Hitchcock, Edward, 1793-1864.

First anniversary address before the Association of American Geologists, at their second annual meeting in Philadelphia, April 5, 1841.

PROF. HITCHCOCK'S

ANNIVERSARY ADDRESS

BEFORE THE

ASSOCIATION OF AMERICAN GEOLOGISTS,

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SECOND ANNUAL MEETING

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PHILADELPHIA, APRIL 5, 1841.

BY EDWARD HITCHCOCK, LL. D.

Prof. Chem. and Nat. Hist. Amherst College; Geologist to the State of Massachusetts, and Chairman of the Association for 1840.

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ADDRESS.

GENTLEMEN OF THE ASSOCIATION:—It may be expected on this occasion, that I should give some account of the origin and progress of this society. The history is short. A number of geologists had for years been employed in prosecuting geological surveys in many widely separated states of the Union, and as they were bringing their labors towards a close, they felt a strong desire to compare notes with one another, that they might clear up points obscure in the districts which they had examined, but which might perhaps be fully developed in others, and that more uniformity might be secured in the final results. The gentlemen of the New York survey at length issued a circular, inviting those engaged in similar surveys in the other states, to a meeting in this city a year ago. The number that responded to the invitation by their attendance, was not large. But I am sure that I shall speak the unanimous opinion of all present, when I say that the meeting was most pleasant and profitable. It was highly gratifying for those, who had long been engaged in the same work in widely separated fields, and who knew one another only by reputation, to be able to exchange salutations, and hear one another's voices, and share one another's sympathies. Particularly important was it for those of us who are very much insulated from geological society and counsel, to meet those who could solve our difficulties, and by detailing the phenomena of their own districts, could throw light upon obscurities that hung over our own.

Under these circumstances, it is not strange that the present meeting should have been appointed; nor that we should have ventured to invite others to join us, who are engaged in similar pursuits, although not in the state surveys; and some of whom are our seniors in cultivating the noble science of geology.

As to the ulterior plans of this Association, I am not aware that any have been concerted, whatever may be in the minds of

individual members. It will be seen that their grand object is to develope American geology in a quiet and unostentatious manner. Whatever measures will promote this object, will meet, I presume, the support of the members;—and whoever has it so much at heart, that he is willing to engage in active and energetic labors to promote its advancement, will doubtless be welcomed to their fraternity. While they acknowledge their indebtedness to similar associations in Europe, for the example which they have set, and especially to the London Geological Society, the noble mother of them all; they do not aspire to be compared to any of them, until the fruits of their labors shall make such comparisons involuntary. They wish to be known only as an association of geologists, who love their favorite science so well, that they will pursue it with almost equal ardor, whether they are noticed or unnoticed, whether patronized or neglected. It is their motto,

Hoc opus, hoc studium, parvi properemus et ampli.

I propose, gentlemen, at this time, to sketch briefly the most important points in American geology, that require your special attention. In doing this, I must of course give some account of what has been already done in this wide field. And as far as possible, I shall treat both of these subjects together.

Until the commencement of the present century, almost nothing had been done by Americans to develope our mineralogy or geology. And until the year 1807, although mineralogy had begun to excite some interest, yet no effort worthy of notice had been made in geology. In that year, William Maclure commenced, single-handed, the Herculean task of tracing out and delineating the great features of our rock formations. This he at length accomplished; after crossing the Alleghany mountains in fifty places! This was certainly a most remarkable example of persevering devotedness to a favorite pursuit; and cannot but embalm his memory in the heart of every American geologist.

We must not presume from this isolated instance, that any correspondent knowledge of this subject existed at that time in our country. On this point we have the striking testimony of one, who is still among us in the vigor of ripe manhood, to witness the wondrous change which his own labors and those of others have produced. "We speak from experience," says Prof. Silliman, "and well remember with what impatient but almost despairing

curiosity we eyed the bleak, naked ridges which impended over the valleys that were the scenes of our youthful excursions. In vain did we doubt that the glittering spangles of mica, and the still more alluring brilliancy of pyrites, gave assurance of the existence of the precious metals in these substances; or that the cutting of glass by the garnet, and by quartz, proved that these minerals were the diamond; but if they were not precious metals, and if they were not diamonds, we in vain enquired of our companions, and even of our teachers, what they were."—*Am. Journal of Science, Vol. I, p.* 36.

I cannot, on this occasion, go into minute details of the labors, or even of the names of those, by whom this state of things in a few years was entirely changed. In 1810, appeared the Mineralogical Journal of Dr. Bruce: in 1816, the work of Prof. Cleaveland on Mineralogy and Geology: in 1818, the American Journal of Science was commenced by Prof. Silliman: a work which has always been an efficient instrument in promoting a knowledge of geology as well as other sciences; and which, by great efforts, has now reached its forty first volume. In this connection, the Monthly American Journal of Geology and Natural Science, by Mr. Featherstonhaugh, which reached only its first volume, should not be forgotten. The transactions of several of our scientific societies, especially of the Academy of Natural Sciences in this city, of the Lyceum of Natural History in New York, and of the American Academy of Arts and Sciences at Boston, have contained many most valuable papers illustrative of the geological features of this continent. An American Geological Society was formed in 1818: but it has accomplished little, except that it has a valuable collection of specimens and books, chiefly through the liberality of its president, William Maclure. The Pennsylvania Geological Society was organized in 1832, and published two volumes of its transactions. Several other societies in the country, of a more local character, have contributed essentially to the promotion of geology; and the recent organization of the National Institution for the promotion of science at Washington, and its vigorous commencement, promise much for this branch of knowledge.

But the feature in the history of American geology, to which I feel bound to call special attention, is the institution of state geological surveys by the civil authorities. I regard this feature

as peculiarly American, for I am not aware that any gene
vey of a large district, had been ordered in any other par
world, till after it had been done in this country. At a
sure I am, that it was entirely original with those who int
it here. North Carolina has the honor of having first di
survey of her territory. This duty was committed to Pro
sted, who made a report of one hundred and forty one p
1824 and 1825, upon the economical geology of the state
year following, South Carolina gave a similar commission
Vanuxem, whose report was published only in the news
An interval of five or six years succeeded, before Massac
engaged in the work. In 1830, she ordered a surve
1832, an annual report of seventy pages, and in 1833,
seven hundred pages, with a second edition in 1835, we
lished. In 1837, a re-survey was directed; in 1838,
nual report of one hundred and thirty nine pages was
and the final report of eight hundred and forty quarto pag
fifty five plates, is just completed. Tennessee began th
only two or three years after Massachusetts, and committ
Prof. Troost, who has published five annual reports in par
of thirty to eighty pages, with a geological map of the sta
Maryland, the work was begun in 1834, and Prof. Duca
appointed to execute it, who has made seven annual re
about fifty pages each, with numerous maps and sections.
survey of New Jersey was ordered in 1835; in 1836, Prof.
D. Rogers, the commissioned geologist, made a report of on
dred and eighty eight pages, with extensive sections;
1840, his final report of three hundred and one pages, wit
ological map of the state and sections. The state of New
was divided into four sections; and Profs. Vanuxem, Math
Emmons, with Mr. James Hall, as geologists, Mr. Conrad a
ontologist, and Prof. L. C. Beck as chemist, were appoi
1836, to survey them. Up to the present time, they have
five reports; the first of two hundred and twelve pages,
cond of three hundred and eighty four pages, the third o
hundred and fifty one pages, the fourth of four hundre
eighty four pages, and the fifth of one hundred and eigh
pages. The work is now nearly completed; and the gen
are engaged in preparing their final report. The survey
ginia was committed to Prof. William B. Rogers, who, since

has made six reports: the first of thirty six pages, the second of thirty pages, the third of fifty four pages, the fourth of thirty two pages, the fifth of one hundred and sixty one pages, and the sixth of one hundred and thirty two pages.

Dr. Charles T. Jackson was appointed state geologist of Maine, in 1836, and he has since made three reports; the first of one hundred and twenty eight pages, the second of one hundred and sixty eight pages, and the third of three hundred and forty pages. He has also surveyed the public lands of Maine and Massachusetts, and made two reports. In 1839, the same gentleman was appointed to survey Rhode Island; and his final report, of three hundred and twelve pages, with a geological map and sections, appeared in 1840. In 1840, he was commissioned to survey New Hampshire, and his first annual report will soon appear. The survey of Connecticut has been made by Dr. J. G. Percival and Prof. Charles U. Shepard. The latter made a report in 1837, of one hundred and eighty eight pages, upon the economical mineralogy of the state. The report of the former gentleman has not yet been published, but is expected in the course of the ensuing year. The survey of Pennsylvania was begun in 1836, by Prof. Henry D. Rogers, who has made five annual reports; the first of twenty two pages, the second of ninety three pages, the third of one hundred and nineteen pages, the fourth of two hundred and fifty two pages, and the fifth of one hundred and seventy nine pages. The survey of Ohio was committed to Prof. Mather, as principal geologist, assisted by Dr. S. P. Hildreth, Profs. John Locke and J. C. Briggs, and J. W. Foster. Their first report of one hundred and thirty four pages, was made in 1837, and their second of two hundred and eighty six pages, with numerous drawings, in 1838. Delaware commenced this work in 1837, under the direction of James C. Booth, Esq., who has made two annual reports of a few pages, and his final report of one hundred and eighty pages, is nearly through the press. In Michigan, the survey was committed to Douglass Houghton, Esq., with assistants. His first report of thirty seven pages, was made in 1838, and his three subsequent ones of one hundred and twenty three, one hundred and twenty four, and one hundred and eighty four pages, in successive years. In 1837, Dr. D. D. Owen commenced a survey of Indiana, and he has since published two reports of thirty four and fifty four pages. In Kentucky, the

work was begun in 1838, but has yet proceeded no farther than a reconnoissance by Prof. Mather. In Georgia, Mr. John R. Cotting was commissioned in 1836; he informs me, that about half the state has been surveyed; that three section lines, from three hundred to four hundred miles long, have been explored; that "a vast amount of interesting materials, both geological and agricultural, has been collected; and that it is in contemplation to publish a volume of six hundred pages the present year."

In 1834, the United States government directed Mr. Featherstonhaugh to examine, geologically, "the Territory of Arkansas, and the adjacent public lands." He has made two reports, one of ninety seven pages, and another of one hundred and sixty eight pages, with numerous sections. In 1839, Dr. D. D. Owen was commissioned to examine the Territory of Iowa, and his report, in connection with that of Dr. Locke, made in 1840, contains one hundred and sixty one pages. Mr. Nicollet has also been surveying, both astronomically and geologically, the northwestern portion of our country, including a vast region beyond the Mississippi; and his report is now in a course of publication, with a geological section tracing a distance of nearly two thousand miles.

I ought not to omit to mention an act of private munificence, which occurred before any of the state surveys were commenced. The late Hon. Stephen Van Rensselaer directed a geological survey to be made of the entire route of the Erie canal, at his own private expense. This work was executed by Prof. Amos Eaton, who in 1824, published a report of one hundred and sixty three pages, with a section from the Atlantic to Lake Erie. I might also mention with propriety, the surveys of several mineral districts by private companies; such as those of the coal-fields of Pennsylvania, by R. C. Taylor, Esq., and Prof. Johnson; of the gold region of Virginia, and of portions of the coal-fields of Pennsylvania, by Prof. Silliman; of the iron region of Missouri, by Prof. Shepard, &c. But time will not permit me to enter into fuller details.

From these statements it appears, that within the last sixteen or seventeen years, surveys have been commenced in no less than nineteen states, and two of the territories of this Union; embracing an area of nearly seven hundred thousand square miles. For the last four or five years, not less than twenty five principal geologists, and forty assistant geologists, have been con-

stantly employed in the examination of this vast region, under the patronage of the state governments or of that of the Union. In three or four of the states, the surveys are for the present suspended; not, however, from a conviction of their being useless, but from peculiar circumstances. In Massachusetts, New York, Ohio, and Michigan, zoological and botanical surveys are connected with the geological; in Maryland, Ohio and Michigan, there is a topographical department;—and on these various subjects several valuable reports have already appeared, which this is not the proper place to notice.

I ought also to mention here that the British provinces of New Brunswick and Nova Scotia, have been geologically examined by Dr. Gessner, who has made reports. I am credibly informed, also, that the governor general of Canada, will recommend strongly to the House of Assembly at their next session, to order a geological survey of that territory.

Another very important feature of most of these surveys, is the chemical department. In the New York survey, one gentleman devotes himself to it exclusively. In some other states, also, as in Virginia, Pennsylvania, Maine and New Hampshire, laboratories for the sole purpose of analyzing the substances discovered, are fitted up, and one or two chemists are employed in them through the year. The number of analyses already executed in these establishments is immense, amounting to several thousands, and when they are all published, it will be seen that they have a most important bearing, not only in an economical, but also in a scientific point of view.

The annual reports have been confined chiefly to economical geology;—but it was understood from the commencement, that careful attention should be given to the scientific geology of the regions examined, and that the details should be given in the final reports. An immense mass of materials must now be in the hands of the gentlemen concerned in the surveys; and we may anticipate from their publication, most interesting disclosures respecting the geology of this country. Then too, the extensive and complete collections of our rocks, fossils, minerals and soils, which have been made and will be deposited in the capitals of the states, will prove an invaluable treasure. Another important result, which I trust only a few years will see consummated, will be the construction of an accurate geological map of the whole of

the United States;—for it can hardly be doubted, that su
will be soon ordered in the comparatively few states that y
main unexamined;—or if they should not, if I form a rig
timate of the spirit that actuates American geologists, a w
such importance will not be left incomplete. But the libera
ing that has led so many of our state governments, within
years, to do so much for geology, forbids the idea that any
work will be left for volunteer labor. I cannot but feel
the liberal governmental patronage which geology has
received among us, and the fact that this patronage has
from all classes in the community, should make us justly pr
the enlarged views and extensive knowledge displayed b
countrymen. I speak advisedly, when I say, that probab
favorite science is now in this country twenty years in adva
what it would have been, if left to individual efforts.

Let us now enquire how much of American geology ha
developed by all the efforts that have been made, with and
out governmental patronage. As I must depend for these
ments upon what has already been published, I shall of
fall far short of the actual knowledge that is possessed o
subject by individuals.

The primary rocks of this continent, both stratified an
stratified, correspond so exactly with those in other parts
world, as to be easily identified. For the most part, also
compose the principal axes of our extended chains of mou
Thus, we find a range of these rocks, commencing in Ala
and extending northeasterly, in a belt from eighty to one hu
miles broad, to New York; and thence through New En
occupying nearly the whole surface; and probably from
to Labrador. In the northern part of New York, a range
ges from that just described, and extends in a westerly and
westerly direction, till it approaches the Rocky Mountains,
are also primary. Thus the vast basin of the Mississi
bounded for the most part, on three sides by primary rocks,
the secondary and tertiary strata are found chiefly in that
and on the Atlantic slope, as far north as New York.

Only a small portion of these vast primary deposits ha
been carefully examined;—nor have many features been d
ered in them that are very peculiar. The vast deposit of
dor feldspar and hypersthene rock, in the north part of New

as described by Prof. Emmons, is one of the most interesting. The same gentleman has, also, given us some remarkable details respecting the occurrence of genuine injected veins of limestone in granite, in the county of St. Lawrence. The facts have led him to discuss the question whether all primary limestones ought not to be classed among the unstratified rocks. This question, I apprehend, we have in this country abundant means of deciding, as we have the analogous question respecting serpentine; since we have numerous and extensive beds of both these rocks associated with the oldest of our strata. That they are metamorphic in a high degree, no one can doubt: nor is it less certain that serpentine connected with talcose slate and gneiss, exhibits numerous divisional planes; and often these are parallel to the planes of stratification in the adjoining strata;—but the question still remains, whether that divisional structure may not be the result of metamorphic agency instead of original deposition.

The northwestern border of the primary stratified belt of rocks, extending from Alabama to Canada, a distance of at least twelve hundred miles, is composed of interstratified beds of talcose and mica slates, gneiss, and granular limestone. I do not doubt (at least, from all that I can learn) that these rocks are continuous over this vast distance; forming perhaps the longest belt of limestone on the globe. A considerable part of this limestone is more or less magnesian; and in many places pure dolomite. It furnishes, therefore, a fine field for studying the phenomena and the origin of dolomitization. As to that portion of this field which has fallen under my observation, I find, that with one or two unimportant exceptions, all the cases of dolomitized limestone occur, either in the vicinity of a fault, or of unstratified rocks, or of the oldest gneiss. The pure dolomite is usually found where there is reason to believe extensive dislocations of the strata occur; and the marks of stratification in the limestone disappear, nearly in proportion to the amount of magnesia which it contains, so that the pure dolomite shows scarcely any traces of it. I doubt not that similar conclusions will follow an examination of other parts of this deposit, so remarkably uniform is the geology of this continent;—and moreover, these conclusions correspond to the history of dolomitization in Europe. They seem to render probable the theory of sublimation from the interior of the earth.

I have noticed another analogous and singular fact in con
tion with this limestone, and doubt not that it is common thro
out its whole extent; although I have seen it mentioned by no
except Prof. Mather, in his account of the rocks of eastern
York; but am informed by Prof. Rogers that it is commo
Pennsylvania and Virginia. Where the limestone comes in
tact with mica and talcose slates, they are often highly impre
ted with carbon, for several feet or rods from the line of junc
There can hardly be a doubt that the carbonic acid, which
penetrated the slates, has been decomposed to produce this re
Farther examination, in other localities, will probably throw a
tional light on the subject.

The phenomena of dykes and veins, especially along the
ern margin of the primary ranges of New England, are
highly interesting character. Some of the dykes of greens
appear to be of great size and extent. Dr. Percival has,
great labor, traced two of these, through gneiss and mica s
nearly across the state of Connecticut; and I think I have fo
their continuation across the whole of Massachusetts; nor
doubt that they extend far into New Hampshire. Already t
two dykes have been followed nearly ninety miles in length;
they are usually several rods wide. Their direction almost
cides with the strike of the strata. In Maine, they have
found in great number and extent, by Dr. Jackson, in the prin
strata, and they have more distinctly the character of gen
dykes than in Connecticut and Massachusetts.

In some of our sienitic rocks, we find a perfect plexus of d
and veins. I have examined one spot in the city of Salem
a good deal of attention, and I cannot see why it does not a
us evidence of the protrusion of unstratified rocks at eleven
ferent epochs; admitting that the intersection of one vein
another proves the posteriority of the latter. The dykes at
spot are varieties of greenstone, and the veins chiefly feldspa

Among the multitude of substances in our primary rocks
deserve further attention, I can here mention only the oxi
tin. Three localities of this mineral, affording however
small disseminated crystals, have long been known in Massa
setts. But within the last year, Prof. Shepard has discover
more promising locality in Connecticut, and Dr. Jackson and

in New Hampshire. The probability is, therefore, strong, that this interesting metal will ere long be obtained from our own mountains.

You will perceive that under the term primary rocks I have included none that are fossiliferous. The latter, especially those usually denominated transition, have, as is well known, an immense developement in our country. A single vast basin, extending from the Apalachian chain nearly to the Rocky Mountains, and from the centre of Alabama, in a northern direction, perhaps even to the Arctic sea, not less than two thousand miles long and twelve hundred broad, and consequently covering about two and a half millions of square miles;—this wide region forms almost one uninterrupted deposit of older secondary or transition rocks; the largest undoubtedly on the globe. Until recently, these rocks could be described only under the vague designation of graywacke. But light is beginning to shine in upon the chaos. The upper member, that which embraces the bituminous and anasphaltic coals of Pennsylvania, Ohio, Indiana, Illinois, Michigan, and Missouri, seems now to be well identified with the coal measures of Europe. This forms a convenient starting point, and all that remains is to compare the groups below the coal, with those similarly situated in other parts of the world. Professors Henry D. and William B. Rogers have divided this vast series into twelve formations; and these, including the coal measures, which make the thirteenth formation, they find to be not less than forty thousand feet thick. Whatever may be their views as to the identity of these groups with rocks described in other parts of the world, they have refrained from expressing an opinion, in their annual geological reports. But other gentlemen suppose they have discovered marks of identity, in respect to several of the groups, too strong to be resisted. It is difficult to read the reports of the Ohio geologists, especially that of Dr. Locke, and those of Dr. Houghton, Mr. Featherstonhaugh, Prof. Troost, and that of Dr. Owen on the mineral lands of Wisconsin and Iowa, and that of Mr. Conrad on the New York survey for 1841, without being convinced that the carboniferous or mountain limestone is extensively developed from Pennsylvania westward at least fifteen hundred miles; while here, as in England, it forms the repository of an immense accumulation of lead ore. Mr. Taylor, I believe, first pointed out the

probable existence of the old red sandstone, or Devonian system, in the western part of Pennsylvania and New York; and this opinion becomes more probable, since the discovery by Mr. Conrad, of remains of the *Holoptychus nobilissimus*, a fish very characteristic of the old red sandstone in Great Britain. Mr. Hall makes this group four hundred feet thick, lying immediately beneath the coal-measures.

Strong reasons have been presented by Messrs. Conrad and Vanuxem, founded upon a comparison of organic remains, for supposing that a large part of the rocks below the old red sandstone, in the vast area under consideration, and especially in New York, are identical with the Silurian rocks of Great Britain. The former gentleman recognizes all the important subdivisions of this group described by Mr. Murchison, except perhaps the Llandeilo rocks, which are the lowest. The Caradoc sandstone, the Wenlock shale and limestone, and the Ludlow rocks, are distinctly marked.* And in speaking of organic remains, as a means of identifying strata, he remarks, that "an instance never occurs in this country, where the species of one formation are continued into an upper one in such numbers as to cause the least perplexity or dispute regarding its geological age. All the various eras are admirably recorded, each by its peculiar group of animal or vegetable remains; and to him who has carefully studied them, they are quite as intelligible as if the hand of nature had arranged them in a cabinet for his use."—*Am. Journal of Science, Vol. 35, p.* 237.

These suggestions open a wide field for investigation. It is one of the most important problems in American geology;—and from the immense extent occupied by these rocks, I can hardly doubt that here will be found the most complete type of the transition formations that has yet been described. Accordingly, in his report for 1841, Mr. Conrad says, that "nature has probably enabled the geologist to apply this classification (of Murchison) in a more clear and satisfactory manner to the rocks of this country than to those of Europe, since the series is certainly more complete, and the organic remains more abundant in species." I

* He says also, that "the inhabitants of the seas (in which these rocks were deposited) have been destroyed, and new creatures succeeded, at five different epochs; and one of these groups is no more to be compared with another, than is the oolite with the green sand formation."—*Am. Journal of Science, Vol.* 35, *p.* 246.

rejoice that the work is in such able hands, and that so many observers are busy at so many points, and on different sides of the vast field.

Besides the principal basin of the transition rocks just described, detached deposits are sometimes met with in our country; as for example, in the eastern part of Massachusetts and Rhode Island;—and I mention this, just to say, that I have recently come to the conclusion, that even that limited district probably contains, in a descending order, coal measures, the old red sandstone, and beneath these, older transition strata.

Are we to infer that the coal-bearing strata once extended over the immense basin of the Mississippi, and that they have been worn away, except in particular districts? I shall not discuss this question: but if the negative be true, we may still lay claim probably to the largest coal-fields in the world. It is a fact of great interest, also, that the coal along the eastern part of the great valley, or in the vicinity of primary rocks, as has been abundantly shown by Professors Rogers and Johnson, is almost destitute of bitumen; and that as we go west, it becomes more and more bituminous. It is an interesting inquiry, whether the coal in the vicinity of the Rocky Mountains exhibits a similar change, as we recede from the chain. It is also a curious fact, that gypsum and salt springs should usually be found below the coal measures in this country, and not above them, as in Europe.

In extensive troughs of the primary rocks, along the Atlantic slope of the United States, there occurs a formation of fine and coarse sandstones and shales, with a predominant red color, associated with beds of limestone and calcareous breccia. The most extensive deposit of this group commences on the Hudson river, in New Jersey, and thence pursues a southwesterly course through that state, Pennsylvania, Maryland, and Virginia, into North Carolina, and perhaps beyond that state. A smaller deposit occupies the valley of Connecticut river, and extends across the states of Connecticut and Massachusetts. A third deposit, according to Dr. Jackson, is found in the eastern part of Maine; and a fourth has been described in Nova Scotia; where, according to Jackson and Alger, it contains gypsum and salt springs, and overlies bituminous coal.

The lithological characters of the rocks in all these deposits, are so similar, that the observer is at once satisfied of their iden-

tity. Besides, in all of them we find limestones of a similar c
racter, extensive ridges and dykes of greenstone, and ores of c
per, associated with the sandstones and shales;—so that there
hardly remain a doubt as to the identity in age of all these
posits. But can we determine their true place on the geologi
scale?

The Professors Rogers, who have extensively examined this f
mation in the middle states, have ascertained that it is more
cent than the coal measures; and with commendable cauti
they have called it the middle secondary. With less of p
dence I long since ventured to denominate it the new red sa
stone;—and I hope it is not prejudice which makes the argum
in favor of this opinion appear to be now almost complete.
careful comparison of numerous specimens of this formation w
a series from the new red sandstone of continental Europe, a
Great Britain, shows a striking resemblance in lithological c
racters. But the argument from the organic remains is the m
decisive. In the shales of this formation, especially in New E
land and New Jersey, have been found numerous specimens
fossil fishes of the genera Palæoniscus and Catopterus, all
which have heterocercal tails.* Now in Europe, Prof. Agas
finds that such fish rarely, if ever, occur in any rock above
new red sandstone. But in that formation he finds not less th
a dozen species of the genera just mentioned. They occur, ho
ever, in the coal formations, beneath the red sandstone. But
seems to be admitted on all hands, that the group in our coun
under consideration, is more recent than the coal measures. A
since the heterocercal fishes found in it show that it must
older than the lias, I see no escape from the conclusion that i
the new red sandstone. There are other arguments to the sa
point; but they are less decisive. Whether we shall find all
subdivisions of this formation in our country that exist in E
rope, remains to be seen. I have little doubt, however, th
several of them may be easily recognized; as, for example,
variegated marls and sandstone, the new red conglomerate, (*Ro
todte liegende,*) and the *zechstein.*

* I am informed by Messrs. Redfield, the father and the son, who have so s
cessfully devoted themselves to an examination of our fossil fishes, that they h
found not less than nine species of these genera in our rocks.

Thus far, as we have ascended on the scale of rocks, we have found, if I mistake not, so full a developement of the European formations on this side of the Atlantic, that it would not be strange, if at no distant period, this country should become classic ground for their study. But we now reach a wide hiatus of the extensive groups of the lias, oolite and wealden, which have as yet been scarcely identified on this continent. Humboldt did, indeed, express the opinion, that he had met with the oolite in the equinoctial zone of South America; and Mr. Lea has described some fossils from New Grenada, in the seventh volume, second series, of the Transactions of the American Philosophical Society, which he refers to the same formation. But Von Buch, in his recent splendid work on some of the fossils of South America, regards them as belonging to the cretaceous group. Mr. Conrad, however, has just announced the existence "of well characterized and undoubted oolite in the state of Ohio."—*Report on the New York Survey for* 1841.

When we rise still higher on the geological scale, we meet with a remarkable group of rocks, occupying a wide belt from New Jersey to Alabama, and much surface also in Mississippi, Louisiana, Tennessee, Arkansas, and, as I am informed by Mr. Nicollet, extending from Council Bluffs on the Missouri, several hundred miles westward, nearly to the Rocky Mountains, all of which was identified, I believe, first by Prof. Vanuxem, with the cretaceous formation of Europe, although it contains no chalk. The subsequent extensive and accurate researches of Dr. Morton, Mr. Conrad, and others, have completely confirmed this opinion;—and it furnishes an interesting example of the value of organic remains in identifying groups of rocks very much unlike in lithological characters. It is another instance, moreover, of the enormous scale on which geological operations have taken place in this country. From the recent memoir of the veteran geologist, Von Buch, just referred to, it appears that this same formation extends through a considerable portion of South America, and decidedly predominates among the secondary rocks of the Andes.

Equally successful, as in the case of the cretaceous rocks, have been the labors of Conrad, Vanuxem, Morton, Lea, the brothers Rogers and others, in developing the tertiary deposits of this country. The most northerly point along our coast where these are found, is the island of Martha's Vineyard, or perhaps Nantuck-

et. Thence in passing southerly, we find them occupying Long Island and the eastern part of the Atlantic states, from New Jersey to Florida, and the southern part of the Mississippi valley. These too correspond to the other features of our geology, in being of vast extent and of decided characters. Three principal groups of these strata, as described by Conrad and Morton, viz. the lower or eocene, the medial, and the upper or newer pliocene, seem to be well made out on this side of the Atlantic. The group named post-tertiary by Mr. Lyell, is found also in the northern part of New York and in Canada, containing shells of a more arctic character than those now living in the same latitudes.

Excepting the remarkable insulated labors of Mr. Hayden, the drift, or diluvium of this country, has, until recently, received less attention than almost any other formation. The same has been true in Europe. This results in part from the fact, that it cannot be successfully studied until the character and limits of all the subjacent formations are well understood. The state surveys, however, have brought to light enough of our diluvial phenomena to show us, that though a difficult subject, it is one of the most interesting in the whole history of our rocks.

It is an important inquiry, whether the phenomena of drift in this country, correspond with those of the eastern continent. Until recently, I confess, I have doubted whether some of the most striking of these phenomena were not much more fully developed here than in most countries of Europe. I refer particularly to the smoothing, polishing, scratching and furrowing of the rocks in place, and to those accumulations of gravel, bowlders, and sand, which form conical and oblong tumuli, with tortuous ridges of the same, and which abound in the northern part of the country, from Nova Scotia to the Rocky Mountains. But the recent investigations and accurate descriptions by Agassiz, Buckland, Lyell, Sefstroom, and others, have satisfied me of the almost exact identity of the facts in relation to drift on the two continents. The resemblance, however, seems to be most complete in this respect between Scandinavia and this country. Except in Sweden, I have not yet seen evidence that the scarification of the rocks is as common in Europe as in New England, where if they were denuded of soil it seems to me, one third of the surface would be found smoothed and furrowed. But it is now found to be very common in Scotland, England, and espe-

cially in Switzerland. It appears too, that those countries abound in those peculiar accumulations of gravel and bowlders to which I have referred, and which are now regarded as ancient *moraines*. Bowlders, also, appear to have been dispersed in a similar manner on both continents.

If I do not greatly mistake, the drift of this country exhibits usually the following lithological characters and superposition. The principal mass of the drift consists of coarse sand, pebbles, and bowlders, often several feet in diameter, usually mixed together confusedly, but sometimes exhibiting, at least for small distances, more or less of a stratified arrangement. This mass of detritus, not unfrequently one hundred feet thick, occupies the lowest position; that is, it rests immediately on the smoothed and striated rocks in place. Sometimes there is mixed with it fine sand or mud; and occasionally a limited mass of clay, appearing as if out of its original position. Above this deposit, in most of the larger valleys, as those of the Hudson, Connecticut, and Penobscot, and in many smaller ones, we find horizontal layers of fine blue clay, rarely as much as one hundred feet thick. Above the clay, and of less thickness, we have a bed of sand, becoming coarser towards the top, and exhibiting sometimes at its surface, marks of a stronger movement in the waters by which it was deposited, than could have taken place while the clay was in a course of formation. Scattered over the whole surface, but confined chiefly to the region abounding in gravel, we find insulated blocks, sometimes rounded and sometimes angular.

Now if I have not mistaken the recent descriptions of European drift, its composition and arrangement correspond with those of the drift of this country; and scarcely any thing seems wanting to make out a complete identity.

It is well known that the theory of drift has for some years been the most unsettled part of geology. The mass of geologists have, indeed, admitted that in some way or other, currents of water have been the principal agency employed, because they witness somewhat analogous effects from aqueous action; and, until recently, no other power of adequate energy and extent has been known to exist. Hence they have been willing to retain the term *diluvial*, as a generic expression, implying simply aqueous agency in general. Yet so many difficulties attend any theory of mere currents, that many geologists have become sceptical

in regard to every particular theory that has been proposed. I confess myself to have been long of that number. Yet it has seemed to me of useful tendency to make isolated inferences from the facts developed; and although they may seem to favor rival hypotheses, and will need modification, as new light falls on the subject, yet they will form the elements out of which a legitimate theory will ultimately spring. Allow me to present for your consideration, a summary of the most important of these inferences, as they have been developed to my own mind in examining the diluvial phenomena of this country.

In the first place, these phenomena must have been the result of some very general force, or forces, operating in the same general direction; that is, southerly or southeasterly. For in a southerly direction has the drift been so uniformly carried, and the furrows and scratches on the rocks so generally point southerly, that the force which produced these effects must have tended thither. Our valleys have, indeed, considerably modified the course of the drift; but not enough to contradict the general statement. It would be strange if careful examination should not discover here, as in the Alps and in Great Britain, that the moving force had sometimes been exerted outwardly from the axes of high mountains. But I am not aware that as yet any facts of importance in favor of such an opinion, have been brought to light. At any rate, the evidence of a force urging detritus and bowlders in a southerly, or more strictly in a southeasterly direction, is too marked, and has been noticed by too many independent observers, over a breadth of nearly two thousand miles, to be doubted; even though local exceptions should be discovered;—and such a uniformity of direction over so vast an area, indicates a very general agency.

Secondly, this agency has operated at all altitudes, from the present sea level, and probably beneath it, to the height of three thousand or four thousand feet. In New England, most of our hills and mountains, not excepting insulated peaks, not higher than three thousand feet, are distinctly smoothed and furrowed on their tops and northern slopes, and upon their east and west flanks, to the bottom of the lowest valleys. Dr. Jackson supposes he has found transported detritus on Mount Katahdin, four thousand feet high. But he could discover no marks of this action at the summit of the White mountains of New Hampshire,

which are six thousand two hundred and thirty four feet high; although the nature of the rock there, is most unfavorable for preserving furrows and markings.

Thirdly, the smoothing and furrowing of the rocks exhibits almost equal freshness at all altitudes, which indicates an approach to synchronism in the producing cause.

Fourthly, the almost perfect parallelism preserved by the grooves and scratches over wide regions, shows that they were made by the projecting angles of very large and heavy masses of great extent, moving over the surface with almost irresistible force, by water or some other mighty agent. There is sometimes more than one set of scratches, which intersect one another at a small angle, as has been shown by Prof. Locke to occur in Ohio, but each set preserves its parallelism most perfectly. Even where they pass over high and precipitous ridges, they are rarely turned out of their course.

Fifthly, this agency appears to have been less and less powerful as we go southerly. We have as yet, indeed, had but few trusty reports on this subject from the southern portions of North America; but had the phenomena of drift been as striking there as in New England, New York and Canada, they would certainly, ere this, have been described. It ought not to be forgotten, however, that De la Beche has described the drift of Jamaica as very similar to that of New England.

Sixthly, the relative levels of the surface have not been essentially changed by vertical movements, since the epoch in which this agency was exerted. They could not have been much changed without disturbing the detritus, often fancifully arranged in the valleys and on the flanks of the hills; nor without sometimes breaking up the smoothed, and furrowed surfaces of the rocks along their joints or planes of stratification. But such a disturbance I have never witnessed.

Seventhly, the North American continent must have attained essentially, its present height above the ocean, previous to the exertion of this agency. For all our formations, as high at least as the eocene tertiary, are covered with drift; and I know of no evidence of any important uplift subsequent to that which has tilted up our tertiary strata. This work, therefore, could not have been accomplished while the continent was beneath the ocean. Other evidence of this position might be adduced, did time permit.

Eighthly, water must have been one of the forces employed in this agency. The regular deposits of clay and sand which form the upper part of the diluvial deposit, must surely have been accumulated at the bottom of bodies of water, which have subsequently been drained off. Much, also, of the finer part of our drift is more or less stratified, and exhibits that oblique lamination which is peculiar to aqueous deposits. Nor can I conceive of any other mode in which detritus has been transported hundreds of miles, as ours has been, but by the aid of water; although this alone could not do it. In New England, we have been able to trace erratic blocks not more than one hundred or two hundred miles, because we then reach the ocean. But in the central parts of the country, I am informed by Prof. Mather, that the primary bowlders from Canada and the western part of Michigan, are found as far south as the river Ohio; which would make their maximum transit from four hundred to five hundred miles; about the same distance as the bowlders from Scandinavia have been carried into Germany. What agency but water could have effected such a transportation?

It is very natural, also, to ascribe the smoothness and furrowing of the rocks to the action of water. But I have in vain examined the beds of our mountain torrents and the shores of the Atlantic, where the rocks have been exposed to the unshielded and everlasting concussion of the breakers, and can find no attrition that will compare at all with that connected with drift; and I am satisfied that to explain it we must resort to some other agency.

Ninthly, ice must have been another agent employed to produce the phenomena of drift. What else could have transported large blocks and gravel over such a wide space as has been mentioned, and have lodged them too, upon the crests of narrow and precipitous ridges; and especially, what other agent could have produced those singular mounds and peculiar ridges of gravel and bowlders that meet us in so many places?

Tenthly, this agency must have been exerted previously to the existence of man upon this continent, and have been of such a nature as to destroy organic life almost entirely. For the remains of man and other existing animals have not been found in drift; but those occurring there belong chiefly to extinct species, while the deposits of clay and sand made during the same period, scarcely contain a species of animal or plant.

Yet eleventhly, this agency must have been comparatively recent. For the disintegration of the surface of the smoothed and furrowed rocks to the depth of half an inch, would usually obliterate all traces of their erosion. Yet in how many places does this effect appear as distinct as if produced during the present century!

Finally, this agency must have been far more powerful than any now operating upon the globe. In the language of Prof. John Phillips, which he applies to the phenomena of drift in general, "such effects are not at this day in progress, nor can we conceive the possibility of their being produced by the operation of existing agencies operating with their present intensities and in their present directions."—*Treatise on Geology, Vol. I, p.* 296.

Beyond such independent inferences as these, I confess I have been of late years unwilling to go; and have regarded the numerous theories of diluvial action, which have recently appeared, only as ingenious hypotheses. But it is well known that the *Glacier Theory*, originally suggested by M. Venetz, and subsequently adopted by M. Charpentier, and more fully developed of late by Agassiz, is now exciting great interest in Europe. To say nothing of geologists in this country who have expressed themselves favorably towards it;* it is surely enough to recommend it to a careful examination, to learn that such men as Agassiz, Buckland, Lyell and Murchison, after long examination, have more or less fully adopted it; although on the other hand, it ought to be mentioned, that such geologists as Beaumont, Sedgwick, Whewell, Mantell, and others, still hesitate to receive it.

In a country like ours, where no glaciers exist except in very high latitudes, and with the very defective accounts which have hitherto been given of those in the Alps, it is not strange that the attempt to explain the vast phenomena of diluvial action by such an agency, should appear at first view, fanciful, and even puerile. But the recent work of Agassiz, entitled *Etudes sur les Glaciers*, gives a new aspect to the subject. It is the result of observations made during five summers in the Alps, especially upon the glaciers; about which so much has been said, but con-

* See Mr. Conrad's Notes on American Geology, in Am. Journal of Science, Vol. xxxv, p. 237.

cerning which so little of geological importance has been known. Henceforth, however, glacial action must form an important chapter in geology. While reading this work and the abstracts of some papers by Agassiz, Buckland and Lyell, on the evidence of ancient glaciers in Scotland and England, I seemed to be acquiring *a new geological sense;* and I look upon our smoothed and striated rocks, our accumulations of gravel, and the *tout ensemble* of diluvial phenomena, with new eyes.* The fact is, that *the history of glaciers is the history of diluvial agency in miniature.* The object of Agassiz is, first to describe the miniature, and then to enlarge the picture till it reaches around the globe.

The glaciers are vast masses of ice, often leagues in extent, formed of melting and freezing snow, which are sent out from the summits of the Alps by the force of expansion into the valleys below, often to the distance of twelve or fifteen miles. Those elevated and wide *plateaux*, called in Switzerland *Mers de Glace*, exhibiting only one thick sheet of ice, through which the crests and summits of the mountains sometimes rise like volcanoes, are the grand source or birthplace, of the glaciers. In their descent they plough their way through the soil, pile up pebbles and sand along their sides and at their extremities, and even upon their backs; which, upon the retreat, or melting of the glacier, constitute *moraines*, and correspond exactly in composition and shape to those accumulations of gravel and bowlders that have been ascribed to diluvial action. The stones and sand frozen into their lower surface, also, like so many fixed diamonds, smooth and furrow the surface of the rocks in precisely the same manner as they

* I trust that the members of the Association will pardon me for having made some alterations in the form, though not in the leading thoughts, of this part of my Address, since it was delivered. They will recollect, that while I expressed a very favorable opinion of the Glacial Theory, so far as I understood it, I stated that I had not seen the work of Agassiz named in the text. Through the kindness of Prof. Silliman, I have since been favored with the perusal of the copy of this work which, with its splendid alpine illustrations, he received from the author. I am indebted, also, to Dr. J. Pye Smith, of London, for an abstract of the papers of Agassiz, Buckland and Lyell, read before the London Geological Society last autumn, on the ancient glaciers of Scotland and England. A flood of light having thus been unexpectedly thrown in upon my mind, I am free to acknowledge that many of my difficulties in respect to this theory have been removed, and that the great mass of evidence in its favor, thus brought before me, has led me to express a warmer admiration of its leading features and a greater readiness to adopt its leading principles, although satisfied that it will need important modifications.

are abraded over all northern countries. Vast blocks of stone are likewise conveyed without abrasion, by the advance of the glaciers, and lodged in peculiar situations.

From year to year, the evidence has been increasing, of the prevalence of intense cold in northern regions in the period immediately preceding the historic. The elephants and rhinoceros found, undecayed, in the frozen mud of Siberia, the arctic character of the few organic remains found in the post-tertiary strata of Scotland and Canada, and described by Lyell and Bowman, and of the borders of Lake Champlain, as described by Emmons and Conrad; and the great extension of the ancient moraines in the Alps, are the evidence from which Agassiz infers that in that period, all northern countries were covered with a vast sheet of ice, filling the valleys and extending southerly as far as diluvial phenomena have been observed. Glaciers would then be formed on mountains of moderate altitude; and, indeed, he supposes that all the northern parts of the globe might have constituted one vast Mer de Glace, which sent out its enormous glaciers to the south; thus giving the same direction to the drift and the striæ on the rocks. As these vast masses of ice melted away, when the temperature was raised, immense currents of water were the result, which would lift up and bear away huge icebergs, whereby extensive erosions would be produced, and blocks of stone be transported to great distances. Subsequently, lakes would be formed where moraines had produced barriers, clay and sand would there be quietly deposited, and the waters be ultimately drained by the wearing down of the barriers of detritus.

It is doing injustice to this theory to attempt so brief a description of it. A detailed account of existing glaciers, which cannot here be given, forms the best preparation for a just appreciation of the theory. Admitting its truth in the main, let us see how it applies to the phenomena of drift in this country.

In the first place, it explains satisfactorily, the origin of those singular accumulations of gravel and bowlders, which we meet with, almost every where, in the northern parts of our country. I cannot doubt that these are ancient moraines; just such as exist in Scotland and England. Were this the proper place, I could point out a multitude of localities of these, most of which have been a good deal modified by subsequent aqueous agency; but some of them retain the very contour which they had as the

ice melted away.* The lateral moraines are perhaps most common, especially if, with Dr. Buckland, we regard our terraced valleys as modifications of these; but I am confident that in our mountain valleys, the terminal and the medial moraine are not infrequent. I have long been convinced that the agency of ice was essential to explain these accumulations; but I was not aware that their antitypes existed in the moraines of the Alps.

In the second place, this theory explains in a most satisfactory manner, the smoothing, polishing and furrowing of the rocks at different altitudes. All these effects are perfectly produced beneath the glaciers in the Alps; nor can I conceive of any other agent by which the work could be executed. It certainly was not done by currents of water alone. One has only to cast his eye upon the splendid plates by Agassiz, of the polish and striæ produced by the glaciers, to be satisfied that the multitudes of examples of analogous phenomena in New England, and in New York and Ohio, as described by Profs. Dewey, Emmons, and Locke, and Dr. Hayes, are precisely identical with those in the Alps.

In the third place, it explains the transportation of bowlders, and their lodgment upon the crests and narrow summits of mountains, and that often without having their angles rounded.

In the fourth place, it accounts for the occurrence of deposits of clay and sand above the drift. For it furnishes the requisite quantity of water to fill the valleys, and the means of damming up their outlets for a season.

In the fifth place, it shows us why these deposits of clay and sand are almost completely destitute of organic remains, either of animals or plants, although probably centuries must have been consumed in their formation.

In the sixth place, it accounts for some rare and peculiar phenomena connected with diluvial action, which seem to me inexplicable on any other known principle. I shall name only two. The first is, that the northern slopes of some of the mountains of New England, although quite steep, and their summits rounded, exhibit striæ and furrows which commence several

* Descriptions of some of these with sketches, will be found in my Report on the Geology of Massachusetts, published in 1833: but more numerous descriptions and drawings are given in the Final Report just published. See especially Figs. 15, 19, 73 and 74, of the wood cuts, and plate 3 of the lithographs.

hundred feet below their tops, and pass over them without losing their parallelism; and yet the situation of the drift shows that these markings were made by an ascending and not a descending body. Such might be the effect, if the whole surface of the country were covered by a thick sheet of ice expanding in a southerly direction.

Of the other case, I have met with two examples in New England, and know not that they have been noticed elsewhere. In these cases, the perpendicular layers of agillaceous and hornblende slate, covered in one place, by fifteen or twenty feet of drift, have been fractured to the depth of ten to fifteen feet, so as to be more or less separated, producing horizontal fissures, which are filled by mud, while the laminæ are inclined, at various angles. In short, it seems as if an almost incredible force had been exerted upon the surface in an oblique direction. Such a force might be exerted by an immense mass of ice in the process of expansion; but I know of no other source from which it could have been derived.*

On the other hand, there are features in the phenomena of diluvial action in this country, which are explained by this theory in a much less satisfactory manner. One is the southerly direction which our drift has taken, and the great distance to which it has been carried. It cannot be conceived that any single glacier should have expanded several hundred miles in a southerly direction, especially over a surface which could have had scarcely any southerly slope. Even if we admit a Mer de Glace in the northern regions so lofty as, in the beginning of the work, to send glaciers a vast distance, yet the force seems to have continued to operate in the same austral direction, even to the bottom of our valleys. It is, however, probably true, that the great mass of our drift will be found within fifteen or twenty miles from its original place; and that which occurs at greater distances, may perhaps, have been transported by powerful currents of water. It is almost certain that the sheet of ice which covered the surface, according to this theory, must have been at least three thousand or four thousand feet thick, because our mountains have been to that height, swept over. Now if, as Agassiz and others suppose, the fall of temperature, at the beginning of the glacial period, was

* Descriptions and sketches of these cases are given in the Final Report on the Geology of Massachusetts, Vol. ii, p. 396 and 559.

very sudden, why may not the return of the heat have been equally sudden? If so, the most powerful debacles must have been the result;* and as the ice would disappear most rapidly along its southern border, perhaps in this way a current in that direction may have been produced. And yet, I confess that I regard this theory more defective in not furnishing an adequate cause for the southerly course of our drift, than in any other point.

I find another difficulty in explaining satisfactorily by this theory, how drift could have been often carried from lower to much higher levels; as it has been sometimes if I am not greatly mistaken. Thus, the Silurian rocks of New York, and the quartz rock in the valleys of western Massachusetts, have been carried over, and left upon, Hoosac and Taconic mountains and the Highlands of New York. It is easy to conceive how an immense sheet of ice, by its expansive power, should force portions of its mass to ascend moderate declivities, of a few hundred feet, but not so easy to imagine them thus forced upwards one thousand or two thousand feet, as they undoubtedly have been in New England.†

Another difficulty results from the fact that some of the most remarkable of our moraines are found, not in valleys, but on the sea coast, some of them fifty, and others one hundred miles distant from any mountains much higher than themselves. I refer to those remarkable conical and oblong tumuli of drift, sometimes

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* A curious example illustrative of this point has just been communicated to me by Rev. Justin Perkins, American missionary in Persia, not far from Mt. Ararat, in a letter dated at Ooromiah, Nov. 6th, 1840. In giving an account of two very powerful earthquakes experienced on and around that mountain in the summer of last year, he says, "The vast accumulation of snow which had been increasing on and about the top of the mountain for so many centuries, was broken into pieces, and parts of it shaken down on the sides of the mountain in such immense quantities, that (it being midsummer, and the snow descending down as far as a warm climate, and suddenly melting,) torrents of water came rolling down the remainder of the mountain, and flooded the plain for some distance around its base."

† In the north of Europe, also, the drift has been carried "from lower to higher levels," according to Mr. Murchison; and he imputes the striæ to "icefloes and detritus, set in motion by the elevation of continental masses, and grating upon the bottom of a sea." *On the Geological Structure of Northern and Central Russia, &c., by Murchison and Verneuil, p.* 13. *London*, 1841, pp. 16. Very likely the Glacier Theory may need some analogous modification to adapt it to this country; and yet it seems to me that expanding ice is a far more powerful agent to force detritus up an inclined plane, than currents of water.

more than two hundred feet high, which occur in Plymouth and Barnstable counties in Massachusetts. I see nothing in this theory that will explain such astonishing accumulations in such circumstances; and yet their existence may not militate against its truth. For even the present mighty glaciers of the Alps, may give us but a faint idea of the effects of the advance and retreat of a sheet of ice thousands of feet thick. We have no evidence in this country, that any of our mountains have been elevated since the glacial epoch; as seems to be proved to have been the case with the Alps, and this circumstance may have produced a considerable modification of glacial action on this continent.

I do not mention these difficulties (to which I might add more,) as any strong evidence against this theory. For so remarkably does it solve most of the phenomena of diluvial action, that I am constrained to believe its fundamental principles to be founded in truth. Modifications it may require: for it would be strange enough if it had already attained perfection, even in the skillful hands that have thus far framed and fashioned it. But I can hardly doubt that *glacio-aqueous* action* has been the controlling power in producing the phenomena of drift. Having hovered so long over the shoreless and troubled ocean of uncertainty and doubt, I may be too ready to alight on what looks like *terra firma.* But should it prove a Delos, I have only to plume my wings again, when it sinks beneath the waves.

I have dwelt long on this subject; its great importance, its interesting aspect at this time, and its wide developement in our country, must plead my apology.

In referring to our alluvial formations I shall call your attention only to a single subject, and that is, *microscopic palæontology.* The splendid discoveries of Ehrenberg in this department, were yet fresh among us, when Prof. Bailey demonstrated that similar relics abound in this country. They form extensive deposits, covering many acres, and sometimes several feet thick, beneath our peat-bogs. The substance appears to be the *Bergmehl*, or *mountain meal*, or *fossil farina*, of the Germans, and is mostly composed of the *Shields* or *Carapaces* of the family *Baccillariæ.* Some do, indeed, yet doubt the animal origin of

* By which I mean the joint action of ice and water, without deciding which has exerted the greatest influence.

this family; but the weight of opinion seems to be on the other side. Hitherto I believe, in this country, these relics have been found only in primitive regions; but as it is not always the case in Europe, (Am. Journal of Science, Vol. xl, p. 177,) we may believe it is not so here. Over the primary regions they have been found from Maine to Wisconsin, and south to Virginia. So numerous are the localities, that in New England at least, I am confident they may be found in nearly every town based on primary rocks. The report on the geology of Massachusetts is enriched with a valuable paper on the fossil infusoria of that state, by Prof. Bailey; and a memoir on the same subject, embracing the whole of the United States, may soon be expected from that gentleman. It will give some idea of the wide field which the microscope has opened to palæontology in this country, to state, that in a single specimen of fossil farina from West Point, Ehrenberg has detected fourteen species of siliceous infusoria. Besides, it can hardly be doubted that our iron ores and other deposits in addition to the Bergmehl, will afford these remains.

These remarks receive strong confirmation from the interesting discovery by Prof. W. B. Rogers, in the tertiary strata of Virginia, as announced in his Geological Report of 1841, of a deposit of these infusoria. It is composed almost entirely of their siliceous shields, occupies areas of considerable extent, sometimes attains the enormous thickness of twenty five feet, and is rarely less than twelve feet thick. If such is the beginning, what, gentlemen, will be the end of this *infinitesimal geology!* We seem fast advancing towards a realization of the proverb, *omnis calx e vermibus, omnis silex e vermibus, omne ferrum e vermibus.*

Having thus ascended to the top of the scale of American rocks, and briefly shown how far their characters have been fixed, and their equivalence to European strata demonstrated, a few miscellaneous topics only remain for examination.

One of these subjects is that of concretions. And it seems to me that it needs to have light thrown upon it as much as any in the whole range of mineralogy and geology. It needs a second Haüy to develop the fundamental principles of concretionary structure. Brongniart, De la Beche, and Fitton, have, indeed, thrown out many valuable hints on the subject, and rendered it probable that concretions result from segregation by means of elective affinity. But why the particles should arrange them-

selves in curved rather than straight laminæ, and why the curves should differ from one another, does not appear. The siliceous limestone of Fontainbleau contains more sand than the calcareous concretions of this country, called claystones; and yet the former assumes a polyhedral and the latter a spheroidal form.

These claystone concretions, which abound in our diluvial clays, seems to me to afford a better opportunity than any other for studying this subject. They appear to consist of the clay containing them, cemented by carbonate of lime, which usually forms about fifty per cent. of the mass; although I doubt whether it exists in definite proportion. I have found in them, also, both in those of New England and in specimens from the diluvial clay of Sweden, a small amount of organic matter, very probably resulting from the crenic acid, which existed in the water when the clay was deposited. I am informed, however, by Dr. Tamnau, of Prussia, that "the Swedish scientific men believe these claystones to be something of organic remains:—some sort of mollusca, which were more or less wrapped in a mantle." But even if we admit that some soft animal formed the nucleus, it is impossible to doubt that the claystones have assumed their present forms as the result of a concretionary agency. Those forms are often so very regular, and furnish such mimic representations of numerous artificial objects, that we need not wonder they should be regarded, both in this country and in England, as the work of art; that among us, they should be imputed to the ingenuity of the aborigines; and in England, be supposed to have been turned in a lathe, as a substitute for metallic coin, and have taken the name of *Kimmeridge coal money.*

An examination of numerous specimens from New England, has led me to the conclusion that certain predominant forms may be discovered, which they affect; although between them are numerous intermediate varieties; and sometimes there would seem to have been a struggle between two of these forms for the mastery. These predominant forms are the sphere, the oblate spheroid, the prolate spheroid, the annulated, the lenticular, and the cylindrical. The first is the most important, though least common; and perhaps all the others may be conceived to result from it. I think, also, that if we may suppose the clay to have been in a plastic and not a fluid state, so as to admit of the permeation of carbonate of lime in a state of solution, and that differ-

ent centres of attraction existed in the clay, it is not difficult to conceive how all the varieties of form assumed by the concretions, may have been produced by a modification of circumstances. I find, that as in crystals of minerals, certain forms predominate at particular localities, so it is with the claystones. And finally, I am led by all the facts to the conclusion, that these concretions are produced by laws as fixed and definite as those of crystallography. To discover and develop these laws, therefore must be an object of great interest.

There is another interesting concretion in the same diluvial clay, in all parts of our country, consisting generally of concentric alternating layers of clay or loam, and the same material more or less colored and consolidated by the hydrate of iron. The axis consists usually of the root of a vegetable, or some other organic body. Portions of the same clay are sometimes crossed by parallel divisional planes, so as to produce rhomboidal prisms, precisely like those in the older consolidated rocks, which have usually been referred to the agency of heat. But this clay can probably, never have been even sun-dried; and, therefore, we must resort to some other explanation of this jointed structure. And since the experiment of Mr. Robert Weare Fox upon the influence of galvanism upon clay, I can hardly doubt but this agency might have produced it, and also the ferruginous concretions that have been described, and perhaps have aided in forming the claystones. But to settle these points will require numerous observations and experiments; and my chief object in these remarks is to show that this is a promising, though long neglected field of research.

It is expected in many of the state surveys, that particular attention will be given to the connection between geology and agriculture. To do this, the geologist is obliged to call in the aid of organic and analytical chemistry; obviously the most difficult branches of that most useful science. Hence the analysis of soils, of the plants which they produce, and of the various fertilizers which are applied by the farmer, as well as of the rock whose disintegration produces the soil, ought to form the object of a commission distinct from that of ordinary geology: and I hope the time is not far distant, when such an office will exist in all the states of the union. For although we ought not to look for striking benefits from such a work so soon as from a geologi

cal survey, yet, with sufficient time given to a geological chemist, there can be no doubt but most valuable ultimate results would follow his labors.

Although the science of agricultural chemistry had a vigorous commencement in the labors of Davy and Chaptal, yet its subsequent progress has not been correspondently rapid; and it must yet be regarded as in its infancy. Hence too much has been expected from the analyses of soils in our country, and a consequent disappointment has been felt. Distinguished chemists are not yet agreed in respect to some of the fundamental principles of the science. The recent able work by Prof. Liebig on organic chemistry, affords evidence of the truth of this statement in the numerous new views which it presents, and which he declares to be different from those usually maintained. Many of these views will be adopted at once, as original discoveries; but in regard to others, it is not to be expected that chemists will receive them without discussion. With Raspail he maintains, that plants are nourished solely by the absorption of carbonic acid from the atmosphere and from soil; whereas, the prevailing opinion is, that they derive their support partly from carbonic acid and partly by the direct imbibition of organic matter in some of the forms of humus, by their roots. He supposes that the humus acts no other part than to furnish carbonic acid by its decomposition. Others maintain that some of it is taken up in a state of solution, by capillary attraction, or by galvanic action. And as all chemists were not convinced by the arguments of Raspail, they may not be satisfied with the more able reasoning of Liebig, on the same subject. His views of the agency of nitrogen in vegetable nutrition,—his discovery of ammonia in the atmosphere, and his many new views respecting the agency of salts upon vegetation, and on other subjects, will render this work a most valuable addition to agricultural chemistry.

The earlier agricultural chemists laid by far too much stress upon the mineral constitution of soils, and disposed of the organic matter by one simple act of combustion. But more recent experimenters have found, that the composition and condition of the organic matter are of the highest importance in relation to vegetation, and they have made great efforts to ascertain the true character of mould or humus. It is agreed on all hands, that it is composed of several distinct compounds. But, in determin-

ing their nature we find, as we might expect, that distinguished chemists differ somewhat in their conclusions. Berzelius includes all the organic matter of soils under the term *humus*. In this he supposes that he finds crenic, apocrenic, and humic acids, with extract of humus and humin. This was his view of the subject, if I understood it, in 1840; and it does not differ from his views seven years before, except in substituting recently the term humic acid for geine, and humin for carbonaceous mould. In this country, Dr. S. L. Dana employs the term geine in two senses. When he speaks *agriculturally*, he means by it "all the decomposed organic matter of the soil," which he divides into the soluble and insoluble; and in this sense he regards crenic and apocrenic acids, humin and extract of humin, as *forms of geine*. When he speaks *chemically*, he regards geine as a distinct compound, the same in composition as the substance denominated geine by Berzelius in 1833, and humic acid in 1840; although he supposes the humin and carbonaceous mould of the same chemist to be identical with humic acid, and of course only varieties of geine. Dr. Jackson, however, contends that geine is not a distinct compound, and that it is essentially composed of crenic and apocrenic acids. I mention these facts, not with a view to enter at all in this place, into the discussion of these points, but merely to call the attention of gentlemen to them as matters of great interest. I am too well acquainted with the gentlemen who have adopted different views on these subjects, not to believe that they will thankfully accept of light from any quarter, and consider it an honor, rather than a disgrace, to give up opinions which experiment or sound argument shows to be untenable. For they well know, that in a progressive science, like agricultural chemistry, the honor of original discovery belongs to him who makes an advance upon his predecessors; nor can it pluck the laurel from his brow, although others aided by his labors, should subsequently go beyond him. In the present case it may be thought, that rules for the analysis of soils, founded upon different views of the character of their organic matter, must be useless. But I must express the opinion, that the agricultural value of analyses, conducted according to these conflicting views, cannot be very different; and in a scientific respect, in the present state of agricultural chemistry, analyses performed in different modes must be an important means of arriving ultimately at the truth.

The remarkable fertilizing power of green sand, first discovered in this country, has raised another question in agricultural chemistry, of great practical interest, concerning which, there is not so much of an opposition, as of an unsettled state of opinion. The question is, which of the ingredients of this substance produce the fertilization. All will agree, probably, that the potassa found in some green sand, acts an important part. But if this is the only ingredient, then the green sands of New England and old England, will be of no agricultural value, as they are destitute of potassa. But others suppose that the iron exerts a favorable influence; and others, that the minutely divided state of the silica is important; as it seems to be in the Bergmehl, which is also useful in agriculture. But I have time only to express the confident expectation, that some of the gentlemen who hear me, will, ere many years, clear up this subject.

Had not these subjects been so intimately connected with several of the state surveys, they might seem irrelevant on this occasion. I return, therefore, to one more appropriately geological.

But little has yet been published respecting the anticlinal and synclinal axes and their correspondent systems of strata in our country; although I doubt not that numerous facts on the subject are in the note-books of our geologists, in respect to the particular sections of country which they have examined. But this is one of those subjects upon which, as upon diluvial action, general results, applicable to the whole country, can be made out only after long examination; it is one, therefore, peculiarly proper for such an association as I now address;—and I predict, that when the facts from different parts of this continent are collated and compared, it will be found that we have some of the most remarkable and magnificent systems of elevation and depression on the globe. There is no small reason to believe, indeed, that on the western side of this continent, from Cape Horn to the northern Arctic Ocean, one vast anticlinal axis exists, along the crest of the Andes and the Rocky Mountains. Subordinate and perhaps intersecting systems of strata will undoubtedly be found along this extended line; but this appears to be the great controlling and probably the most recent uplift on the continent. The occurrence of volcanic vents along the whole line, while they do not exist in the eastern part of the continent, renders it probable that the former has been upheaved at a later epoch than

the latter. But there is another fact that makes this almost certain, or it shows at least, that the western, and particularly the southwestern part of the continent, has been raised to a much greater height than the eastern side. It is well known that the cretaceous formation of North America passes under the Atlantic Ocean near New York, with its superincumbent tertiary strata. The latter reappear on Long Island, and in great distinctness on Martha's Vineyard, near the coast of Massachusetts, beyond which they are no more seen south of Greenland. But as we go southwesterly from New York, the chalk formation gradually rises, and between Council Bluff and the Rocky Mountains, as I am informed by Mr. Nicollet, it sometimes reaches the height of two thousand feet, which is much higher than on the Atlantic coast. It appears, also, from the recent memoir of Von Buch, on the petrifactions of South America, that the same formation exists extensively developed in the Andes, from 10° north to 15° south latitude. It there attains the astonishing height of thirteen thousand feet above the ocean. Subsequent to the cretaceous period, therefore, the Andes must have risen to that height; while the coast of New England and the middle states has been elevated only a few hundred feet. In the southern states the uplift appears to have been still less.

The Appalachian range of mountains forms another anticlinal ridge, extending northeasterly through New England, and not improbably to Labrador. The rise of this chain elevated the cretaceous and tertiary rocks on the Atlantic slope, as well as the new red sandstone, and tilted up the southeastern margin of the transition rocks in the valley of the Mississippi. The uplift of the Rocky Mountains raised the western side of the same rocks, and produced the easterly slope of the strata extending to the Mississippi. That river, therefore, flows through a synclinal valley, and it was the existence of that valley which determined its course. The same is true of the river Ohio, which, according to Dr. Hildreth, flows through a synclinal valley. The sections given by Prof. Emmons, show that the same is true of the St. Lawrence. From the last report of Mr. Houghton, it appears that Lake Superior occupies a synclinal valley, and not improbably a valley of elevation. East of Little Falls, according to Mr. Conrad, the Mohawk flows many miles through a valley of depression. In New England, the primary strata dip towards the Connecticut

river on both sides, at least through a considerable part of its course; and there is evidence, also, that an extensive fault in the primary rocks runs through that valley. Prof. Mather describes "a line of fracture and anticlinal axis" as passing a little west of the Hudson river, as well as numerous joints and fractures in the valley of the Hudson, which not improbably may be a valley of dislocation. Indeed, I doubt not that in most of those cases where rivers have found their way through gorges of lofty and precipitous ridges, it will be discovered that a break previously existed in the strata. To give an example:—the great western railroad, leading from Boston to Buffalo, and destined, ere long, to reach St. Louis, and ultimately perhaps the Pacific Ocean, is carried across the Hoosac range of mountains through a deep cut made across the ridges by Westfield river; and in no other place, probably, could it have been carried through. But I have recently satisfied myself that the course of that river was determined for a considerable distance, at least, by the existence of a wide fissure in the primary strata, which was subsequently filled in part by an enormous vein of granite. Is not this a beautiful example of prospective benevolence on the part of the Deity, thus, by means of a violent fracture of primary mountains, to provide for easy intercommunication through alpine regions, countless ages afterwards!

These slight sketches are sufficient to show that the great and striking features of our country are dependant upon a few extended axes of elevation and depression; and that probably subordinate anticlinal and synclinal lines will be found connected with most of the minor features of our surface. To trace them all out will be a great, yet most interesting work; as it will be to ascertain the systems of strata connected with them. Of the latter, we have in New England no less than five or six distinctly marked. They are all of them of ancient date, and most of them very ancient. The oldest, which may be called *the oldest meridional system*, because it runs not far from north and south, is composed chiefly of gneiss and mica slate; and crosses Massachusetts near its centre, including, although this is not certain, probably the most elevated land in New England. The second, which I call the *northeast and southwest system*, because it runs in that direction, is more distinctly marked than any other; having a high and uniform northwesterly dip. It corresponds in

direction with that of the Alleghany mountains, and probably forms a part of their most easterly ranges. It extends, also, through almost the whole of Maine. It is composed chiefly of primary rocks. The third system, I call the *east and west system*. It is composed of primary and the oldest fossiliferous rocks; having a northerly dip. It occupies no great space in New England. But perhaps the east and west ridges of mountains described by Dr. Houghton, on the south side of Lake Superior, may belong to the same system; although I think we ought to be very cautious in referring the rocks of widely separated regions to the same system; especially if their strike is merely parallel, and not upon the same continuous line. The fourth system embraces the rocks from gneiss upwards, so as to include most of the clay slate and Silurian groups. The strata have a perpendicular or inverted dip. I call it the *Hoosac or Green mountain system*, because it embraces most of those mountains: but if I mistake not, it extends through the whole of the Appalachian chain of mountains, and possesses some remarkable peculiarities, to which I shall shortly call your attention. The fifth system embraces only the new red sandstone and its associated trap; and hence it may be called the *new red sandstone system*. But I am in doubt whether it ought not to be embraced in the fourth system. The sixth system I call the *northwest and southeast system*, because such is its strike, with a small northeasterly dip. It occurs in Rhode Island, the southeast part of Massachusetts, and southwest part of Maine: but it is very limited, unless it should be found that the four ranges of mountains, described by Dr. Richardson, in the extreme northwesterly part of this continent, belong to it. I regard it as the most recent system in New England; because, although composed of gneiss and the older slates, it corresponds, in strike and dip, with the eocene tertiary on Martha's Vineyard; and probably both were elevated at the same time.

The whole number of systems of strata, corresponding in their general strike and dip in this country, will undoubtedly be found to be much greater than those now described. Nor should I have mentioned these, which have been observed in a limited district, had I not great confidence in the uniformity and great extent of the geological features of this country; so that if we find a particular arrangement in one district, we may safely presume upon the existence of its counterpart in other parts of the land. These

hints, therefore, may afford some feeble aid in the great work of tracing out the systems of elevation that exist on this continent.

I have alluded to some peculiarities in the Green Mountain system of strata; and if I may venture a little longer upon your patience, I will ask a few moments' attention to what I must regard as one of the most remarkable features in American geology. Still, I have so imperfect a knowledge of the subject, as to be conscious of venturing forward with few landmarks to guide me, into an almost unknown region. I am aware, also, that there are gentlemen before me, who have given the subject more attention than I have, and who are perhaps prepared for its full developement.

We have all read of the enormous dislocations and inversions of the strata of the Alps; and similar phenomena are said to exist in the Andes. Will it be believed, that we have an example in the United States on a still more magnificent scale than any yet described? I have mentioned in another connection, a series of strata, consisting of gneiss, mica, talcose, and argillaceous slates, with limestones and Silurian rocks, extending from Canada, along the western side of New England and the eastern side of New York, to the Highlands on Hudson river, and thence southwesterly through the Appalachian mountains as far as Alabama; a distance of at least twelve hundred miles. Along a large part of this distance, a remarkable apparent inversion of the dip exhibits itself; so that the newer rocks appear to pass beneath the older ones; and that too over a great width of surface. Certainly this is the case from Canada to New Jersey, and thence through Pennsylvania and Virginia, I infer from the reports of the Professors Rogers, that similar phenomena occur, which these gentlemen have been studying with great care and success; and the results, I learn, will soon be given to the public. The effects of the extraordinary agency under consideration, has not been simply to toss over the strata, so as to give them an inverted dip, but in general to produce a succession of folded axes, with a gentle slope and dip on their eastern sides, and a high dip, or more frequently an inverted one, on their western side.

Such a disturbance as this would be far less remarkable, were it not so extensive. I cannot describe the width of the belt that has been thus plicated, except in that portion of it which has fallen under my notice. It appears to me, that in the latitude of

Massachusetts, at least all the strata between the Hudson and Connecticut rivers, and probably a little west of the Hudson, about fifty miles in breadth, were affected by this disturbance. The first ridge, in going westerly from the Connecticut to Hudson river, is Hoosac mountain, and its eastern slope is gentle, while its western side is very steep, and the strata are nearly perpendicular, or radiate from the axis of the mountain. This appears to have been the principal axis of elevation. Next succeeds a deep valley and then the Taconic range of mountains, which also slopes gently on its east side, while its west side is very steep, and its crest very narrow. The dip of the strata is also small on the east side, and high on the other. Between this ridge and the Hudson, are no ranges of mountains very well marked, but the same large inverted dip continues, and probably more than one folded axis may be found in this space. Whether the belt of strata that have been subjected to this singular disturbance, is as broad, north or south of Massachusetts, I have no certain knowledge; but presume it to be as wide and probably wider.

I am aware that some able geologists,* whose opinions I highly respect, and who have carefully observed these phenomena, endeavor to explain them by supposing that we have mistaken the secondary divisional planes of the rocks for true planes of stratification; or that the character of the slaty and calcareous rocks of Taconic and Hoosac mountains has been misunderstood; and that they are in fact more recent than the fossiliferous rocks near the Hudson; in other words, that they are metamorphic. But for reasons that cannot now be given, for want of time, I have been forced to relinquish all these modes of explanation; and although I will not say that I fully adopt, yet I cannot but look with a favorable bias upon the only remaining solution of the problem already hinted at, that the strata have actually been tossed over from their original position.

Let us suppose the strata between Hudson and Connecticut rivers, while yet in a plastic state, (and the supposition may be extended to any other section across this belt of country from Canada to Alabama,) and while only slightly elevated, were acted upon by a force at the two rivers, exerted in opposite directions. If powerful enough, it might cause them to fold up into several

* See Prof. Emmons and Mather's views in the reports of the New York survey for 1837, p. 232, and for 1841, p. 92.

ridges; and if more powerful along the western than the eastern side, they might fall over so as to take an inverted dip, without producing any remarkable dislocations, while subsequent denudation would give to the surface its present outline.

Now in support of such a supposition, it may be said, first, that it would satisfactorily explain the present position of the strata. For if they could now be lifted up and made to dip in an opposite direction, every thing, for the most part, would be brought right; that is, the natural order of superposition would be restored. Secondly, this supposition explains the moderate dip of the rocks in the valleys, and the gentle slope of the mountains on their eastern sides, and the abrupt escarpment of their western sides. Thirdly, the occurrence of thermal springs along many of these folded axes, as is the case in New England and Virginia, and the extensive dolomitization of the limestone in the valleys, afford presumptive evidence of long lines of fracture, just where, by this hypothesis, they ought to exist. Fourthly, we should readily admit that such a plication and inversion of the strata might take place on a small scale. If for instance, we were to press against the extremities of a series of plastic layers two feet long, they could easily be made to assume the position into which the rocks under consideration are thrown. Why then should we not be equally ready to admit that this might as easily be done, over a breadth of fifty miles, and a length of twelve hundred, provided we can find in nature, forces sufficiently powerful? Finally, such forces do exist in nature, and have often been in operation. After we have admitted, as every geologist does admit, that the existing continents and mountains of the globe have been elevated from the ocean's bed, there is scarcely any effect, short of an impossibility, which we may not impute to the same agency. Merely for illustration, without maintaining its truth, let us suppose with Beaumont, that the vertical movements of our continents result from the shrinking of the internal parts of the earth, which causes a plication of its crust, simply by the force of gravity. And suppose the present crest of the Appalachian and Green mountains to have formed the line of least resistance on this continent. Is it difficult to conceive, that by such a power, a broad belt of the earth's crust, more than a thousand miles long, might have been ridged and overturned, with just as much facility, as a section two feet long, with the force which a man could exert? I

apprehend that the chief difficulty is to bring the mind up to a realization of so mighty an agency. In other words, the difficulty lies in the narrowness of our views, rather than in the inadequacy of nature. I confess, that as I have sometimes stood upon some of our loftiest mountains, that seem to have been overturned, and looked into the valleys, from one thousand to two thousand feet deep, and abroad upon the vast ridges that stretched away far as the eye could follow them on every side, and then tried to conceive of them extending from Canada to Alabama, and to have been ridged up and thrown over, my mind has staggered under the mighty thought, and I have involuntarily exclaimed, that such a work could have been performed only by the immediate agency of Him, who *meted out heaven with a span, and comprehended the dust of the earth in a measure, and weighed the mountains in scales, and the hills in a balance.*

But I must not dwell longer upon this fascinating theme:—and I must desist also, not for want of materials but for want of time, from pointing out other objects of interest in American geology that deserve the special attention of this Association.

And now, on looking back upon the ground which I have gone over, I am astonished and delighted at the progress of American geology, and it seems to me more like a dream than the reality. Only twenty five years ago, when first my attention was turned to the subject, excepting the grand but rough outline sketched by Maclure, and a few insulated efforts by Professors Silliman, Cleaveland and Eaton, and Dr. Hayden, all was darkness and perplexity. A geologist was as rare as an oasis amid the sands of Africa; and to be seen accoutred geologically, with hammer and knapsack, would subject one to ridicule, if not to a suspicion of insanity. But how changed the scene! From the top to the bottom of the series, the principal groups of our rocks seem now to be nearly settled and identified. And as the rapid rise and developement of this great nation is a spectacle of deep interest and sublimity, so our geologists find a correspondent grandeur in our rock formations. Now too, nearly all the state governments of this country extend their patronage to geological researches; lectures upon geology are demanded and given in all our larger towns; and the wonders of this science form the theme of discussion in the drawing-rooms of taste and fashion.

You perceive, therefore, gentlemen, that in the work which we have undertaken, we are urged forward by powerful motives;—and although much has been done, still more remains to be accomplished. Indeed, the enterprise is as yet only just begun. Even when the state surveys are completed, there will be abundant opportunity to gather fresh laurels in the same field. For, then the way will be prepared to go into particular districts, unincumbered by horses and carriages, and spending time enough there on foot, fully to explore and understand their structure; a work, which can hardly be done, except in a few instances, during the limited time devoted to the state surveys. A multitude of points in our geology, also, are yet only dimly seen, or imperfectly settled. In fixing these, and developing new discoveries, there will arise differences of opinion, and we may expect to fall into frequent perplexities and mistakes. But let not such differences generate distrust and alienation, among those who have an important common cause to sustain, and an interest as well as fellow-feeling in sustaining one another. Let discussion be as free as air; and let every man keep his mind open to conviction;—but American geologists, above all other scientific men, have no time for personal altercation. They have too great a work before them; they are scattered over so vast a field, that it will be difficult to interfere with one another; and all of them, I doubt not, would welcome other laborers, to aid in gathering the abundant harvest.

I make these remarks, not because I have observed among our geologists any peculiar tendency to alienation and controversy, but because I have witnessed the reverse; and, therefore, such remarks may have some influence in preserving them from those jealousies and personal altercations that have too often broken up the harmony of scientific associations.

As motives to continued exertion I have mentioned the favor of government, and the just estimation in which the community are beginning to hold our favorite science. But there are considerations of a much more elevated character, to urge onward the genuine student of nature. The cultivation of this science carries with it its own reward. It is continually disclosing to its votaries, facts and inferences of most thrilling interest. How eagerly does the antiquary unroll the newly discovered papyrus, that reveals an earlier chapter in a nation's history, or the exist-

ence of some hitherto unknown race! The farther back the new record carries him, the deeper is his interest and enthusiasm. Such developements of lost races and lost ages in the world's history, are continually rewarding the labors of the geologist;—and in point of antiquity, I had almost said, that the most ancient event in chronology, the six days work of creation, is the most recent in geology. From that beginning of *registered* time, we wander back through cycles of duration, which we can measure only by a succession of events, and not by chronological dates, except to be assured that they are inconceivably long;—and yet, the relics of those early periods are as fresh as if entombed yesterday. The fossil reptile, or fish, or shell,—nay, even their most delicate parts, are as perfect as when alive; although tens, and perhaps hundreds of thousands of years have rolled away since they died. We see their footmarks following one another in regular succession, as distinct as those of living animals upon the snow and the mud; and even the pattering of a shower, that fell thousands of ages ago, is as fresh before us, as if every drop had been instantly petrified. In short, there passes before us a series of distinct creations of organic beings, adapted to the varying condition of our planet; each successive group becoming more and more perfect, until every thing in nature was prepared for the existing races, with man as the crown of all.

Such developements as these are no longer to be regarded as the dreams of disordered fancy, but as the sober and legitimate deductions of science. And what large and refreshing views do they present of the plans and the benevolence of the Deity! They open back a vista as far and as wide into the arcana of time, as astronomy discloses into the arcana of space. They show us that the brief space of man's existence on the globe, is but one of the units of a vast series of cycles that have passed already away;—and the time is at hand, when geology, equally with astronomy, will be celebrated for its power of liberalizing the mind and filling it with noble conceptions of the universe and its Infinite Author. Surely, in such ennobling thoughts, the geologist finds a rich reward for all his toils.

I know indeed, that our science has been regarded as coming into collision with that sacred volume, to which, as Christians, we are bound to bow as the invariable standard of religious truth. Geologists, too, have been represented, and I must say without

any proof from their writings, as exulting in the supposed collision ;—but I am happy to believe, that such apprehensions are rapidly passing away. Theologians, of enlarged and impartial minds are beginning to study geology ; and instead of finding its truths hostile to revelation, they find, that it furnishes them with new and interesting matter, such as no other science can, for illustrating the perfections and government of Jehovah ;—and such men as Drs. Chalmers and Smith,* have already reaped from it a rich harvest. I trust that the day is not distant, when the supposed geological objection to revelation will be as little remembered, as is now the analogous objection derived from the Copernican system of astronomy ; and which, two or three hundred years ago, was supposed to be fraught with so much danger.

Another mode in which practical geology carries with it its own reward, is by bringing us into constant communion with unsophisticated nature, in her most sublime and interesting aspects. It is hardly possible to place the geologist in any spot on the globe, where he does not witness around him the marks of mighty agencies and revolutions, that are unheeded by the common mind, but which furnish him with a rich fund for reflection. But his most appropriate place is among the wildest scenery of nature ; now, plunging into the deep cavern, studded with glittering spars, and perhaps the charnel-house of the antediluvian world ; now, tracing his way through the dark gorge, with jutting rocks rising around him, as if they formed the battlements of heaven ; now, mounting the lofty ridge and drinking in the glories of the vast landscape ; and now, standing upon the edge of the yawning precipice, to witness the roaring cataract, as the waters thunder down their steep and rocky bed, until, escaping from their narrow passage, they flow out quietly, as the calm and majestic river, to fertilize and beautify the extended plain. In all these scenes, he sees the arm of Omnipotence laid bare, and is initiated into the sublimest mysteries of nature. There, while his body and his mind are invigorated, he acquires a permanent relish for all in creation that is sublimely great and elegantly little. Henceforth, he possesses a source of gratification of which

* See Chalmers's Natural Theology, and Smith's Lectures on the Relation between the Holy Scriptures and some parts of Geological Science. An able view of this subject is also given in the sermons of Rev. Mr. Melville, of London, Vol. ii, p. 297, Am. edition.

all the fluctuations and calamities of life cannot deprive him. Other sources of happiness, as circumstances change and age advances, will pass away. But, a genuine attachment to nature clinging to the heart will buoy it up, when the powers begin to fail, and the floods of affliction to roll over us; and like the volcano surrounded by polar snows, the flame will seem more bright and beautiful amid the frosts of age. *Hæc studia adolescentiam alunt, senectutem oblectant, secundas res ornant, adversis perfugium ac solatium præbent; delectant domi, non impediunt foris; pernoctant nobiscum, peregrinantur, rusticantur.* (Cicero, Orat. pro Archia.)

Gentlemen, in these remarks I am confident that I am describing your own experience. For this love of nature, and not governmental or individual patronage, has been your chief stimulant in geological research. Should that patronage, which is now extended to your efforts, be withdrawn,—of which I have little fear,—and should the tide of popular favor turn against you, I know that you will not, therefore, be diverted from your favorite pursuit. No: let us rather pledge ourselves to more vigorous efforts in this noble enterprise, which has already done so much, and is destined to do much more, to develop the resources of our beloved country; so much to awaken youthful genius; so much to promote our personal happiness; so much to enlarge the boundaries of science; and, above all, so much to unfold the glories and illustrate the perfections of the INFINITE DEITY.

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Prof. B. Silliman, LL. D., &c. to deliver the opening address.

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