REPORT ON THE GEOLOGICAL SURVEY OF THE STATE OF VERMONT

1858-1859

Edward Hitchcock

REPORT

ON THE

GEOLOGICAL SURVEY

OF THE

STATE OF VERMONT,

BY

EDWARD HITCHCOCK,

STATE GEOLOGIST.

BURLINGTON:
DAILY TIMES OFFICE PRINT.
1858.

REPORT

ON THE

GEOLOGICAL SURVEY

OF THE

STATE OF VERMONT,

BY

EDWARD HITCHCOCK,

STATE GEOLOGIST.

IN SENATE, Nov. 2, 1858.

Communicated by the Executive, laid on the table; and, *Ordered*: That 1000 Copies be printed for the use of the General Assembly.

(Attest,) CLARK H. CHAPMAN, Secretary.

BURLINGTON:
DAILY TIMES OFFICE PRINT.
1858.

HON. BURNHAM MARTIN,
President of the Senate.

SIR:

I have the honor to transmit to the Senate, for the use of the General Assembly, the Report of Rev. Edward Hitchcock, State Geologist.

HILAND HALL.

EXECUTIVE CHAMBER,
November 2, 1858.

REPORT ON THE GEOLOGICAL SURVEY.

To His Excellency, Ryland Fletcher,

Governor of Vermont.

Sir :—

Agreeably to my instructions, I have the honor to present my Second Annual Report, as State Geologist.

Like the last, this Report will be brief, and consist of a statement of what myself and assistants have been doing during the year, with suggestions as to the future. I have supposed it to be understood that we should not attempt to give any detailed description of the rocks of the State, till our Final Report. Our time has been occupied in obtaining materials for that Report, and we are now ready to enter upon its preparation.

Last year, I suggested the desirableness of pushing the Survey with so much energy, that the essential part of the explorations abroad should be completed by the present time; and I pledged myself that this should be done, if the annual appropriation were increased to fifteen hundred dollars. As this was not done, the question came up, Shall we, nevertheless, attempt to accomplish an object so desirable? We knew that the usual appropriation of one thousand dollars would probably have been entirely exhausted by our expenses, leaving nothing for services, either to myself or assistants. We determined, however, to take this course, not doubting that we might depend on the liberality and generosity of the State as to a compensation, provided its Legislators shall see evidence, in our reports and collections, that we have been faithful in the work. Two and sometimes three parties have, therefore, been in the field during most of the summer. We entered into an arrangement with the Rev. S. R. Hall, of Brownington, who was early associated with Professor Adams in the Geological Survey, to go over the

three northern sections, giving special attention to the north-east part of the State, which had never been but imperfectly examined. For this service he is to receive the moderate sum of seventy-five dollars ; and as he is quite familiar with the geology of the State, especially its northern part, he was requested to extend his report as far south as he should choose, and present some views upon Agricultural Geology ; although that subject was not included in my commission.

The rest of us have been employed in reviewing and finishing the sections commenced last year, and in measuring several new ones ; so that fourteen are now completed. The specimens collected for the State Cabinet now amount to several thousands : the exact number we cannot specify, because the room in the new State House, where they are to be displayed, is yet unfinished ; and therefore, the specimens, though chiefly sent to Montpelier, are still in boxes. We have, also, been endeavouring to fix more accurately the outlines of the different rocks, on the Geological Map, and to look up new facts of economical importance.

We have, likewise, made some progress in that most difficult of all the problems in Vermont Geology, to determine what the rocks were before they were metamorphosed. It is not very difficult to give an appropriate name to these rocks in their present condition, but every careful observer finds that they have, almost without exception, undergone important changes; and the inquiry is, What were they before the change ? Or, to make the question, more specific, Are the non-fossiliferous rocks of Vermont merely the fossiliferous strata of New York metamorphosed ? And if so, Can we identify the varieties of the crystalline rocks of Vermont with those of the New York series ? It may seem of little practical importance to determine such points. Yet in fact, questions as to the useful substances that may be expected to occur in particular rocks, can sometimes be answered only by tracing them back through the mazes of metamorphism to their origin. We hope to be able to do this to some extent; but in some cases, with the light we now have, the identification will be little better than conjectural.

It will be needless to go into detail as to all the points to which our attention has been directed, during the year. The result of the whole is, that by our extra efforts we feel prepared to enter upon the preparation of a Final Report. We cannot, indeed, settle all the scientific questions that relate to the rocks ; but we hope to be able to give a fair view of them. So far as their economical value is concerned, we trust we have the materials for its full elucidation ; and this we suppose to be the chief object of the survey. We hope, also, to present not a little that will be interesting to the enquiring and scientific.

I do not mean that there are no points in the Geology of the State which do not need further examination. We know of several such points, and of importance too, about which we are still very much in the dark. But the examination of those can be made while we are proceeding with the preparation of the Report. Other points, also, will doubtless suggest themselves as we get the specimens in their proper order, and as we transfer to paper the labours of the past summer.

The subjects that have received less attention than they deserve, are the following ,—

1. *The Mineral Springs.*—I should judge there might be ten or twelve of those, important enough to demand an analysis. But analyses cannot be made without expense, and hitherto we have had no money to devote to the mineral springs. A part of their analysis (the determination of the gaseous ingredients,) must be made at the springs, and a part in the laboratory. I think it could be done for about $8 or $10 for each spring, exclusive of traveling expenses, If the Government wish this work done, the Chemist of the survey will see that it is accomplished, without delaying the preparation of the Report.

2. *Analyses of other substances.*—In the course of the survey not a few analyses have been obtained ; but during my connection with it, no charge for them has been made, because I knew that no money could be spared for this purpose, It has been left, therefore, with the Chemist of the survey, to secure as many analyses as he felt willing to execute without compensation. But many substances remain without analysis, whose composition might be of great use, both economically and scientifically. I think that one or two hundred dollars would enable the Chemist to obtain the most important of these analyses.

3. *The scenery.*—I cannot believe that the citizens of Vermont will be willing to have a Geological Report appear, that does not contain at least a few sketches, of the fine scenery for which the State is so well known ; especially when those sketches can be taken where they will afford fine geological as well as scenographical illustrations. We have not, however, employed any one to make such sketches, for the reason specified under the last head ; although a competent artist is ready to do this work, charging only for his traveling

expenses. If fifty or seventy-five dollars were at our command, I think we might secure a least a dozen views, that would not only attract the tourist but the geologist.

I think, then, that 300 or 400 dollars would secure the accom plishment of the three objects above specified; I mean that sum as an extra appropriation. For I think the Government will see that the usual sum devoted to the survey will not be sufficient for the purpose. Whether the objects be worth the outlay, the Legislature must judge.

4. *Surface Geology.*—As the bearings of this subject are almost wholly scientific, we have not thought it proper to devote but very little time exclusively to it; but have, nevertheless, collected many facts in surface geology while at work upon things more essential. Yet the deficiences are numerous. We shall not be able, for instance, to map the terraces along but a part of the rivers; nor to give but a part of what we regard as sea beaches and sea bottoms, when the continent was under the ocean; nor to trace out only a few of the old river beds of a former continent. But we hope to present enough of all these and similar phenomena, to answer as specimens, and stimulate others to hunt up more. And we do not think it a sufficient reason for delaying our Report, because we might find a greater number by delay.

5. *The identification of metamorphosed rocks with known fossiliferous strata.*—I have already described the great difficulty of this work, yet we find, from year to year, that the leaves of the rocky volume are slowly opening, and the papyrus unrolling. I doubt not that, were the survey to be continued longer, each year would add something to our present imperfect knowledge. Yet perhaps the interest which we hope to awaken by what we shall present, may do as much as our continued labours.

6. *An examination of the regions bordering on Vermont.*—On the South, the Vermont rocks extend into Massachusetts and New York, and on the North into Canada. On the West and East the rocks of New York and New Hampshire are intimately connected with those of Vermont. It is fortunate that those of Canada, New York and Massachusetts, by means of the Geological Surveys that have been executed in those States, have been mapped. But, as every geologist knows, we ought to have opportunity to examine them for ourselves, in order to compare them with those of Vermont. Without such examination to some extent, indeed, no geologist would feel safe in deciding upon the character of the latter. The rocks of Canada, especially, ought to be examined; since the Vermont rocks extend into that province and are there less metamorphosed. But we have not done it to much extent. Indeed, the only explorations we have made out of the State, have been, to pass once to the top of the White Mountains, carrying thither one of our sections; and extending another a few miles West of Lake Champlain. Had we the means, most gladly would we make these border explorations; and we doubt not that the Vermont survey would reap the benefit.

In spite of these and similar deficiencies, I judge that the most important objects of a Geological Survey, which the State has had in view, are now so far accomplished that we may set about arranging our materials for a Final Report, provided that, while engaged in this work, we may be allowed to go abroad, occasionally, to get more light on certain unsettled points, and resolve other questions that will undoubtedly arise, when we can see all the specimens arranged in their true places in the State Cabinet, and attempt to transform our field notes to Sections and Maps. Several years more of exploration would, indeed, be necessary, to enable us to make a Report entirely satisfactory to ourselves. But we trust that we are sufficiently masters of the Geology of the State not to do discredit to ourselves, or dishonor to the Commonwealth.

I might allude to more personal matters, as a reason for entering at once upon the preparation of our Report. It is certainly desirable to do it while the Geological Corps is unbroken. For it has been understood that each man should report upon some particular department of the survey, and this has turned the attention of each one to his specified department, and he can probably do it more justice than any other person. I know enough of the plans of some of our number, to suppose that they do not feel able to devote more than one year more to this work; and the frailty of my own physical system admonishes me not to make much calculation upon the future for the performance of labour.

It is presumed the Government will wish me to present as definite a description and outline of the Report which we propose to make, as I am able to do. The following synopsis will give an idea of the work, as it at present lies in my mind. I would reserve the right, however, to modify its subordinate parts, should further reflection make it desirable.

Scientific Geology.

1. A brief outline of the leading principles of Geology; ex. gr., *a* Stratified and Unstratified Rocks; *b* Palæontology; *c* Surface Geology; *d* Metamorphosing rocks fully considered.

Rocks of Vermont.

1. *Stratified.*

1. Alluvium, or Surface Geology.

1. Drift.

a Common Drift; *b* Drift Striæ; *c* Embossed rocks; *d* Bowlders; *e* Crushed ledges; *f* Trains of angular Blocks.

2. Modified Drift.

a Ancient Beaches; *b* Terraces; *c* Moraine Terraces; *d* Old Sea Bottoms; *e* Ancient Glaciers, (their striæ and moraines); *f* Pond Ramparts; *g* Old river Beds; *h* Vallies of Erosion; *i* Clays; *j* Marl; *k* Peat; *l* Bog Iron Ore; *m* Wad, (manganese); *n* Fossil Marine Shells; *o* Fossil Cetacea; *p* Fossil Mammalia.

2. Tertiary Deposits: *a* Kaolin and coloured Clays; *b* Ochres; *c* Limonite, (brown hematite); *d* Manganese; *e* Fossil Fruits; *f* Brown Coal.

3. Silurian Rocks.

a Potsdam Sandstone; *b* Calciferous Sandrock; *c* Chazy Limestone; *d* Trenton Limestone; *e* Utica Slate; *f* Hudson River Group.

4. Metamorphic Rocks, schistose, slaty and massive, (probably Silurian and Devonian Rocks originally.)

a Gneiss; *b* Mica Schist; *c* Talcose Schist; *d* Argillaceous Slate; *e* Quartz Rock; *f* Hornblende Schist; *g* Soapstone; *h* Serpentine.

5. Hypozoic Rocks, (Laurentian); *a* Gneiss.

2. *Unstratified Rocks.*

1. Granite.

a Common; *b* Concretionary; *c* Conglomerated; *d* Porphyritic; *e* Graphic; *f* In Veins.

2. Syenite.

a Common; *b* Conglomerated and Brecciated; *c* In Dykes.

3. Porphyry.

a Granitic; *b* Trachytic.

4. Trap.

a Augitic; *b* Trachytic.

5. Dykes and Veins.

a Granitic; *b* Porphyritic; *c* Trappous; *d* Quartzose; *e* Calcareous; *f* Epidotic; *g* Metallic.

2. Economical Geology of the State, *or substances useful to the arts.*

a Limestone as a fertilizer; *b* as Cement; *c* as Marble; *d* Soapstone; *e* Serpentine; *f* Granite; *g* Flagging Stones; *h* Roofing Slate; *i* Iron; *j* Copper; *k* Lead; *l* Gold; *m* Chrome; *n* Nickel; *o* Titanium; *p* Manganese; *q* Iron Pyrites; *r* Ochres; *s* Clays; *t* Quartz; *u* Feldspar; *v* Brown Coal; *w* Whetstones; *x* Hones; *y* Marl; *z* Peat; *aa* Mineral Springs.

3. Detailed Reports.

1. On the Sections generally. By Charles H. Hitchcock.

2. On the three Northern Sections, with applications to Agriculture. By Rev. S. R. Hall.

3. On the simple Minerals of the State. By Edward Hitchcock, Jr.

4. On the Chemistry of the Survey. By Charles H. Hitchcock.

5. On the Economical Geology. By Albert D. Hager.

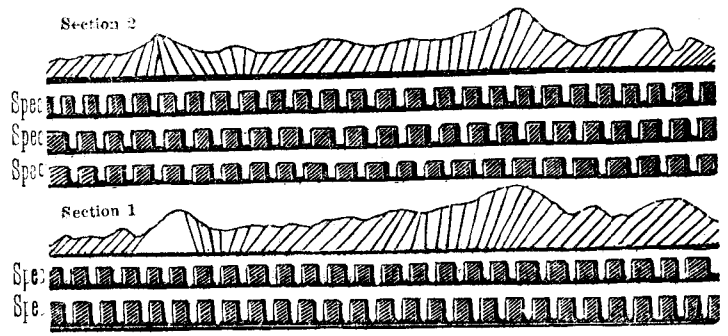
As to the size of a Report drawn up according to this outline, I think it would form a quarto volume of some 5 or 600 pages, perhaps some less—possibly larger. I must be more indefinite as to the number of Plates. There must be, first, a Map of the General Geology; next, a Map of the Surface Geology; next, 14 or 15 Sections, occupying, say three or four plates; next, (if possible to obtain them,) 10 or 12 views of Scenery, two of which might generally be put upon a plate, making six plates more. If it should be thought best to figure all the organic remains found in the State, as well as many of the curious concretions in the newer deposits, it would require quite an addition to the plates. But I judge that if we increase the number already mentioned, (say twelve), to twenty, it would be sufficient. That number might be conveniently bound with the text into one rather thick quarto volume. Besides these plates, I think that probably 200 wood cuts would be required.

I have made these estimates in the belief that the Government would wish to know what sort of a Report we have been proposing to make out. A smaller one, with fewer illustrations, might, indeed, be prepared. But I have presumed that Vermont, taking a prominent place as it does among the States, in its subterranean resources, and in the scientific interest of its rocks, will not wish to fall behind them in the manner of exhibiting its geology. I would, indeed, practice a strict economy in this matter. But I cannot believe that it will be creditable to the State, or in accordance with the wishes of its enlightened citizens, to bring out a meagre and stinted account of its geology; and such I think it must be, if on a much less scale than the above estimate. I am unable to state the cost of getting out such a volume; but from the details given, I presume that those familiar with such matters could determine the expense approximately.

I have another object in this attempt at definite statement; viz. to ascertain the wishes of the Government. For if they do not approve of our plan, we shall be glad to know it, and thus be saved much useless labour.

As to the time requisite for the preparation of such a Report as I have indicated, much will depend upon health, and the greater or less number of unsettled points we may find requiring re-examination. But it would be unreasonable, if I may judge from experience, to expect that such a volume could be got ready for publication, (should the Government wish to publish it,) in less than a year. If, however, they choose to refer the question of the publication of the Report to a Committee, with power to proceed with the work as soon as a part of it is ready, if they should judge it worthy, the work might be got out several months earlier than otherwise. This course has been adopted once or twice by the Government of Massachusetts, in similiar cases, and with such a result as I have indicated.

Allow me to make a few suggestions as to the arrangement of the specimens, collected by us, in the State Cabinet. I have been shown the room in the new State House, which is understood to be appropriated to this object, and I have supposed that without doubt the specimens of rocks illustrating the Sections, would be placed upon the walls. If the South wall and the West wall, as far as the door, were to be used for this purpose, I would suggest the following arrangement: Along the line of the Sections, it may be remembered, the greater part of the specimens were collected. Suppose we begin with Section No. 1, near the bottom of the wall. Let a space, say six inches wide, be marked across the wall, leaving room enough beneath the strip for one, two or three shelves, on which, in the order in which they were collected, all the specimens obtained on that section may be placed. In the strip above them, let the section itself be painted, each rock having its proper thickness and dip. Section 2nd may be placed in like manner immediately above section 1, and one, two, or three shelves be put beneath for specimens, according to their number; and so on till all the sections are placed upon the wall, one above the other. The sketch below will give an idea of this arrangement. I have never



seen one like it; but it seems to me as if a cabinet, thus arranged, would give visitors, at a glance, an idea of the Geology of the State, and enable them at once to determine what the rock is, in any particular district.

I know not how soon the room in the State House, appropriated to the Cabinet, may be so nearly finished that we can display the specimens in it, even upon the floor. If not till next summer, it may delay our Report, since we need to examine the specimens, lying in their proper order, before we are able to describe them. or discover deficiencies. If they must be kept in boxes till next year, I beg leave to suggest the expediency of obtaining an insurance upon them, which would be some consolation, should they share the fate of the previous collection. I think it a moderate estimate to say that the cash value of the whole cannot be less than $1500; though it would cost more than that, probably, to obtain another like it.

Our expenses, the present year, up to this time, have amounted to *Seven Hundred and Thirty Seven Dollars and Twenty-five cents.* This leaves a balance of $262.75 for compensation. I divided it between my two assistants, (A. D. Hager and Charles H. Hitchcock,) whose whole time is given to the work, making *One Hundred and Thirty-one Dollars and Thirty-seven cents to each.*

I have spent over six weeks in the field, this season, but shall present no bill except for expenses. As to compensation for services, I shall leave it to the liberality of the State, when the work is done. At this time, I ask only that the annual appropriation of One Thousand Dollars, which the Act for completing the Survey directs to be paid, " until otherwise ordered by the Legislature," be continued another year.

With high respect,

Obediently yours,

EDWARD HITCHCOCK.

Amherst, Oct. 12th, 1858.

PRELIMINARY REPORT

ON THE

GEOLOGY OF VERMONT

BY

EDWARD HITCHCOCK,

State Geologist.

PRINTED BY ORDER OF THE SENATE.

MONTPELIER:

E. P. WALTON, PRINTER.

1859.

REPORT.

To His Excellency, Hiland Hall,

Governor of Vermont:

Honored Sir:

I have the pleasure of being able, at last, to lay before you a Final Report on the Geological Survey of the State. A few preliminary remarks from myself, as the responsible head of the survey, seem requisite.

The history of this survey has been so eventful and extraordinary, that a volume might be devoted to it, which would be full of moral interest at least. It startles one to find that the first movement on the subject was made in the General Assembly as early as 1836. In 1837, Governor Eaton, then Chairman of the Committee on Education, made his able report on the subject, which was never lost sight of till the first act authorizing a survey was made in 1844. Professor Charles B. Adams, the first State Geologist, entered upon his duties in March, 1845. He made four annual Reports, which, in the aggregate, formed a volume of 399 pages, with illustrations. In 1853 Professor Zadock Thompson was appointed to take charge of the work upon the decease of Prof. Adams. He never made any formal Report, though in other modes he brought out many facts, which were the result of his researches; and the outline of his proposed Final Report, published by Judge Young, shows how wide

were his plans, and how valuable the final result would have been, had he lived. After his decease another attempt was made to carry forward the survey to completion, by the appointment of the Hon. AUGUSTUS YOUNG, as its principal. His feeble health prevented Judge YOUNG from much active labor in the field. But he published a valuable Report on the History of the Survey, in a pamphlet of 88 pages, and then he, too, died.

A fourth effort was made by the General Assembly to resuscitate and complete the work in the autumn of 1856, and I was requested to take charge of it. Meanwhile, during the following winter, another heavy Providential disaster fell upon the work, in the destruction by fire of the fine collections made by Prof. ADAMS and others: a ruin so complete, that probably not fifty specimens remain fit to take a place in the new Cabinet.

In view of so many calamities, I confess to have been somewhat affected by a feeling, which my judgment would call a superstitious fear, as if the frown of heaven rested upon the work, and that I too might expect to follow the triad of distinguished men who had been summoned away before the completion of the survey; especially as I knew my constitution to be apparently more frail than theirs. Yet I accepted the appointment, and through the kindness of Providence, have lived almost to the time when I can say that a Final Report is completed.

I apprehend that an impression is quite common, that there has been a want of competence or of integrity on the part of some who have had a part in this survey in former years, or of proper care on the part of those who had the lost collections in charge. But it seems to me that such a feeling is unreasonable and unfounded. With Judge YOUNG I had not the pleasure of a personal acquaintance; yet his Report on the History of the Survey is certainly a valuable document, and his plans seem to have been judiciously laid. With the two first principals I was not only personally acquainted, but on terms of cordial friend-

ship. No one familiar with Professor ADAMS' rigid adherence to scientific accuracy in every other enterprise, and his exact fulfilment of every promise to the very letter, could believe that he did not do his work thoroughly and faithfully; and though it might be more labor, as Prof. THOMPSON suggests, to decipher his hieroglyphic notes than to go over the ground anew, it was all clear as crystal to him, as would have been manifest had he made out his Final Report. Indeed, his annual Reports were above the average of such documents that have appeared in other surveys, and they contain a large amount of valuable information upon the Geology of Vermont, and upon general Geology. With such a preliminary, we shall feel authorized to pass over the general subject much more briefly.

Professor THOMPSON'S notes were kept with great neatness, distinctness, and accuracy: but after all, it is chiefly what he has published in his History of Vermont and elsewhere, that is of value. For the fact is, until a man has actually put down his facts and mature thoughts in writing or on Maps and Sections, his notes will be of no great service to those who come after him. At first, they are crude to himself, and it is not till he has gone through many tentative processes, and made many comparisons, that he gets a clear idea of the Geological structure of a country, or of its Zoology. The Appendix to Prof. THOMPSON'S History of Vermont, as I apprehend, gives us the first fruits of the Geological and Zoological Survey he had undertaken; and his plan, as given by Judge YOUNG, shows how rich the entire harvest would have been, had he been permitted to gather it in.

In fine, in looking back over the history of this Survey, I see evidence every where of eminent ability, untiring industry, economy and integrity in the principals and their able assistants; nor are the fragmentary results of their labors to be despised. If blame is to be imputed anywhere, it must be to the Providence

of God, which has so often sent death into the ranks of those who have been engaged in this work, and thus severely tried the patience of the people of the State by dashing their hopes so often, just on the point of realization.

In this point of view, this history, as I remarked in my report of 1858, is truly a melancholy one. Leader after leader has been stricken down, and calamity after calamity has fallen upon the work, and did not our duty to the living forbid, the impulse of our feelings would be to dedicate the results of our labors to the dead.

When this work was committed to my hands, it was obvious, that though prosecuted for ten or twelve years, it must be essentially commenced anew. For though a general idea of the geology of the State was obtained from an outline map left by Prof. ADAMS, as well as from my own cursory examinations, yet since the notes that had been taken were of little or no avail, and the specimens were destroyed, every part of the State must be visited again, to trace out the rocks and collect new specimens for another State Cabinet.

The plan I adopted was the following: I had ascertained that the formations were nearly lengthwise of the State. If, therefore, we could measure sections across the State, from east to west, at intervals of only a few miles, we should be able to fix the limits of the formations, ascertain the dip and strike of the strata, and by collecting numerous specimens along the sections and properly arranging them in a cabinet, a very complete view of the Geology of the State might be presented to occular inspection. The towns lying between the sections were not to be neglected, but examined with care, and sub-sections made whenever necessary. This plan has been carried out with a constantly increasing conviction that it was the best and most economical which we could adopt. We regret only that time and means do not allow us to review our work as much as

ought to be done to rectify the errors of first observation. But thirteen Sections have been measured, which are delineated in this Report, and illustrated by thousands of specimens in the State Collection.

After the receipt of my commission, the corps of assistants in the Survey was constituted as follows, with the approbation of Governor FLETCHER:

ALBERT D. HAGER, A. M., *Assistant.*

EDWARD HITCHCOCK, JR., A. M., M. D., *Assistant.*

CHARLES H. HITCHCOCK, A. M., *Chemist.*

It was understood that though I was to assume the responsibility of the whole survey, yet it would devolve upon my assistants to work out the details of the Sections, collect the specimens and the facts of economical interest, while I should visit the most important points, and go over the whole State so far as to feel satisfied that the results might be depended on. This has been done on their part, as I have reason to believe, with great ability, industry and success. On my part, some tangled spots of much scientific interest remain to be unravelled, which sickness, during the present autumn, has prevented me from visiting; and, indeed, to make the Geological Map what it ought to be, several spots must be more thoroughly examined, and several difficult scientific questions settled: so that I must still ask for the opportunity to make some further explorations, though they need not retard the publication of our Report, if that should be the disposition made of it. For all my experience in the publication of scientific Reports shows that months must elapse before a large quarto, with numerous illustrations, can be got through the press creditably either to authors and artists, or the State.

The work of exploration was commenced in the spring of 1857, by the measurement of the most southerly section by myself, in connection with A. D. HAGER and C. H. HITCHCOCK.

The two latter have devoted nearly their whole time to it ever since. The latter had, indeed, expected to devote the winter to a chemical examination and analysis of substances collected; but though the Act of the Assembly made this his duty, yet the appropriation was so small, that it was found, after the expenses of the summer explorations, that if chemical analyses were undertaken, which are necessarily expensive, even if the time of the chemists be reckoned as nothing, but little would be left even for a scanty salary to the assistants in the field. The next year the case was still worse: so that up to this time, since I have had charge of the survey, whatever analyses have been made, or in any way obtained by the Chemist, have been entirely gratuitous. But his time has been fully occupied in the geological part of the survey. Such has been the situation of my other son, EDWARD HITCHCOCK, Jr., that he has been unable to spend but a little time in the field, without making such sacrifices as could not be expected. He has done something, however, as will appear by our Report. We were so fortunate as to secure the services of Rev. S. R. HALL of Brownington, a well known assistant of Professor ADAMS, in connection with Professor THOMPSON, in the examination of the three most northern sections, and the collection of specimens. The results of his valuable labors will appear in our Report. I ought not to forget, also, the kind assistance rendered by Rev. C. A. WILLIAMS, who, not professing an acquaintance with Geology, joined us as an amateur, but ultimately rendered us important aid. Valuable facts and suggestions were also made to us by Rev. AUGUSTUS WING, of Stockbridge, a gentleman who has studied the Geology of the State with great perseverence and success. Nor can I omit acknowledging the many acts of kindness and generosity of JASPER CURTIS, Esq. of St. Albans.

The first act, pointing out the duties of the Geological Surveyor, included Agricultural Chemistry and Geology, and the

second act, Natural History also. These subjects were omitted in the act under which I was appointed, and wisely in my opinion, for each of them deserves to be made the object of a separate survey; and then they will receive the attention which their importance demands. I trust that Vermont will not rest satisfied till both of them have been accomplished.

Physical Geography is named among the objects on which we were to report. But to this we have been unable to give much attention. Most of the mountains of the State have indeed been climbed by us, and their heights, too, measured by the Aneroid Barometer, as well as that of a multitude of other points on the surface. But the grand object of these measurements has been to be able to show the true form of the surface on the sections. To fix the latitude and longitude of particular spots, and delineate the topography, would require costly astronomical and geodetical instruments, and more than the whole time which we have spent in the geological survey. It would in fact be a trigonometrical survey, which we hope will be made in Vermont, but which we could not undertake.

The main objects which we have aimed to accomplish are the following:

1. To gain such a knowledge of the solid rocks of the State as to be able to delineate them upon maps and sections, according to the established system of geological science.

2. To study the loose depcsits lying upon the solid rocks, and trace out the astonishing changes which the surface of the State has undergone; the whole forming what we call *Surface Geology*.

3. To collect, arrange and name specimens of rocks, minerals and fossils from every part of the state for the State Cabinet.

4. To obtain a full collection for the same Cabinet of specimens valuable in an economical point of view; embracing many that are smoothed and polished.

5. To identify the metamorphosed rocks of the State with those that have not been changed. This last point has been the most difficult of all; and yet in a scientific respect, a very important one: indeed, it is so economically. For until we can determine the true character of the rocks, we cannot tell what useful substances we may expect to find in them, and what ones we may not expect. And really, in my judgment, this is the most important use of a geological survey. It is not, as many suppose, to make discoveries of new substances that are useful, though this is occasionally done; but it is so to delineate the geological structure of the country, that practical men may be directed in their researches, and be saved from useless expenditures. Hence the value of a scientific description of the rocks, even of those parts that seem not to have much bearing upon the economical interests of a people: for we do know, that the most abstruse scientific principle often has a most important and unexpected practical application. On this ground it has been the practice in all our geological surveys to go into full scientific details. We do not feel that in such a State as Vermont, it is needful to apologize for trying to follow such an example, nor that its people will be satisfied with any thing short of a careful scientific exposition of its Geology. With the means and time at our command, it has been quite impossible to go into each town and examine minutely its Geology. We have hoped only to be able to delineate the great features of the geological structure of the State, and thus prepare the way for minute surveys of each town, should the inhabitants wish it done. This work has already been commenced, and we shall append to our report one of these town surveys, executed by Mr. HAGER by request of the people of Plymouth.

As to the character of the metamorphic rocks of Vermont, it is well known that eminent Geologists have not been agreed; that this has been a sort of battle ground for opposing theories.

It so happened that neither I, nor my assistants, had ever taken sides in this contest, or had made up our minds concerning it. We have gone through with the whole work, quite indifferent which side would be favored by the facts we should bring to light. To use a common but expressive phrase, *we have gone it blind*, in all our researches. We have, indeed, been satisfied that a mighty wave of metamorphic influence has swept over the State from north to south, increasing in intensity as it advanced. But whether the facts we present favor one theory or another, we hardly even yet know. Our main desire is that the facts may aid in the development of the truth.

To carry out such a plan as above indicated over an area of more than 10,000 square miles, every one must see to be a gigantic work for less than three years; and we fear that it will be thought only imperfectly performed. I confess that such is the fact; but hope we have laid a foundation on which a finished superstructure will ultimately rise. The main labor of measuring the sections, collecting the specimens, tracing out the formations, and collecting the statistics of mines and quarries, has devolved upon A. D. HAGER and C. H. HITCHCOCK, who have been indefatigable in their labors during the summer, and also in the winter so far as was necessary. Mr. HAGER, in accordance with his own wishes, was requested to give special attention to the economical geology, that he might report upon it. C. H. HITCHCOCK was directed to give special attention to surface geology, so as to be able, if possible, to map the terraces: also to take full notes upon the extent, dip and strike of the formations, that he might be able to mark them on the Geological Map, and construct the sections:—a work which I wished done under my own inspection, and therefore more convenient for him than for Mr. HAGER, although the notes of the latter, as our Report will show, were essential to the work. So, also, were those of Mr. HALL, as to the northern parts of the State. My elder son, E. HITCH-

cock, Jr., was directed to attend specially to the simple minerals and to the fossil mammals of the post-tertiary strata. He will, however, make no separate report, but merely describe these objects in their appropriate places in the general Report.

This Report, which I have now the honor of laying before your Excellency, will be made up of the following parts:

1. I would request that this preliminary letter from myself may stand at the head.

2. Joint Report on the Scientific Geology. This will be signed by myself and all my assistants, because all have been concerned not only in collecting the facts, but in describing them. I have, indeed, taken a leading part in the preparation of this report, but I have been dependent upon others for the details and most of the illustrations, and some of the leading descriptions. And in order that justice should be done to each one, I have attached the initials of my assistant's names to each of their contributions. Nay, where any facts have been referred to, as for instance, the dip and strike of strata, I have given the initials of the individuals who furnished them, whether one of my assistants or a previous geologist: for instance, C. B. A. for Prof. Adams; Z. T. for Prof. Thompson; A. D. H. for A. D. Hager; and C. H. H. for Charles H. Hitchcock.

3. Report on the Economical Geology by A. D. Hager. The facts in this report have been mainly collected by him.

4. Report on the Chemistry of the Survey by Charles H. Hitchcock. This brief report embraces all the chemical analyses that have been made from the beginning of the survey under Prof. Adams, amounting to one hundred and three. Of these, thirty-four have either been made or obtained during the present organization of the survey. Yet, as stated elsewhere, no money has been expended for them: they are all gratuitous.

5. Catalogue of 2800 specimens of rocks, 370 specimens of simple minerals, and several hundred specimens of organic remains collected by the present geological corps; all of which, excepting the fossils, have been arranged, ticketed and named, and are ready to be displayed in the State Cabinet. Great care has been taken to make the specimens just three inches square, where it was possible; and my assistants have been very successful in this operation; and when arranged in the new State House, according to my suggestions in my last Report, with the several Sections drawn above them, will present a very clear exhibition of the Geology of the State to every spectator. The Economical Collection has not yet been catalogued.

6. Report of Rev. S. R. Hall, specially on the three northern Sections, with a Report on the Agricultural Geology of the State. It is very gratifying that this gentleman, who, as assistant geologist, began a systematic exploration of the geology of the State fifteen years ago, and much earlier as an amateur, should have been willing to take up the work again, and especially explore the northeastern part of the State where the reign of the wild animals has hardly yet been much disturbed by man. And though my commission did not require any attention to agriculture, I felt confident that some remarks on that subject from one so competent would be acceptable.

I regret that our Reports are so imperfect, and that, especially the part I undertook, contains so many gaps; yet I have worked up to the very limits of my strength, and trust that enough is done to enable the Assembly to judge of the character of the work; and if they shall deem it worthy of publication, we ask liberty to take the Reports back to supply the deficiences and make corrections, before their final appearance. I still think that the size of the work would not vary much from the size suggested in my last report, viz: a quarto volume of 500 or 600 pages, with from 20 to 25 plates. This is the form for Reports in most of the States: witness, for instance, those of Massachusetts, New York, Pennsylvania and Iowa, in the State Li-

brary. After looking at these, I cannot believe that any inhabitant of Vermont would be willing to have the geology of his own State appear in a volume, reduced by important omissions, and got up in an inferior style. We are sorry that a few plates of scenery could not be added to such a volume, but the means were not in our power. We lament this deficiency the more in a State so remarkable for its scenery as Vermont. And also our inability to present any analyses of its mineral springs, and of some other important substances, especially when a few hundred dollars would have secured these objects. But having, last year, laid these points fully before the Government and received no response, I will urge it no more, although it might not yet be too late. We are free to confess that our failure here did produce a disheartening effect upon us; because, whether justly or not, we were led to infer from it that our labors were regarded as of small importance. But we presume the Government had good reasons for their course; and it became us not to complain, but to do our duty, as far as the means in our hands would permit.

The act of 1856 requires me to report annually as to the expenses of the survey, and to give an estimate of what is necessary for its completion. The act appropriates $1000 dollars annually, "until otherwise ordered." In 1857 the expenses were $332,10, the remainder I divided between my two assistants (A. D. H. and C. H. H.) whose whole time was devoted to the work, making the salary of each $333,95. In 1858 the expenses were $737,25. The remainder I divided as in 1857, making the salary of each, $131,37. I received no compensation in 1857 or 1858, nor has my other assistant, E. H.,Jr., ever charged or received anything save for expenses. The expenses of this year, up to the present time, are but $188. We have been employed chiefly in preparing our reports. I shall propose to my assistants to retain myself $300 of the residue, dividing the rest between them as

before. Though we have been abroad less, the last has been our hardest year; for while explorations abroad promote health, the confinement of the study has a contrary tendency.

As to the future, it seems hardly possible for us to bring out our report without visiting again a few spots, to settle questions of great difficulty, though this need not retard the publication of the report if the government order it to be thus disposed of. We are specially anxious to take a hasty glance at some of the rocks of Canada, which, as they have been so ably studied by Sir William Logan and his assistants, really form the key to those of Vermont. These things might be done while the process of publication is going on; for much experience in such matters has satisfied me that such a volume as above suggested cannot be got out, creditably either to authors, artists or the State, much short of a year. Should it be printed, we expect as hard a year's work as any we have had. But we mean to do all we can consistently to bring the work to an honorable conclusion.

In conclusion, allow me to express the hope, that though the people of Vermont may not realize all they had anticipated from this long protracted survey, yet when they look over the large array of facts which we now present, respecting the subterranean resources of the State, and see how many questions of deep scientific interest are here started and in part resolved, and how wonderful and even sublime have been the changes which the solid frame-work and the surface have undergone, they will feel that they have some return for their patience and perseverance in carrying the work through. As to myself, every year has deepened my impressions of the amount and value of the mineral resources of the State, and of the scientific interest connected with its Geology. The rocks of Vermont are the most difficult with which I have ever attempted to grapple; but they have taught me many a valuable lesson: and as to their economical value, I have been impressed with the following facts.

First and most important of all, we think we have discovered the reason why Vermont so excels all the other New England States in the agricultural capabilities of its soil. It is the existence, in almost all of her rocks, of lime in such a state that natural processes bring it out in just about the quantity needed by vegetation. This is the case in many parts of the State where the inhabitants hardly suspect the existence of lime, and those parts of the State most fertile are just the places where the lime is most abundant and decomposable. This is a treasure which Providence has hidden in the earth and provided for its elimination at the right time and quantity, and it is of far more value in my estimate than all the other subterranean wealth of the State, yet I had no suspicion of its existence and use till a late stage in this survey.

Secondly, most of the valuable rocks and minerals in Vermont run lengthwise of the State, and are thus made accessible to most of the inhabitants. This is the case with the granites, the marbles, the slates, the soapstones, the serpentines, the iron and the gold, to say nothing of others of less value.

Thirdly, these mineral treasures are inexhaustible in quantity.

Fourthly, they are of such kinds as will always be in increasing demand all over the country, as its population increases.

I cannot, therefore, but look upon Vermont as a giant, whose full proportions and strength are yet in a great measure undeveloped; and in this, which is probably my last literary labor, I cannot but pray that God would continue to prosper and bless a State so strong by nature and so rich in noble institutions!

Most respectfully submitted,

EDWARD HITCHCOCK.

AMHERST, Oct. 1, 1859.