. Since then they have steadily increased

and the report comes this year, 1900, from all the companies producing marble, that the sales are increasing considerably.

In 1898, Georgia and Tennessee exceeded Vermont in the quantity of marble sold in the rough, but this state sold more cut stone used in building than any other state, and of the marble used in monuments, Vermont furnished nearly ten times as much as any other state, and over six times as much as all others combined.

Vermont marble seems to be increasingly in demand for building. As we have seen, it has always been more in demand for ornamental purposes than any other marble, but the stone from several other states has been used in larger quantities for outside building. In 1897, however, the sales of Vermont marble for this purpose were nearly double those of the previous year, that is, they grew from $207,319 in 1896, to $402,912 in 1897, and $441,439 in 1898. This is an important matter because the coarser grades of stone which can not be used in monumental work, are often excellent for building. Much that is produced in some quarries is waste material if only monumental material can be sold, but if this can be utilized as building stone it is a great gain. Many quarries which cannot be profitably worked for monumental stock alone, may be worked to advantage if all the stock obtained can be marketed, if not for monuments, for building or some other purpose.

Figures 9, 10 and 11, illustrate the use of the Rutland marble in buildings. Figure 9 shows a church in New York City, in which the darkest Pittsford, the "Mountain Dark," is used, in part of the building finished over the whole surface, in part rock faced. Figure 10 is a library building in Troy, N. Y., in which the dressed white marble is used. Figure 11 is a church in which dark rock faced stone is very effectively used.

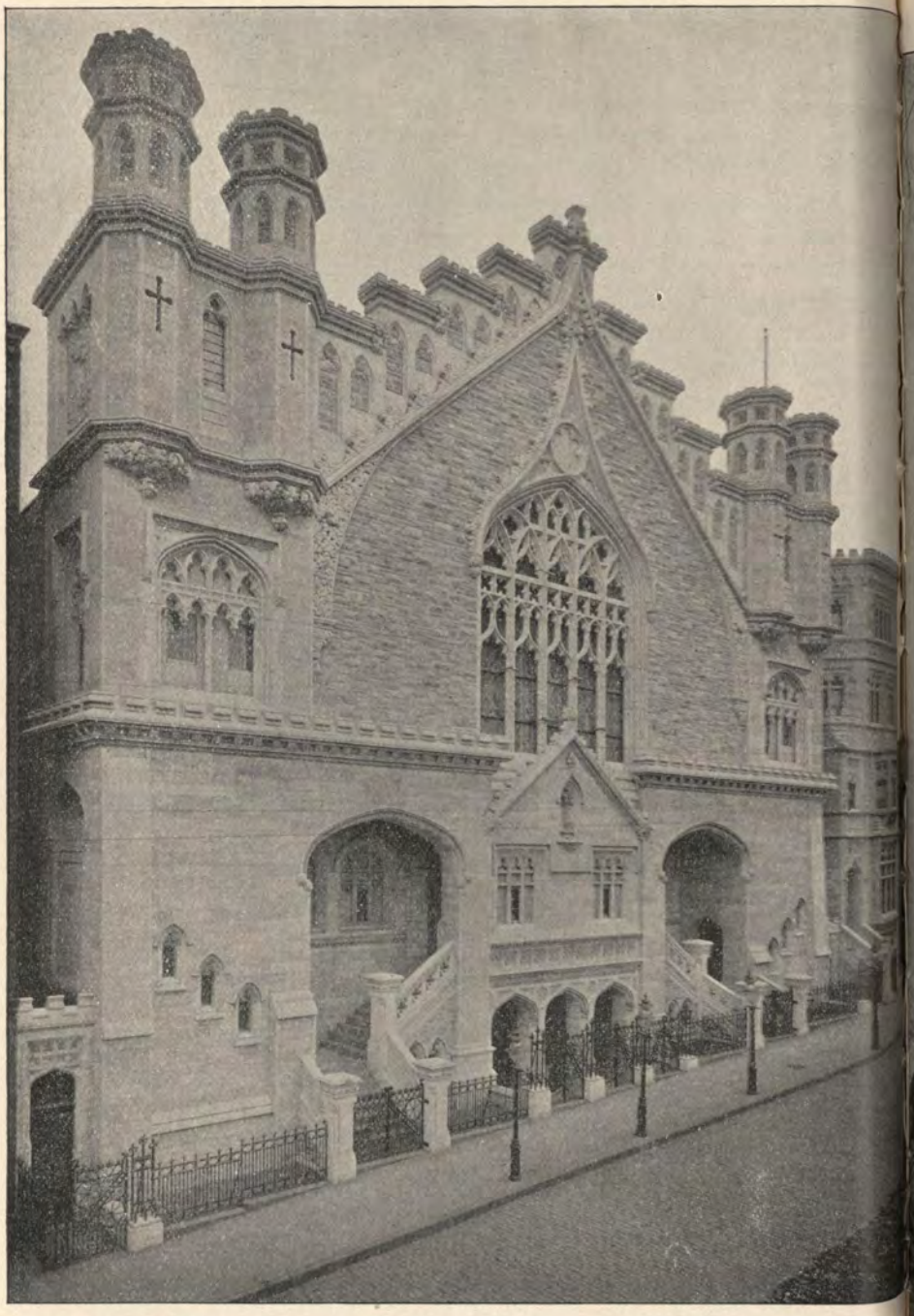

FIGURE 9. LARGE CHURCH OF DARK MARBLE. The stone is part of it full hammered, part rock faced. New York City.

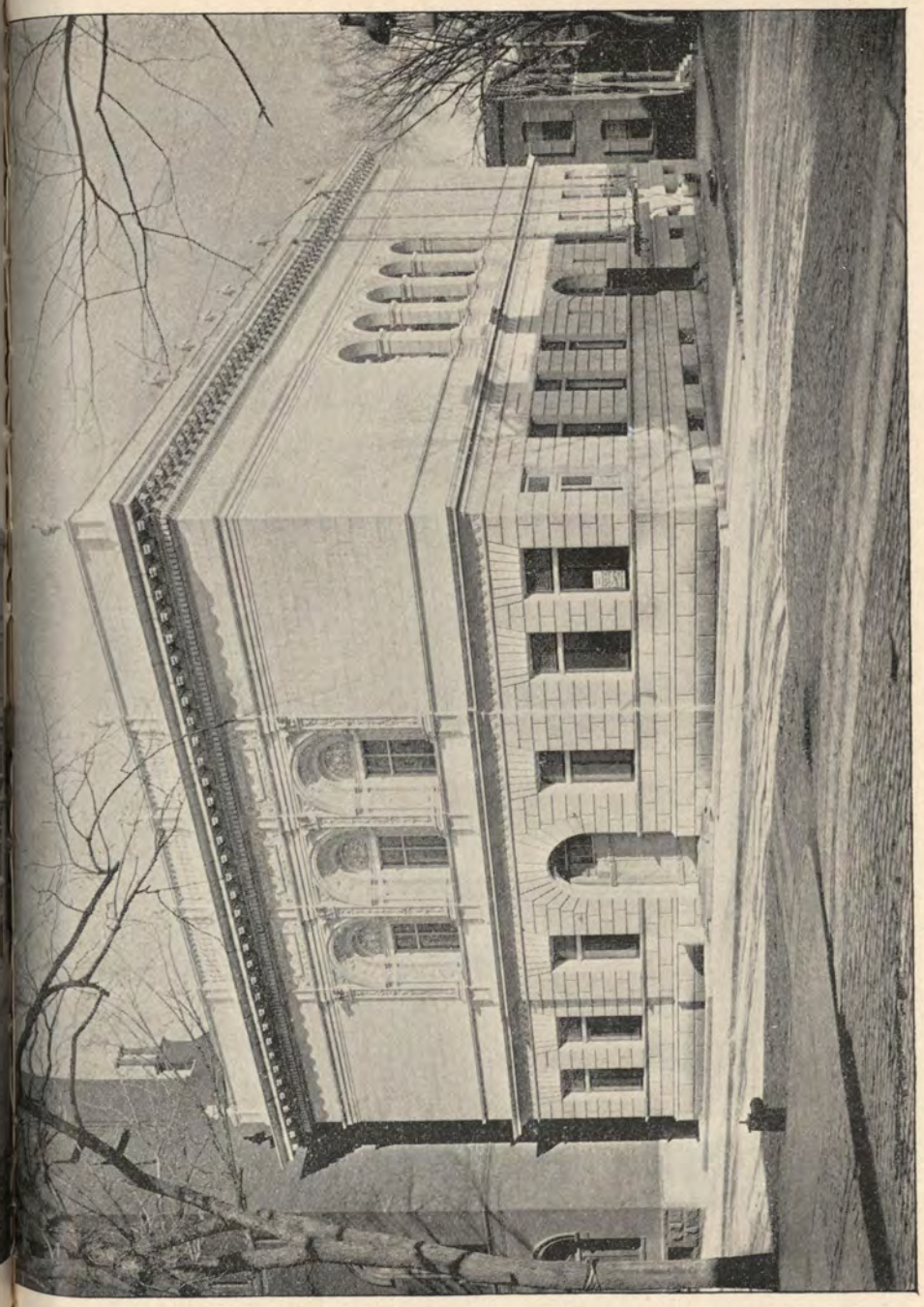

FIGURE 10. LIBRARY BUILDING, TROY, N. Y. White, smooth faced marble.

pany. This Company has also quarries at West Rutland and Bristol. Besides blue and white marble, they quarry colored marble. North of the quarries mentioned at Florence there are no worked quarries south of that of the Brandon Italian Marble Company. This quarry, which is located near the railroad a short distance south of the station,is large and deep. It has been worked a good many years. The quarry is of peculiar shape as it is very much longer and narrower than any other quarry which I have seen. The bed of marble runs approximately north and south and is quite deep. The stone is light clouded and finely bedded. The large mill of this Company was burned in 1898 and the new one which takes its place is located at Middlebury where the water power of Otter Creek is used. The work of this Company was necessarily considerably hindered by the loss of their mill and the delay in getting settled in the new one. Yet they report good sales and the prospect of better, now that they can better fill orders.

About two miles southwest of Brandon village is the Bardillo quarry and mill. Both of these are in active operation. The marble at this quarry is, on the whole, dark and is not like any other that I have seen in its abundant veining. It is a very handsome stone.

North of Brandon, the Corona Marble Company have three quarries from which white and blue marbles are obtained. The Company has also a mill. Both quarries and mill are now leased.

The siliceous limestone, which has been to some extent quarried in the town of Washington,is still worked, though in the case of most of the quarries, rather irregularly. This stone was so fully described in the last Report, that little more need be said here. It is unfortunate that it sometimes goes on the market as "granite" for it has no claim to the name, being in no sense granite, but a well defined limestone and it should always be considered as a marble in trade. In general the polished stone is a very pretty bluish gray, strongly and numerously veined with dark gray or black. The stone is fine grained, takes a fine polish

and must be very durable. The main difficulty in selling it to advantage is found in the distance of the localities where it is quarried from any railroad. Larger capital than appears to be available at present is needed to develop the beds properly. The supply seems to be ample.

The deposits of this stone are well deserving of investigation for they furnish a very distinct and very attractive variety of marble. The principal quarry and the only mill in Washington is that of the Warner Granite Company. The quarry is now thirty-two rods wide and seventy rods long. The mill is not large, but is equipped with some good machinery for cutting and polishing the marble.

The variegated marbles of Swanton and Colchester are not only of older geological formation, but very different in every way from the lighter Rutland marbles. There are two firms now producing the Champlain Marbles, that which has been so many years established, The Barney Marble Company, and the Champlain Marble Company, both of Swanton.

The stone is a siliceous dolomite and different layers afford most pleasing combinations of many shades of red mingled with more or less of clear white. Olive and green veins also occur in some of the beds.

The great difficulty in profitably working the Champlain, also known as the Winooski and Swanton Marbles, consists in the hardness of the stone, which is much greater than that of other marbles. This same quality, however, causes it to take a more brilliant and durable polish. Unfortunately it adds very much to the cost of sawing, cutting and polishing and of course to the price at which it can be furnished.

Nevertheless for many years tile and polished work have been produced at Swanton, first by George Barney and after by his successors, the Barney Marble Company. This marble may be seen in many of the finest and most costly buildings all over the country. I regret that it has not been possible to give in this connection colored plates of some of the varieties of these Champlain Marbles. Anyone who is sufficiently interested to take the

trouble to look them up, may find very good representations of the Champlain, and also of some of the Rutland marbles, in Volume *10, United States Census Report*, 1880, Plates 30, 31, 33, 34, 35, 36, 37.

The Champlain Marble Company has within a year or two opened quarries near Swanton Junction, where stone similar to that in the Barney quarries at Swanton is found in abundance. There is also a small quarry of this stone near Burlington, which has been recently opened. The large quarry and mill at Malletts Bay have not been in operation for years.

In the early days of the marble industry at Swanton the harder variegated marbles were neglected and at first only the dove limestone, already mentioned as that used for the manufacture of lime, was sawed and polished. This was in 1812. It was used for hearths and to some extent for mantels. Some years later the black limestone from Fisk's Quarry on Isle laMotte largely displaced the Swanton "Dove." Like its predecessor, this was used in hearths, mantels and tiles. It is said that the first black marble tiles ever made in America were those furnished by George Barney in 1848 for a large building in New York. Mr. Barney was also probably first to put the Champlain marble on the market.

The Barney Company also own and work a quarry of Serpentine, Verde Antique. The stone quarried at Roxbury, is taken to Swanton to be worked up. It is a most elegant stone, though, because of the difficulty of working it, very costly.

Serpentine is found in many localities in the state, but only two quarries have ever been worked. The first of these was opened at Cavendish over sixty years ago, but the expense of getting out good blocks and conveying them to market was too great and the enterprise was abandoned.

The Roxbury quarry has had a similar experience, having been worked for a few years and then for many years left idle, no work having been done there since 1858. Two or three years ago the Barney Company took hold of the old quarry and have taken out some magnificent blocks. The stone is elegantly veined in various shades of green intermingled with black and white. Perhaps as good specimens of this Verde Antique as any are to be seen in the water fonts in the South Union Station in Boston. This stone is composed of silica, magnesia, ferrous oxide, lime carbonate and water in varying proportions in different samples. In general it is a magnesian silicate.

GRANITE.

In the last Report I called attention to the wonderful progress made by the granite industry of Vermont since 1880. This business is still increasing and seems likely to grow on indefinitely. From nearly all of the granite quarries comes the report that sales were never so large as at present, and that they are constantly becoming larger. During the past two years granite has been quarried at Barre, Williamstown, Woodbury, Dummerston, Kirby, South Calais, Ricker's Mills, Beebe Plain. Different varieties of granite are obtained in different localities, and indeed often in the same quarry. These varieties are mainly produced by different arrangement of the ingredients, quartz, feldspar and mica, which compose the stone. As these are in fine or coarse particles, the texture of the granite is fine or coarse, as the dark mica prevails rather than the lighter quartz or feldspar, the granite is dark. All known shades of gray granite are found in the state, but nowhere has red granite been found. Much of the Vermont granite is fine grained, compact, strong and very even in color and texture.

The supply is practically unlimited. Besides the great beds at Barre and Woodbury and Dummerston, and the smaller beds quarried here and there over the state, there are great areas as yet wholly untouched. Vermont has granite of the best quality sufficient to supply the world for many years. Hitherto Vermont has taken precedence of all other states in the production of marble and now within ten years, she has become one of the great and promises to be in the near future the greatest granite center in the world, if not so already. According to the official returns at Washington, Massachusetts produced somewhat more granite in

1898. In the finer sorts of granite such as is used in monuments and the like, Vermont leads, having sold in 1898, $416,000 worth, or more than twice the quantity sold by any other state. This is a strong proof of the superiority of the Vermont granite. And it should be added that I have good reason to believe that the above amount is far below the truth as will be seen later. Vermont also sells more granite in the rough to be wrought elsewhere than any other state, but the sales of granite cut for building and broken into paving blocks are greater in several states. Very little Vermont granite goes into paving stones.

The demand for Vermont granite for the finer grades of work in which this stone is used, is plainly increasing rapidly. Some companies report an increase of thirty per cent annually for the past three or four years. Others report a less increase, but yet one that is very gratifying. Men who are in position to know, estimate the average increase in the business of all the Barre companies taken together, as not less than twenty per cent for 1899 and a similar increase is probably true of Woodbury and Hardwick. It is possible that the forthcoming Census Reports will give more complete and definite figures than I have been able to obtain, but I have not found it possible to get at the exact figures in all cases. Still I have statements from most of the larger firms and the statements given may be considered at least fairly correct. It may be noticed in passing, that men in the granite region, especially if they are interested in the prosperity of the industry, invariably estimate the value of the granite and of the quarries at too great a figure. This is not by any means necessarily intentional, but the interest which they have in the business, I mean general interest, in many cases it is not pecuniary, leads them to over estimate the extent of the business. I speak of this because I have many times found it to be true that men enthusiastic in the development of a business, though intending to give entirely accurate statements, find it almost impossible to do so. This is especially true in the present instance, for I find a wide discrepancy between the estimates which the granite men give in answer to inquiries and the reports which have

come from various companies in response to blanks which were sent out. The most accurate figures should be those given in the volume of the United States Geological Survey on MINERAL RESOURCES and undoubtedly these are intended to be complete and correct, but I have in course of my investigations found reason to doubt some of them.

According to MINERAL RESOURCES for 1898–99, the last published, the total granite production of Vermont in 1898, amounted to $1,084,218. I think, however, that this is decidedly too small a sum. For several years the wages paid in Barre, leaving out all other quarries in the state, have amounted to more than the sum given as the value of the whole output, and anyone who is conversant with the business at Barre and the other granite centers knows that all, or the greater part of all, these mills and quarries are not being carried on at a loss as must be the case, of course, if the output is less than the cost of getting it. During 1899, and especially during 1900, more quarries have been in operation and the finishing works more busy than ever before. So far as I can get at accurate figures there are employed in the quarries and finishing works in the state not less than three thousand men. In Barre there are now on the rolls of granite cutters, not less than fifteen hundred names and in addition to these are polishers, carpenters, teamsters, etc., who together must materially add to the number of workmen, and at the quarries there are from eight hundred to a thousand more. At Woodbury, Hardwick, Dummerston and a few other places there cannot be fewer than five hundred more. Now it is evident that enough granite must be sold to pay this army of laborers. From all this it would appear that $1,500,000 is a very moderate estimate of the wages paid to the different classes of laborers in the granite works.

While my efforts to obtain figures which I could report as certainly accurate have not been wholly successful, I may yet report that it seems to me very probable that the total value of the granite produced in the state in 1900, is not less than $2,500,000. Some of those who are acquainted with the business of

Barre, estimate the amount produced in those quarries and mills as much greater than the above sum indicates and none of the quarry owners in Barre whom I asked to give the value of the stone sold in that place in 1900, put it as low as given above for the state.

Taking the figures given in the Report named, we find that the total product was divided as follows and, whether we accept the figures as a whole as accurate or not, it is interesting to note the proportions of the sales of granite in its different conditions.

Sold in the rough	$513,634
Cut for building	113,922
Value of monuments sold	416.878
Paving blocks	4,446
Crushed stone for roads	5,204
Curbing	12,134
Total	$1,084,218

If this table is to be trusted, it appears that about half of the granite quarried is sold in the rough, or much more than half in quantity, for the value of the rough block is, of course, far less than that of the same or a similar block which has been cut. I very much doubt, however, if it is at all true that the value of the stone sold in the rough is more than that of the monuments, etc., sold.

Nor do I believe that the army of cutters mentioned previously, are occupied in working up no larger amount of stone than that given. Certainly the Vermont granite workers are an exceptionally cheerful set of men if they are doing a losing business, as must be true if the above figures are even approximately correct.

The granite business is far less concentrated than is either the slate or marble. That is, the number of companies engaged in quarrying and working is greater, the works are scattered over a greater area and, as a consequence of this, the capital invested is more widely distributed. Mineralogically, the Vermont granites, so far as they have been examined, are largely muscovite granites, though biotite granites are not uncommon. The following analysis taken from the Twentieth Report of the United States Geological Survey, may be of interest to some of my readers.

Silica, SiO_2	69.56
Ferric Oxide, Fe_2O_3	2.65
Alumina, AL_2O_3	15.38
Manganese	Trace
Lime, CaO	1.76
Magnesia, MgO	Trace
Sodium Oxide, Na_2O	5.38
Potassium Oxide, K_2O	4.31
Loss on ignition, CO_2, moisture	1.02
Total	100.00

Figure 18, is a view of a part of Barre and in the foreground, some of the granite "sheds" where the rough stone brought from the quarries is cut and polished.

Vermonters need not be told that the greatest granite interests of the state are those at Barre. From the country village of twenty years ago Barre has grown into a most thriving and active city. It is preeminently a granite city, for this is the one all controlling interest. There is probably no place anywhere in the world where so large quarrying or stone cutting operations are carried on within an eqeal area. Barre is not only the principal granite center of the United States, but I think of the world, and it is rapidly becoming greater. Within a radius of a very few miles there are, in and about this place, according to the most accurate reports that I can obtain, fifteen hundred men employed as cutters and polishers, eight hundred or more in the quarries, besides blacksmiths, tool sharpeners, teamsters and other workmen, more or less directly connected with the business. It is easily seen that such an army of workmen with their families, must be an important part of the population of the place and con-

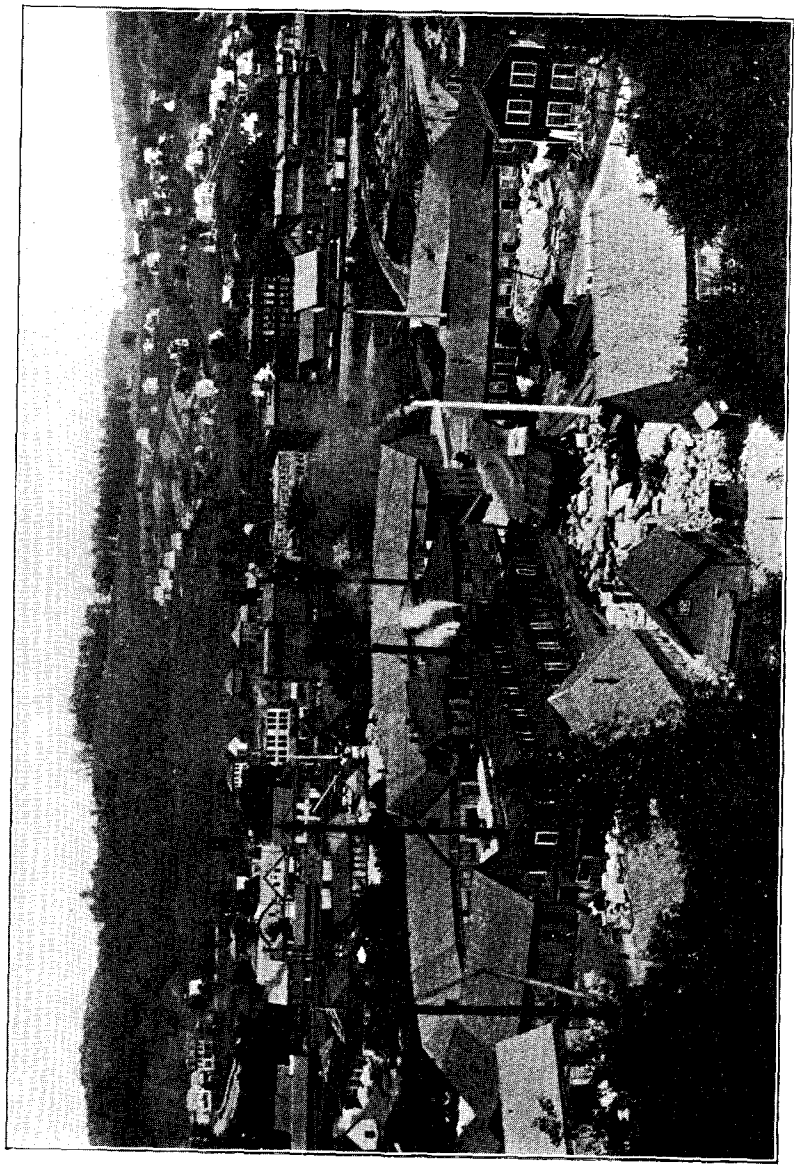

FIGURE 18. SOME OF THE GRANITE WORKS AT BARRE.

tribute very largely to its general business. It is also important to remember that all this increase of wealth and population has come to the state solely through the development of the formerly valueless granite ledges. Nothing of the slightest value in its original condition has been taken out of the state. This granite is of little or no value in its natural bed. The value consists almost wholly in the labor expended in getting it out and dressing it. Hence the gain to the state is wholly gain, and a great gain it has been already, and no one can visit Barre, its granite mills, sheds and quarries without carrying away the strong conviction that the end is by no means reached, but that the future will see yet greater things.

While the cutting, finishing, etc., are mostly done in the mills, or "sheds" at Barre, the quarries are all some four miles east of the town, at Graniteville, Williamstown and East Barre. Figure 19 is a very good view of one of the larger quarries.

How many quarries are now in operation at this locality, I do not know. It is estimated by the quarry owners that there are nearly a hundred, large and small. Most of the stone, however, comes from a much smaller number. About twenty companies supply the larger part of the Barre granite. Most of these companies, however, work several quarries. The quarries are none of them very deep, some are eminently surface quarries. The stone can be used from the start in the ledge so that the expense of opening a granite quarry is much less than that of starting a marble quarry. In the latter case, a large amount of surface stone must be gotten out and dumped before good stock can be obtained, and, of course, this involves no small expense before anything can be realized from the sale of stone. As a rule, which, however, has exceptions, the upper layers of granite are lighter than those farther down.

At Graniteville, the quarries extend along a ridge in a northerly and southerly direction almost continuously for about two miles, the width of the worked area being about half a mile. The quarries vary greatly in size and to a less degree in character. Some cover only a small area, others five, eight, or even

FIGURE 19. GRANITE QUARRY OF WELLS, LAMSON & CO.

FIGURE 20. GRANITE TEAM DRAWING STONE FROM THE QUARRY.

ten or twelve acres. A railroad has been built from Barre to the quarries which, though only a few miles in length, deserves to be classed with the scenic lines of the country for the grade is very steep and, in consequence an, elevation is soon gained that allows of very extended and very beautiful outlooks in different directions. The greater part of the granite is conveyed from the quarries to the cutting and finishing works or to shipping points, by this road, which has branches running directly into some of the larger quarries, but in course of a year many tons are carried down by teams like that shown in figure 20. As the grade from the quarries to Barre is descending, large loads can be drawn.

For figures 19 and 20, I am indebted to the Cummings Printing Company, St. Albans.

The great demand for monumental work in granite, has caused the Barre companies to bring into their service workmen capable of the best grade of work. It is not too much to say that many of these companies are able to take the rough block of stone from their own quarry, and in their finishing works, transform it into a monument that will well bear comparison with any in the country. As showing two of the best examples of this, I have made use of the accompanying figures.

The Burns monument which stands in Barre is made wholly of the local stone, was carved by Barre workmen and given to the city by the granite workers. It shows not only the excellence of the carver, but also, and it is mainly for this reason that I have introduced the illustrations of it, the possibilities of the granite. Figure 21 shows the monument as a whole, giving the front and right side.

Figures 22, 23 and 24 give larger views of three of the panels on the base and show better than the view of the whole, the character of the carving. The scene on the front of the base is the Cotter's Saturday Night, the titles of the other three are given beneath the illustrations.

For the use of figure 21, I am indebted to Mr. E. W. Cummings, Barre. For figures 22, 23 and 24 to the Burns Club, Barre.

FIGURE 21. BURNS MONUMENT, BARRE. The entire monument is made of Barre Granite.

FIGURE 22. TAM O'SHANTER.

FIGURE 23. THE BURNS COTTAGE. PANELS CARVED IN GRANITE ON THE BURNS MONUMENT.

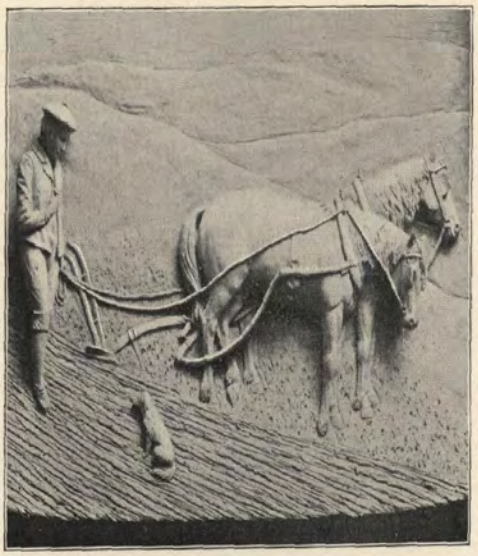

FIGURE 24. BURNS AT THE PLOW. PANEL ON THE BURNS MONUMENT.

Figure 25 shows a monument placed in a cemetery in Louisville, Ky., by Barclay Bros., which is also a fine specimen of both stone and work.

The bedding in the Barre quarries varies greatly from quite thin to very thick. There is often a considerable range in the same quarry, though some quarries are as a whole thin bedded while others are thick bedded. In some of the quarries the layers of stone are remarkably even, extending for many feet with very little variation in thickness or quality. Here, as at some of the Woodbury quarries, there seems to be no limit to the size of the blocks that can be quarried other than that of the ability of the workmen and derricks to handle them.

I saw in one of the quarries a block which had been detached from its bed and, therefore, in a condition to be moved if needed, which was sixty feet long, seven feet wide and six feet thick, and it would have been entirely practicable to get out many other blocks as large, had they been wanted. Out of the block in question, there was to be cut a shaft forty feet long and the rest cut off.

FIGURE 25. MONUMENT OF BARRE GRANITE.

Figure 26 shows a rather thin bedded quarry in the background, and on the cars is one of the longest shafts ever quarried in these quarries.

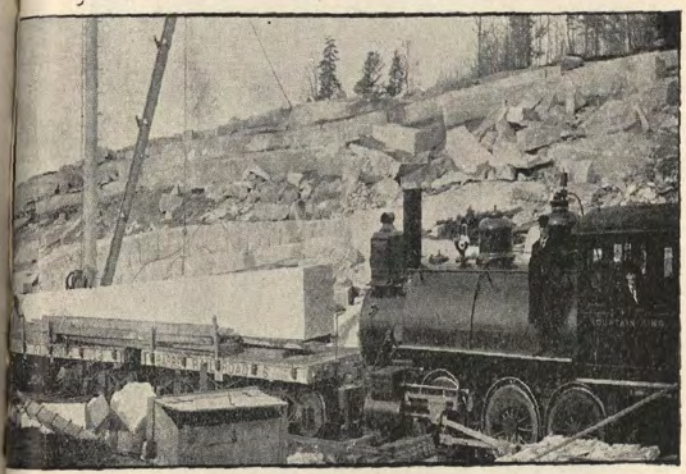

FIGURE 26. QUARRY OF WETMORE & MORSE, BARRE.

Figure 27 shows a moderately thin bedded quarry. In the foreground is a large mass quarried for the roof of a mausoleum.

I have not yet traced the granite belt in which the Barre quarries are situated northward, but I think it very probable that the quarries at Woodbury are in the same belt. At any rate the stone is similar in the two localities and there are quarries at Calais which is between Barre and Woodbury. There are at present about a dozen quarries in operation in Woodbury and numerous finishing works in Woodbuury and Hardwick, especially the latter place where most of the stone quarried in Woodbury is dressed. Like the Barre quarries, these, for the most part, report good and increasing business. There is a railroad which runs from the St. Johnsbury and Lake Champlain Road through Hardwick and Woodbury to the quarries by which the stone can be conveniently brought to the main line for shipping in the rough or to the sheds for cutting. While this region can probably never equal Barre in the extent of its granite business, it nevertheless seems certain to become an important center for the production of the stone. Figures 28 and 29 show one of

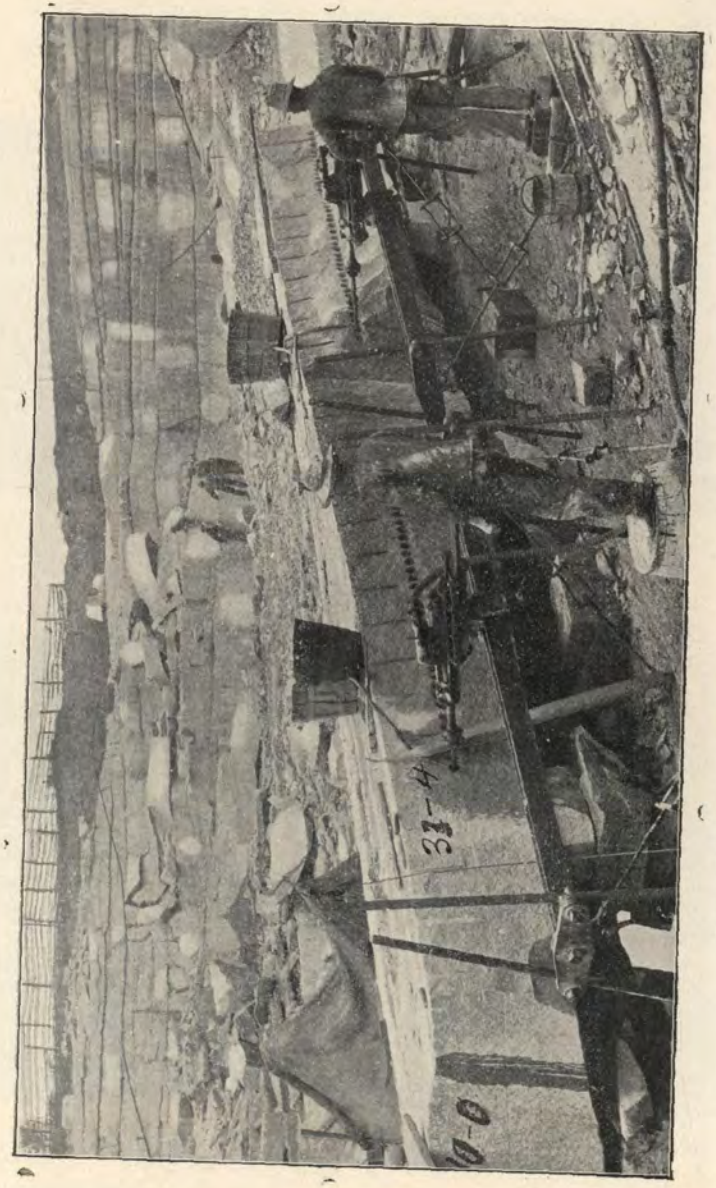

FIGURE 27. ONE OF THE QUARRIES OF E. L. SMITH & CO., BARRE.

the Woodbury quarries, that of the Woodbury Granite Company. This quarry, like others at Woodbury, is located on the side of a small mountain which appears to be largely composed of granite. The equipment of this quarry is reported as follows:

"A derrick capable of lifting 50 tons, operated by steam power both for lifting and turning; a derrick capable of lifting 25 tons, operated in the same way ; two other smaller derricks operated by steam power, and one of the largest and most powerful locomotive cranes manufactured by the Industrial Works, Bay City, Mich., capable of switching five cars and lifting twelve tons, and is operated on the tracks in any part of the quarry. The quarry is also equipped with steam drills, both large and small sizes, and in fact with everything in the way of machinery to facilitate the quarrying and handling of blocks of granite of any size required. The sheets have been opened in an unusual manner in the last few months, and are now at work on four large sheets which lie one above the other. These sheets vary in thickness from 12 to 25 feet. Among the long breaks that have been made during the past season is one in a sheet 15 feet in thickness back 30 feet from the edge and 200 feet long ; another fully 300 feet long, back from the face 12 to 15 feet and in a sheet from 15 to 20 feet thick. These breaks can be made at almost any time, and nearly all of them are capable of being extended when required."

The quality of the Woodbury granite appears to be equal to that found in any other locality. Some of the companies here report that their business has increased fifty per cent since 1898.

The only quarries with which I am acquainted, which are located in Hardwick, are those of the Standard Granite Company. These contain several varieties of granite, from very light to dark and is of good quality.

In the town of Sodom there are several granite quarries in operation. Some of these are increasing the equipment and expect to greatly enlarge their output the coming year. The stone from these quarries is reported to sell readily when placed upon the market.

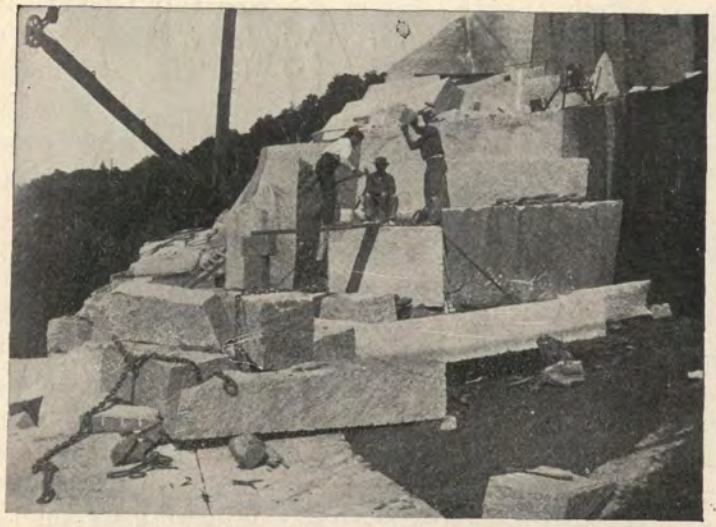

FIGURE 28. QUARRY OF THE WOODBURY GRANITE COMPANY.

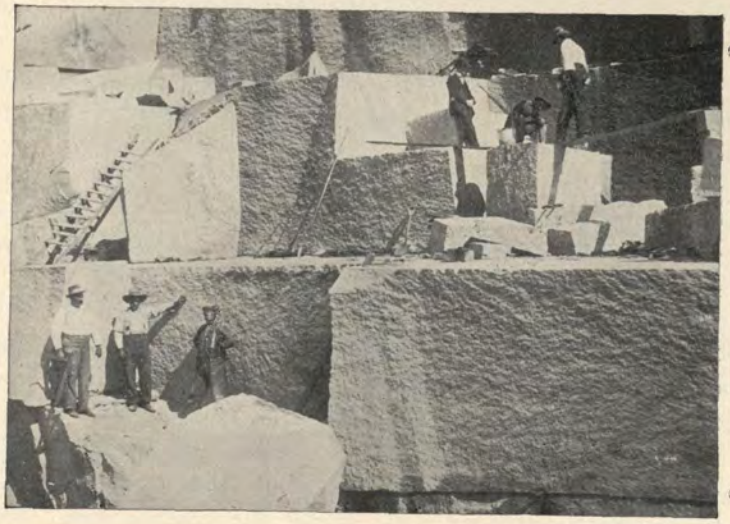

FIGURE 29. QUARRY OF THE WOODBURY GRANITE COMPANY.

The Pine Mountain Granite Company of Groton have done some work during the past two years, and their quarry is being vigorously worked the present season. Pine Mountain is two hundred feet high and is over a hundred acres in superficial extent and contains a large supply of good granite. It is on the border between Groton and Topsham and the quarry is in the latter place. The stone from this locality seems to be of good quality, both light and dark, fine grained and coarser grained. Granite has also been quarried at Ricker's Mills, though not on a very large scale.

At South Ryegate, The Blue Mountain Granite Company has done some quarrying, and also at Topsham.

In Kirby, the Kirby Mountain Granite Company has within a few months opened a quarry and is pushing work on a large mass of stone.

In the extreme northern part of the state, the Standard Granite Company has recently opened a quarry formerly worked, but not for some years, at Beebe Plain.

The largest granite company outside of Barre is the George E. Lyon Granite Company, the office of which is at Brattleboro, but the quarry is at West Dummerston. A small illustration of this quarry may be found in the last Report, but it only imperfectly shows the character of the deposit. The quarry is a peculiarly long one and is situated directly on the side of a small mountain, It is what is called a sheet quarry and is most conveniently located, the stone being easily quarried and loaded on cars directly from the ledge. This is, however, true of a number of other quarries in the state. As in many of our quarries, there are found here both light and dark granite. The layers of granite are from one to twelve feet thick, and of the best quality. The quarry is well equipped, having thirteen steam derricks, five 20-horse power and one 50-horse power engines, steam drills, etc. The stone is taken from the ledges by an overhead trolley which can carry twenty tons per load and is capable of loading, hoisting and carrying six hundred tons a day.

About three miles from the village of Bethel there is a deposit of granite which has in past years been considerably worked, but not to a very great depth. It is a particularly thin bedded deposit, though very likely, if the deeper layers could be reached, they would be thicker. There is a great variety seen in the different layers, some of them being very coarse grained while others are finer and some very fine.

It is said to be a very durable stone and foundations of houses in the region may be seen that are perfectly sound which were put in over seventy years ago.

The Windsor Green Granite Company, the office of which is in Montpelier, have for some seven or eight years quarried a fine dark green syenite on the steep northern side of Mt. Ascutney. The quarry is high up on the mountain and the stone must be drawn by team down a steep descent for a mile or two and then three or four miles to the railroad. This stone is dark olive green and black. I know of no other quarry like it in the state.

The stone is not a true granite, but a syenite, the mica of granite being replaced by hornblende. It is, on this account, a harder stone than granite and takes a very fine polish. The best example of its use for interior work, is seen in the new Library of Columbia University. Here the great central dome is supported by columns of the Windsor "Green Granite." These columns are eighteen feet high and three and a half feet in diameter, though each is in several pieces. At present the quarry is being moderately worked, some three or four thousand feet of stone being annually taken out.

This stone is apparently of volcanic origin, as was noticed some years ago by Prof. Hitchcock. Mt. Ascutney is, at its highest point, about two thousand feet above the valley and somewhat more than three thousand feet above the sea level. The highest cone of the mountain is largely made up of the syenite flanked by schists and slates. According to Prof. Hitchcock, these adjacent rocks have been changed by the heat from the eruption of the lava which hardened into the syenite, for

five hundred feet away from it. What this means is that at some time in the past, the mountain was an active volcano and that then the great mass which is now being quarried, was raised from the depths of the earth as molten lava.

SOAPSTONE, STEATITE.

This substance occurs in many localities in the state. It has been quarried to some extent in Waterbury, Athens, Bridgewater, Bethel, Cavendish, Marlboro, Newfane, Plymouth, Rochester, Townshend, Waterville, Windham and some other places, besides those to be mentioned more fully.

At present only a few quarries are in operation and these are all in a limited area. Beginning at Ludlow, the most northern quarry is a short distance south of the village. This quarry is practically a new one, though some work was done on the same deposit some 18 years ago. The quarry is now worked by Williams & Co. and, at the time I saw it, was well equipped and was being vigorously operated. A very promising bed of stone was exposed and large blocks were quarried. Near the quarry a steam mill was cutting the blocks into slabs, ordinary marble saws being used. Following the Black river for several miles, we come to the next soapstone quarry at Perkinsville. There are really two quarries here, for, just south of that now worked, there is an abandoned quarry from which a large amount of stone must have been taken in former times. The quarry now worked is said to have been in operation for fifty years or more. Indeed, it appears to have been more actively worked formerly than now, for Mr. Hager, in the Report of 1861, says that in 1859 about eight hundred tons of stone was taken out of this quarry which, I should think, is a larger amount than is now quarried, though I have not been able to get a definite report from either this quarry or that at Ludlow.

This quarry is at the top of a hill a mile perhaps from the village, near Baltimore. In the village there are two steam mills where the blocks drawn down from the quarry are sawed and made into sinks, tubs, etc. Here, instead of marble saws, toothed

saws are used, the stone being considerably softer than that at the Ludlow quarry. Still the stone quarried at Ludlow is some of it cut into slabs here, as is that from the quarry at Grafton. The deposits of soapstone in Grafton and the adjoining town of Athens have been worked longer than those at Perkinsville. It is interesting to note that at first the soapstone was quarried and used much as if it were limestone or marble, for door sills, mantels, window caps, fireplaces and hearths, etc. For these purposes, the stone was gotten out at this locality more than eighty years ago. Although the softness of soapstone renders it more liable to injury than if it were harder, yet it is durable for inside work and the great ease with which it can be sawed or cut more than compensates, in many cases, for the softness.

Soapstone has also been quarried during the year at Chester. For some time soapstone was quarried at Cavendish, the quarry being on the road from Ludlow to Proctorsville. It is reported that a large amount of stone was taken out at this place and ground to be used in "asbestos" paint. The amount of soapstone quarried in the whole country is not large and I have not succeeded in ascertaining what portion of it comes from Vermont. In the Report of the United States Geological Survey on MINERAL RESOURCES for 1898–99, seven states are named as producers of soapstone, but Vermont is not one of them. This state, however, has for many years, as has been shown, produced this stone. Blanks were sent to all the quarries now worked in the state, but no reply has been returned from any of them, so that I cannot give the present production. The last statement which I am able to find gives the production in 1880 as worth $20,000.

Soapstone is a compact form of talc. When the mineral is less compact, and especially if it is foliated or fibrous, it is recognized as talc. Talc occurs in all parts of the state, there being over thirty localities. In several of these localities some attempt to mine talc has been made, but with discouraging results. The only mine which has ever amounted to much is that of the New

England Talc Company. The office of this company is in Worcester, Mass. The mine is in Stockbridge, about twelve miles from Bethel and three miles from Stockbridge village. This mine has been quite extensively worked by tunnelling into the deposit which is situated on top of a high and steep hill. Near the entrance to the tunnel there is an engine and machinery for grinding the mineral. There is also a very efficient overhead trolley by means of which the mineral can be easily sent down to the foot of the hill where it can be readily loaded on wagons.

At the time I visited this mine no work had been done in it since spring, 1899. Just what is the real reason for stopping work at this mine no one seemed to know. In the vicinity other beds of talc have been opened to some small extent, but no work of any importance has been done upon them.

KAOLIN.

Beds of kaolin are found in Monkton, Brandon, Wallingford, Bennington, Plymouth, and other places in the state. The principal beds that have been worked are those at Monkton and Brandon. Kaolin is used largely in the manufacture of china and other earthenware, and also for fire bricks. It also furnishes an important part in some kinds of paper.

At present the only bed of kaolin which is worked is that of the Monkton Kaolin Company. The office of this company is at Vergennes; the clay is dug at the Monkton bed.

OCHRE.

Beds of ochre occur in the vicinity of some of the beds of iron and also of kaolin. During past years and in some cases until recently, these beds have been worked, but none are now in operation. In 1880 the ochre produced in the state amounted to 1750 tons valued at $27,750. In 1890 this amount had declined to about one fourth of the above, and since then the production has wholly ceased. The principal beds of ochre in the state are at Brandon, Shaftsbury and Bennington, though there are others of less importance.

The Rutland Fire Clay Company is doing a considerable business in digging clay which is prepared for use as lining for stoves.

The Pike Manufacturing Company of Brownington quarry a sort of quartzite which is made into scythe stones. The quarry covers about two acres and is twenty feet deep.

THE STATE CABINET

As Curator of the State Cabinet I have the honor to report as follows:

During the past two years the collections which were in the cases when I took charge of them have been very largely rearranged so that all allied forms are found together and a considerable number of new specimens, mostly such as were needed to complete series, have been purchased. Quite a number of specimens, some of them of much value and interest, have been given to the Cabinet.

Both in the arrangement of specimens and the selection of additions, I have constantly had in mind the fact that a great number of school children, as well as older persons, visit the Cabinet not merely to glance over the cases, but to study some group of animals or minerals. Hence it has been my aim to make the collections as useful as possible to these student visitors who often come with note books and who must surely carry away some information which they have gained from the specimens seen. I doubt if the people of the state realize the educational importance of the State Collections. They contain many valuable objects, but this alone would simply mean that here is a place of deposit where rare or interesting specimens may be cared for and preserved. Such a depositary the State Cabinet should be and is, but its educational value consists especially in the fact that during the year a very large number of persons of all classes and ages come to the rooms in which the collections are exhibited.

No count of the visitors during a fixed time has been made, but in course of a year several thousand spend more or less time in the Cabinet rooms.

The collections are first of all collections of Vermont objects, designed to illustrate the animal life and mineral wealth of our own state, but, as many very attractive and interesting objects are not found in Vermont, it has been considered wise to supplement in some limited measure our native animals and minerals by specimens illustrating groups not represented in a collection of Vermont specimens.

The collections themselves are of no inconsiderable value and deserve better accommodations. The two rooms devoted to them are too small and not well lighted. In any but the brightest days it is quite impossible to clearly distinguish the contents of many of the cases. If placed in larger and better lighted rooms the specimens would make a far finer appearance. A descriptive catalogue of the various objects displayed in the different cases would be of great assistance to those who desire to gain the utmost profit from an inspection of the museum and such a catalogue is already in process of preparation and it is hoped will be published as soon as completed. No such catalogue has ever been issued and, in lieu of it, the following brief summary of what is to be seen in the rooms will be of some assistance.

The south room contains the birds and mammals of Vermont, with only a very few from outside the state.

So far as is possible, the specimens are arranged according to the modern classifications. Most of the specimens are exceptionally well set up. In all, there are over three hundred birds and fifty mammals. Among these there are quite a number which could scarcely be duplicated, such as the Golden Eagle, Mocking Bird, Sand Hill Crane, Cross Fox, Silver Fox, Beaver, Otter, Panther, Seal and other species which are either extinct in this state or exceedingly rare. Of course all of the above are, at least now and then, taken in other regions, but these are all Vermont specimens.

On the walls of both rooms there are some fine heads, four of which, the Elk, Big Horn or Rocky Mountain Sheep, Black Tailed Deer, and Antelope were given by Dr. W. S. Webb who shot the animals in the west. There is also a recent addition of a fine head of a Moose which was shot near Island Pond. And this is the first Moose which has been killed in the state for many years.

In the north room there are, on the left near the door, fine specimens of the building and ornamental stones of the state, the marbles, granites and slates. Of these the series is nearly complete and many of the specimens are in the form of cubes about eight inches on each side. These show polished, hammered, sawed and rough faced surfaces. About the south wall of both the lower floor and the gallery, there is a nearly complete series of the rocks of Vermont collected by the Geological Survey of many years ago.

Other cases contain a collection of Vermont minerals including the metallic ores found here. It is the intention of the Curator to make this collection complete as soon as possible.

In the northeast corner of this room a case has been arranged with specimens illustrating the main groups of the whole animal kingdom with particular reference to the needs of those pursuing nature studies in the public schools. It is thought that a careful study of this case will be found very instructive.

On the right of the door as one enters, there is a very good series of about a hundred crania of mammals and a few of birds and fishes.

At the east end of the room is a case which contains Vermont fossils. This series is not yet complete, but there are some very valuable and fine specimens, especially of the Cambrian fossils, some of which are figured in the Report of 1861.

In cases near the north and east windows are birds eggs, about a hundred species being shown.

In the case which stands in the middle of the room, there is a small, but very interesting and valuable collection of Vermont Indian Relics. These are mostly of stone, but there are a few of copper and shell.

Underneath this case are drawers filled with insects, mostly butterflies and moths. Of these there are about five hundred mounted on the Denton tablets. The specimens on the south side are nearly all from Vermont or at least from New England, while on the north side, the drawers contain a fine and most brilliantly colored series of East Indian and South American species.

Perhaps not as attractive to the general public as many other specimens, is the skeleton of a fossil whale which is mounted in the long case just under the gallery. This most interesting specimen was dug up in Charlotte in 1849. Only one other has been found. This was in Canada. The skeleton is nearly perfect and is of the greatest geological value. In the same case are parts of two tusks of fossil elephants, Mammoth, one found at Mt. Holly, the other at Brattleboro.

Above this case is one filled with corals, some of which are very fine. In the middle of the south wall is a case of alcoholic specimens of Vermont Reptiles, nearly all the species found in the state being represented.

It is to be regretted that the limitations of the space allotted to the Cabinet necessitate the placing of such a variety of groups together, but it is the best that can be done under the circumstances.

The rooms are open every week day throughout the year and visitors are always welcome as are also gifts of specimens.

Respectfully submitted,

G. H. PERKINS,

State Geologist.