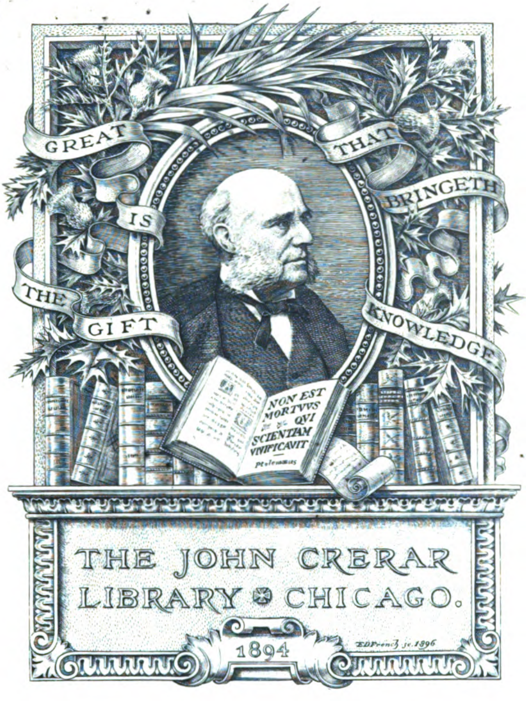
GREAT IS THE GIFT THAT BRINGETH KNOWLEDGE
NON EST MORTVVS QVI SCIENTIAM VIVIFICAVIT
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ADDRESS

DELIVERED BEFORE THE

ASSOCIATION OF

AMERICAN GEOLOGISTS AND NATURALISTS,

AT THEIR MEETING

HELD IN BOSTON, APRIL 25–30, 1842,

BY PROF. B. SILLIMAN,

OF YALE COLLEGE.

WITH AN ABSTRACT OF THE PROCEEDINGS AT THE MEETING.

NEW YORK:
WILEY & PUTNAM.
1842.

ADDRESS.*

GENTLEMEN OF THE ASSOCIATION :—

DURING the past year, my labors have been, with few exceptions, confined to the study, the cabinet, and the laboratory; while their results, such as they are, have been presented in the American Journal of Science, in the lecture rooms of my own university, or in the halls of several of our towns and cities. Since our former meeting at Philadelphia, I have not enjoyed as many opportunities as in gone-by years, of making original geological explorations. In that time, I have been only two days in the field, but those were days of peculiar interest, because they afforded me an opportunity of comparing my own views, respecting a very remarkable region,† with those of one whose experience and knowledge confer peculiar value upon his opinions.

Still, I could have much preferred, that the present duty should have been assigned to some one of the able practical explorers now before us: geologists not of the cabinet, merely, but fresh from actual toil upon the broad field of nature; fresh from exploring tortuous river courses, intricate defiles, precipitous valleys, mazy caverns, deep mines, impending sea cliffs, lofty mountain tops, and alpine glaciers, with their cataracts, their avalanches,

* Delivered in the Swedenborgian Chapel, Boston, on Tuesday evening, April 25, before the Association and the public: republished from the American Journal of Science and Arts, Vol. XLIII, No. 2.

† The red sandstone and trap formation around New Haven.

and their eternal snows—for such scenes are familiar, in a greater or less degree, to some of those whom I have now the honor to address. In the absence of similar opportunities of recent date, permit me to rally a few of the impressions of our science existing in my own mind, and to occupy a portion of the passing evening in speaking to you—

Of the dignity and importance of geology; of its object, means, and ends; of its progress and present condition, especially in the United States; of its desiderata and difficulties; and of some of the powers or dynamics by which its results are produced.

OF THE DIGNITY AND IMPORTANCE OF GEOLOGY.

The planet on which we dwell is our birth-place—it is our cradle, and it will be our grave—the grave of our mortal bodies, but not of our immortal minds. In the present life, it is the scene of our busy action—but we aspire to a better life in a brighter world, where vicissitudes and death are unknown. These exalted hopes we build on our religious faith, founded on the intellectual and moral revelation which God has made to man. But our advancement in natural science is not dependent upon our faith. All the problems of physical science are *worked out* by laborious examination, and strict induction. If the toil is great, the reward is also rich. In this delightful exercise of our faculties, we attain high intellectual and moral advancement; we gratify our curiosity and regale our imaginations, by interesting discoveries, while we constantly improve our condition, and advance to the highest degrees of civilization and social improvement.

Geology, whether studied in the cabinet or in the field, is always replete with interest. Founded on the sure basis of observation, advancing year by year, in the development of new facts, it is, truly, a *noble science*, which is destined to advance to the end of time. In grandeur, geology is inferior only to astronomy; but it is superior to it in its inexhaustible stores of tangible facts, diversified in all the profusion of creative power, and rising to our view in the form of the most astonishing revelations. Astronomy is dependent upon one sense only, aided by telescopes, by the mathematics, and by geometry; its objects, innumerable indeed, are vast in magnitude, and placed at such inconceivable distances that the mind is overwhelmed in the contemplation;—

and when the machinery of the heavens is understood, our triumph in the amazing discovery is chastened by a profound consciousness of humiliation, in view of our own comparative insignificance.

Geology summons to its aid all our senses; its objects are every where around us—they are constantly before our eyes and beneath our feet; we cannot escape from them if we would—we see them—we feel and handle them. The telescope, whose field of vision is the starry sky, is comparatively useless in the fields of geology. We do, indeed, direct it to the snowy pinnacles, the inaccessible mountain cliffs, and the volcanic beacon lights; it is, however, only that we may judge of their bearing, their distances and elevation; but the telescope, while it penetrates the profound darkness of celestial space, and collects in a bright focus the scattered rays, that have wandered from distant worlds, is powerless, if directed towards the earth; for, excepting the occasional glare of volcanic fires, no light comes to us from the profound recesses of our planet.

MICROSCOPICAL RESEARCHES.

Geology has, however, derived powerful aid from the microscope, which, in astronomy, has not the smallest application. The microscope has revealed to us the intimate and concealed structure of fossil plants—of petrified trees, whose delicate vessels had been filled with mineral matter—siliceous, calcareous or metallic—or whose substance had been converted into coal; we discern the fibres and tissue of primeval forests converted into stone; their resins and gums stored away in the dark beds of coal, are now, as it were, created anew, like beings of yesterday, and thus we restore the vegetation of remote ages. The microscope has brought the most signal aid to comparative anatomy; by its assistance, thin sections of both fossil and modern teeth and bones are compared, and thus analogies and contrasts are established between the ancient and the recent races of animals. The earth is the grand mausoleum of the beings that have lived and died upon its surface, in its atmosphere, or in its waters.

The laws of carnivorous as well as of vegetable regimen, and the ordinary course of spontaneous decomposition do, indeed, resolve by far the greater number of living beings into food, or into new forms of animated existence—thus causing their elements to travel in ceaseless circles of organic revolution; but vast numbers of them, escaping from the general ruin, are entombed without being destroyed—their elements are not separated nor their members dissevered; their forms, filled in with and accurately copied by mineral matter, are encased in solid stone, or frequently in metals, and thus unfold to our view—in the firm rocks of our plains, hills, and mountains—a lucid record of their chronology, equally incapable of being falsified or misinterpreted.

Thus among the fossilized animals and plants, we discover forms both of colossal and minute dimensions; until the unassisted eye ceases to distinguish between the organized being, and the mineral matter by which it is enveloped. And here it might well have been supposed, that we had reached the ultimate limit of optical research; and little did our predecessors, or even ourselves, until very recently, imagine, that still another world lay concealed, in senseless mineral matter, and that it would in due time be fully disclosed to our inspection. Wonders on wonders had, indeed, been revealed in former years, by the microscope, among the infinitesimal tribes—our living contemporaries—that at this moment, in full activity, people the bodies of plants and animals, the waters, the atmosphere, and the wide earth. But these are only the successors of similar races now to a great extent extinct, for we are convinced by the evidence of our senses, that animalcules, often of inconceivable minuteness, were not less numerous or various, in earlier ages, than at present.

The microscope, in the hands of Ehrenberg of Berlin and of his pupils and followers, and of other students of microscopic analysis, (among whom Professor J. W. Bailey of West Point is the most distinguished in this country,) has not only passed in review the living infusorial animalculæ, but has penetrated the veil that concealed the fossilized races, whose existence had not been even suspected. We are now enabled to *see*, not vaguely, but in accurate forms and with appropriate organization, the thousands of millions of animalcules, which, encased in shields of flint, peopled, in the dimensions of a single cubic inch, the waters that deposited the polishing slate (rotten stone) of Bilin, and the sediment of peat bogs; the bog iron ores are not less replete with similar beings, clad in ferruginous envelopes, in coats of iron armor, like the knights of historical romance. Even the hard agates and chalcedonies, the opals, the jaspers, and the chalk flints, bear ample testimony, by their included organic forms, that the time was, when they were not in existence, and these evanescent beings, the fossil animalculæ, enjoyed their day or hour of life, before these beautiful minerals were formed.

In the same manner, the vast beds of tertiary, of chalk, and many of the secondary limestones disclose, under the searching scrutiny of the microscope, a world of minute organic forms, that once lived in that earlier ocean by whose waves their elegant structures were first sustained, and then broken down and comminuted into an earthy calcareous powder, which, to the naked eye, appears almost impalpable. In similar circumstances, both in the cretaceous and tertiary strata of New Jersey and Virginia, (as observed by Professors Bailey and Rogers,) the microscope reveals to our eyes myriads of Foraminifera* or polythalamous shells—their divisions perfect, their delicate edges and processes in fine preservation, their porcelain varnish lustrous and beautiful, and still so inconceivably small, that thousands of them have been seen to run, in a few minutes, through a pin-hole in a piece of paper.†

The attention of geologists is now powerfully directed to the results of microscopic analysis, which will probably be carried back through the earlier aqueous rocks, and may not cease until we arrive within the domain of fire, nor perhaps even before we reach to rocks that have been in actual fusion, where, of course, we should expect that all traces of organization would be destroyed. Although we cannot assign a limit to these researches, we are certain that one must exist, since, it is obvious, that mineral matter must have been first in the order of the creation; for no organized beings could have existed, until earth, waters, and air were provided, as the scene of their action, and to afford them the elements of nutrition.

It appears from these instances, that geology takes a high rank among the physical sciences. Indeed, while to a great extent it involves a knowledge of them all, it repays the zealous explorer with a rich intellectual recompense, and affords to civili-

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* This Jour., Vol XLI, p. 213. Prof. H. D. Rogers's final report on New Jersey. Prof. W. B. Rogers's report on geology of Virginia, 1841, pp. 38 to 42.

† This latter fact was observed by Mr. Lonsdale with respect to the chalk of England.

zed communities the most ample means of wealth and of unlimited improvement. Geology, although not carried to perfection, is truly a science; for—

"Its ascertained facts are numerous; they are correctly observed and reported; they are skillfully classed and arranged, and a sufficient number of general as well as particular conclusions, has been drawn from them, to furnish the basis of a most interesting science. Its boundaries are daily extending, and will be extended without limit by continued observations; its evidence will therefore constantly accumulate, and although its theoretical speculations may change, nothing can occur to subvert the grand conclusion that the earth has a regular structure, and that its materials have been arranged, under the operation of general laws of great energy and duration, the physical expression of omniscient intelligence and omnipotent sway, guided by benevolent design, which becomes more and more apparent and convincing with every new and successful research in geology."*

OF ITS OBJECT, MEANS, AND ENDS.

Geology discloses the structure of the earth, and the nature of the mineral masses of which it is composed—the order of their succession and arrangement—the chemical composition of the rocks—the distinct minerals and the remains of organized beings which they contain—the veins and beds of metals—the strata of coal, limestone, plaster of Paris, mineral salt, clay, sand, and other materials useful or indispensable to civilized society; and it investigates the proximate causes which have produced the various effects that we behold, and which still continuing to operate will, in all future time, go on to produce their appropriate results.

It might seem to a common observer, that, treading only upon the crust of the earth, we can know very little of the deep interior of a planet, whose diameter is eight thousand miles; and that therefore any attempt to ascertain its structure, must be equally presumptuous and vain. But the geologist finds much more ample sources of information than might at first appear.

"Every artificial excavation—every well and cellar—every cut for a fort, for a common road, a rail-way, or a canal—every stone-

* The Author's Introduction to Mantell's Wonders of Geology. Am. edition.

quarry and gravel pit—every tunnel through a mountain, and every pit and gallery of a mine—every boring for coal, for salt, or salt water, and every artesian perforation—furnish means of perusing the interior structure. Still more, do the inland precipices and the rocky promontories and headlands that rise along the rivers, lakes, seas and oceans; the naked mountain sides, ribbed with jutting strata, that bound the defiles, gorges, and valleys; the ruins accumulated at the feet of lofty pinnacles and mountain barriers, and those that have been transported far and wide over the earth, present to us striking features of the interior structure of the planet.

"Most of all, do the inclined strata push up their hard edges in varied succession, and thus faithfully disclose the form and substance of the deep interior, as it exists—many, it may be hundreds of miles and leagues, beneath the observer's feet."

"Volcanic eruptions throw up into daylight, the foundations of the fathomless deep below, either in the form of ejected or of molten masses, flowing even in rivers of fluid and ignited rocks, which congeal again on the surface of the ground, either inflated like the scoriæ of furnaces or in solid forms; often retaining no visible impress of fire, and containing, occasionally, very perfect and beautiful minerals, produced by heat in the bosom of the volcano, or dislodged from still earlier beds from a more profound igneous abyss, and impelled along by the irresistible current which often ruptures the crust of the earth, and covers it with a fiery deluge."

"In addition to the products of actual volcanoes—the ignigenous rocks, the granites, the sienites, the porphyries, the serpentines, the soapstones, and the traps—crystallized or amorphously deposited from fusion—injected both in the earlier and in many of the more modern epochs, among other rocks, and cutting across the strata of almost all descriptions and ages, are thus assimilated to the lavas, the known products of internal heat. Thus they give authentic information of the unapproachable gulf of fire, from which they were projected."

"The internal waters that gush cool from the fountains on land or under the sea, or those jets that spout in boiling geysers, from the deep caverns, where their imprisoned vapors accumulate explosive force; all these bring to the surface the materials of the deep interior, and conspire with tornadoes of gas, bursting from volcanoes and other vents, to reveal the deep secrets of the earth."*

From all these sources, we have derived a competent knowledge of the structure of the crust of the earth—of that portion with which we are immediately concerned. Every extension of geographical research, especially as prosecuted in modern times, by the English, the Russians, the French, and the Americans, whether in overland or in maritime expeditions—to the islands of the Indian, Southern, and Pacific oceans, or towards the opposite poles—conspires to confirm the conclusion that a grand uniformity and simplicity of design characterize the geological structure of all countries, however remote. There is the same order in the arrangement of the rocks—there are the same associations of strata and of minerals—the same fossils marking similar geological epochs; and therefore we infer that a uniform code of laws has been prescribed for the whole.

Coal, with its characteristic fossil vegetables, is found in Melville Island, far within the northern polar circle, and Captain Ross, in 78° of south latitude, has recently discovered a powerful volcano in great activity, amidst the eternal snows and glaciers of the southern pole, flashing vividly upon the frozen Antarctic sky, from a crater at the elevation of 12,500 feet—a truly polar Teneriffe.†

Thus it appears that the polar lands of both hemispheres are glowing with intense igneous action. Iceland is a vast classical region of volcanic fire; the antipodal polar zones are sustained, it may be, upon subterranean seas of melted rock, covered by mountains and glaciers of eternal ice and snow, through which the internal fires force, here and there, an opening, and thus reveal the secrets of the nether abyss.

OF ITS PROGRESS AND PRESENT CONDITION, ESPECIALLY IN THE UNITED STATES.

Within our present limits of time, it would be in vain that we attempt even a sketch of a general history of our science, and the effort would be quite superfluous, as the work has been admirably done to our hands, in the introduction to Mr. Lyell's Principles of Geology. I trust I shall therefore be excused for

* *Loc. cit.*

† London, Edinburgh, and Dublin Philos. Mag. for Feb. 1842.

speaking only of my own times and for yielding to the necessity of introducing some notices of my own personal history, as connected, however humbly, with the progress of this science in the United States.

Having been educated to the profession of law, I was induced by the late President Dwight of Yale College, to enter on a new career, and to endeavor to qualify myself for the departments of science, to which I have since been devoted, and of which I was then ignorant. Two or three years of preparation in this country and another year in Europe encouraged me to enter, in 1806, upon a fuller discharge of the duties which I had partially commenced before going abroad. Chemistry was then my leading object, and mineralogy and geology were only appendages. In the latter sciences, it was then almost in vain that we sought in this country for cabinets or instructors. The most common minerals were known to very few, and I accounted it a piece of rare good fortune, that an introduction to the late Dr. Adam Seybert of Philadelphia, then recently returned from the celebrated mineral school of Werner, at Freyberg in Germany, enabled me to spread before that gentleman (Dr. Seybert) the entire cabinet of Yale College, which, for the sake of having the specimens named by him, I packed in a small portable box, and carried with me to Philadelphia. We may now, with pride and pleasure, contrast these *angustæ res* of earlier days, with the ample cabinets which are at present found in our institutions as well as in the hands of private individuals.* Geology was at that period, (1804–5,) less known among us than mineralogy. Most of the rocks were without a name, except so far as they were quarried for economical purposes, and classification of the strata was quite unknown.

Passing over to England in the spring of 1805, and fixing my residence for six months in London, I found *there* no school, public or private, for geological instruction, and no association for the cultivation of the science, which was not even named in the English universities. To the deep ancient mines in the Peak of Derbyshire, in central England, I had already resorted, and to these explorations I added others in the still deeper mines of Cornwall, famous from high antiquity for their tin, and in more modern times for their copper, both obtained at profound depths,

* That of Yale College is particularly large and fine.

and in some instances in galleries carried out beneath the bottom of the sea, where the chafing of the pebbles could be heard over the heads of the miners as they were pursuing their work. Although England was then without accessible means of scientific instruction in geology, and even mineralogy was far from making a considerable figure, many causes were in operation, to prepare the way for the signal development of scientific geology which soon after began to be made. Mining had been carried on for ages in Great Britain; her mines were numerous and deep, and very various in their productions, both in profitable and curious minerals; in this natural school of mines, many mining engineers and practical geologists were forming in various parts of the kingdom.—Among these, William Smith* was laying the foundations of British scientific geology, by examining and comparing, quietly and almost in solitude, the secondary strata of England, especially as to their organic remains, which he found to hold a constant connexion with their order of deposition; and to him, more than to any other man either in Britain or elsewhere, is due the honor of demonstrating that particular fossils are characteristic of particular strata—the types by which they may be recognized, in situations the most remote. Mr. Smith has been therefore justly called the father of English geology, and he lived to see the splendor of its present bright meridian sun. His geological map and sections of England were founded upon his own laborious and long continued exertions, unaided by any public body or scientific association.

GEOLOGICAL SOCIETY.

But private individuals were no longer compelled to labor alone. In 1807, that noble association, the Geological Society of London was founded, and organized in 1811, in which year its first volume of Transactions appeared. Immediately, voices of grat-

* Mr. William Smith, of Scarborough, England, was born in 1769 at Churchill, on the oolite formation in the county of Oxford. His taste for geology was early formed, by collecting terebratulæ from the oolitic rocks in the fields of his native village, which he used as a substitute for marbles. He had often expressed a wish to be buried in this formation, on which he was born and educated, and the history of which he had so much elucidated. He died in August, 1839, on his way to the meeting of the British Association at Birmingham, aged 71, and was interred in the churchyard of the beautiful Norman church of St Peter, in Northampton, which stands on the oolite formation.—*Dr. Buckland's Address*, 1840: *quoted in this Journal*, Vol. XL, p. 219.

ulation from every quarter hailed and cheered onward the new-born institution, which like Hercules, was vigorous even in its infancy, and in its advancing maturity has already performed numerous and most important labors. Its untiring activity, its concentrated scientific talent and zeal, its munificent endowments, and its splendid success, have for more than a third of a century, given it universal and richly deserved celebrity. We cannot on the present occasion, even mention the names of its most conspicuous members, and they stand in no need of our commemoration, for their worthy deeds are fully recorded and amply illustrated in the now numerous quartos of the Society's Transactions.

GEOLOGY IN SCOTLAND.

Returning to my personal narrative in Britain, I beg leave to remark, that having eagerly seized upon every opportunity of making observations in geology, I had learned in the mines and mining districts, *how* and *what* to observe; and in passing through the length and breadth of England in four different directions, I was almost never without some instructive field before me. Glancing at the coal regions of the middle and northern counties, at the chalk downs and escarpments of Wiltshire and the Isle of Wight, at the quarries and cliffs of limestone and oolite of Bristol and Bath, at the sandstone quarries of Liverpool, the granite tors and sea-beaten precipices of Cornwall and the Lands End, the gravel pits and clays of the London basin, and the lime-kilns of Gravesend,—none of these scenes were without instruction to one whose curiosity was awakened and whose youthful enthusiasm was kindled by vivid perceptions of the beauty and grandeur of geology. Nor was a view of the boundless green meadows of Holland—a vast alluvial with immense beds of peat, redeemed from an ocean, whose waves were held in sullen repulse by artificial dykes and natural mounds of sand, thrown up by the billows themselves, along the seaward line of coast;—nor were the interminable sandy plains of Dutch Brabant, nor the rural luxuriance of the Austrian Netherlands, without geological utility, since no scene, however tame to a common eye, is without instruction to a geologist.

A rapid transit, late in November, 1805, through the fens of Cambridgeshire and the picturesque wolds of Yorkshire, brought me across the Tweed to Scotland, to view the bleak and naked hills of Berwickshire, the fertile fields of Mid Lothian, and the castellated trap rocks of Edinburgh, rising in black frowning peaks and ridges, in the very bosom of that beautiful city. Arriving in Edinburgh at midnight, the morning light disclosed to my view the noble outlines of a grand and beautiful country, and I was in an instant transported to my own quiet city of New Haven, the hills near to which, (of whose geological character I was far from feeling assured, even up to the hour of my leaving them behind,) I now felt convinced were true trappean ridges and peaks, adorned, like Salisbury Craig, Arthur's Seat, and the Castle Rock of Edinburgh, with grand colonnades and castellated summits.

In Edinburgh, that focus of talent and knowledge, chemistry was then cultivated with great zeal and success, both in the university and in private courses; it presented ample stores of science, with rich and satisfactory proofs by experiment. All the departments of physical science were indeed well sustained there, but our limits of time will allow us to speak on the present occasion only of geology. In that science, Edinburgh was then far in advance of London. It shone as a brilliant boreal aurora, whose coruscations mounting to the zenith, were observed even in the distant south, soon to be illuminated in its turn by an increasing and steady effulgence. To produce this state of things, various causes had concurred. The region around Edinburgh is rich in geological facts; that for many miles around London was then supposed (although erroneously) to possess very little geological interest; for its tertiary treasures had been little explored, and they, as well as the similar deposits in other countries, had as yet received no distinct classification in geology. Prof. Jameson having recently returned from the school of Werner, fully instructed in the doctrines of his illustrious teacher, was ardently engaged to maintain them, and his eloquent and acute friend, the late Dr. John Murray, was a powerful auxiliary in the same cause; both of these philosophers strenuously maintaining the ascendancy of the aqueous over the igneous agencies, in the geological phenomena of our planet.

On the other hand, the disciples and friends of Dr. Hutton* were not less active. He died in 1797, and his mantle fell upon

* Dr. James Hutton, born 1726, was graduated as M. D. at Leyden in 1749, settled in Edinburgh in 1768. He published various works on science, and in 1795 his Theory of the Earth, in two volumes octavo, which was explained with additional illustrations by his friend, Prof. Playfair.

Sir James Hall, who, with Prof. Playfair and Prof. Thomas Hope, maintained with signal ability, the igneous theory of Hutton. It did not become one who was still a youth and a novice, to enter the arena of the geological tournament where such powerful champions waged war; but it was very interesting to view the combat, well sustained as it was on both sides, and protracted, without a decisive issue, into a drawn battle.

Scotland and its isles present a great geological cabinet, where especially the phenomena attributed by Vulcanists to igneous action, are exceedingly remarkable. They had been examined with a severe and discriminating scrutiny by Dr. Hutton and his followers; Playfair had reviewed them in his splendid illustrations of the Huttonian theory, and had followed them into the few districts of England, Derbyshire, Cornwall, &c. where similar phenomena had then been observed. Dr. Murray had also published a lucid comparative view of the Huttonian and Wernerian theories. Wales, now made classical ground, both for the ancient fossiliferous and for the igneous rocks, by the memorable researches of Murchison and Sedgwick, was then regarded merely as a country of quarries, whose mountains were indeed rich in slate and coal, but presented, as was supposed, no particular geological interest.

The conflicts of the rival schools of Edinburgh—the Neptunists and the Vulcanists, the Wernerians and the Huttonians, were sustained with great zeal, energy, talent, and science; they were indeed marked *too decidedly* by a partisan spirit, but this very spirit excited untiring activity in discovering, arranging, and criticising the facts of geology. It was a transition period between the epoch of geological hypotheses and dreams, which had passed by, and the era of strict philosophical induction, in which the geologists of the present day are trained. No state of things could, however, have been better adapted to excite the enthusiasm and fix the taste of a youthful mind, just beginning to feel the vast power of geological truth, and to relish with intense interest both its researches and its speculations.

I was therefore a diligent and delighted listener to the discussions of both schools. Still the igneous philosophers appeared to me to assume more than had been proved regarding internal heat. In imagination we were plunged into a fiery Phlegethon, and I was glad to find relief in the cold bath of the Wernerian ocean, where my predilections inclined me to linger. But the preference for the aqueous over the igneous agencies gradually yielded to the force of accumulating evidence, until both views became combined in my mind into one harmonious whole.

EARLY CONDITION OF GEOLOGY IN THE UNITED STATES.

Early after the establishment of the European colonies in North America, researches were undertaken for valuable minerals, chiefly the ores of metals, and many remains of ancient diggings are found, which in general contributed as little to the advantage of the adventurers as of science. The records of our learned societies, however, present a considerable number of papers, both of an earlier and later date, containing notices of facts in mineralogy and geology, and sometimes scientific speculations. In looking over the volumes of the Philosophical Society of Philadelphia, we find, that

Belknap wrote upon the White Mountains, 1784. Hutchins on the rock and cascade of the Youhigony, 1786. Franklin proposed a theory of the earth, 1793. Latrobe described freestone quarries, 1807. Maclure gave a geological map in 1809.* Gilmer gave a theory of the Natural Bridge in Virginia, 1816. Steinhauer elaborately described and figured several of our coal plants, 1818. Jefferson described the megalonyx, mastodon, &c., 1818. Drake the valley of the Ohio, 1817. Gibson trap rocks in Pennsylvania, 1820. James the trap and sandstone of the west, 1821. Hayes described mastodon bones, 1834. Harlan the fossil bones of the tertiary, 1834.† W. B. and H. D. Rogers the tertiary of Virginia, 1839. Clemson and Taylor the coal of Cuba, 1839. Lea the oolitic fossils of North America, &c., 1840.

In the Transactions of the Boston Academy, we find—

Belknap on vitriol and sulphur in New Hampshire, 1780. Gannett on a yellow mineral pigment, 1782. Webster on oil stone, 1782. Lincoln on the geology of York river in Virginia, 1783. Gannett and Jones on the West River Mountain, 1783. Williams on earthquakes, 1785. Baylies on Gay Head, Martha's Vineyard, 1786. Hitchcock on frogs found in the earth, 1789. Dewitt on the minerals of New York, 1799. Fothergill on ice islands, 1809. Godon on the minerals near Boston, 1807 and 1808.

* Revised in 1817.

† And bones of the Ichthyosaurus found in Missouri.

Cleaveland on fossil shells, 1808. J. F. and S. L. Dana on the mineralogy and geology of Boston and its vicinity, 1818. Jackson and Alger on the mineralogy and geology of Nova Scotia, 1831.

There are numerous geological notices in our medical journals, especially in the Medical Repository of Mitchill and Miller, of New York; in the Proceedings of the Geological Society of Pennsylvania; in the Physical Researches of Dr. Harlan; the Contributions of Mr. Lea; the works of Vanuxem and Morton, especially in the distinct volume of the latter upon the chalk formation; and doubtless in many other works which we cannot recollect or need not enumerate.

Resuming my personal narrative, I returned to America in June, 1806, and being anxious to compare the region of New Haven with that of Edinburgh, I eagerly reviewed my own immediate district. It is a fine region of trap rocks, with sandstones, through which the traps rise in bold ridges and peaks, while in close proximity, are immense ranges of primary rocks, amorphous and slaty. Of this region, on an area described by a radius of five or six miles, I made a geological survey and a report,* the imperfections of which may claim the more indulgence, as it was, I believe, the earliest attempt, but one, of the kind in the United States.† In the year 1799, a very brief mention is made by Thomas P. Smith, in the Transactions of the Philosophical Society of Philadelphia, (old series, Vol. 4, p. 445,) of some columns of basalt in Pennsylvania, and in the year following my report in the same records. M. Godon, a French geologist then in this country, presented some minutes towards a geological map of a part of Delaware, which I believe was never finished.

In 1807, the year after my return, Mr. William Maclure passed several days in examining the geology of the immediate vicinity of New Haven, and I enjoyed the advantage of being with him on that occasion. He was then engaged in that extensive tour of observation which eventually covered the United States, Canada, and the West Indies. Of these labors he communicated an account to the Philosophical Society of Philadelphia in 1809,

* To the Connecticut Academy of Arts and Sciences.

† At the meeting of the Association in Boston, Dr. Dana read the title of what was probably the first geological report made on American geology, viz.—"Beytrage zur mineralogepfer Keintre und des Cëstlicheu theils von Nord America und sum Gebürsge von D. Johamre David Schöpf."

and a revised and extended account in 1817, which was published in their Transactions for 1818, with a colored geological map.

Mr. Maclure had personally examined almost every remarkable geological field in Europe, and was therefore well qualified, according to the standard of knowledge of that day, for the Herculean labor which he undertook. His geology of the United States was also published separately at his own expense, in a small unpretending volume, of which the motto might well have been, *multum in parvo.* It was however imperfect, especially in the more recent formations, the dividing lines having then been but very imperfectly drawn, between the alluvial and the tertiary, between the tertiary and the newer secondary, and even between the different members of the latter; and, moreover, the study of fossils and of fossil anatomy, having since that period made great advances, it is not surprising that younger geologists, in surveying in detail parts of Mr. Maclure's domain, should have found some things to correct and much to supply.

Still, William Maclure, (who was the William Smith of this country,) performed an immense service for geology, and this, with his munificent endowment of the Academy of Natural Sciences of Philadelphia—in its library, its cabinet, and its noble hall—and his liberal donations in many other ways, for the promotion of useful knowledge, for the education and elevation of the ignorant and the oppressed in various places and countries, richly entitle him to the gratitude of mankind, and to the warm eulogium pronounced upon him by Dr. Morton, the president of this Association.

William Maclure passed the latter years of his life in the city of Mexico, to which he was attracted by its fine climate, and there he died about two years ago, at the age of very nearly fourscore. Mr. Maclure brought large collections of specimens of minerals into the United States, but the earlier cabinets formed in this country, or imported from abroad, had more reference to mineralogy than to geology. They however excited attention, promoted inquiry and observation, and gradually attracted geological collections around them.

Such were the cabinets of Harvard University, presented by Dr. Lettsom and the French republic, and since splendidly enlarged by Professor Webster; the collection at Bowdoin College, Maine, by Prof. Cleaveland; that of Dr. Samuel L. Mitchill, and of Dr. Hosack, and more especially of Dr. A. Bruce, of New York; that of the Philosophical Society, and of Dr. Seybert, in Philadelphia; that of Prof. Frederick Hall, recently presented by him to Dartmouth College, with a foundation for a professorship of mineralogy and geology; that of B. D. Perkins and of Col. Gibbs, the latter a splendid collection, since purchased, as that of B. D. Perkins had been before, by Yale College. Col. Gibbs was a zealous promoter of geology as well as of mineralogy. He freely gave time, influence, and money for these objects; and it was my fortune during the summers of 1807 and 1808, to explore with him the beautiful fields of Rhode Island. He was fresh from the French school of mines of Paris, and fully imbued with the science of that fine national institution.

It will be observed, that the period of which we are speaking was contemporary with that of the formation of the Geological Society of London. The impulse given in Europe had reached America, and now geology began to be taught among the physical classics of our country, in most of the higher institutions of learning.

Individuals, either alone or associated, undertook geological explorations. Among the earlier were those of Prof. Cleaveland in Maine, and his fine work on mineralogy, with an appendix on geology, produced a powerful effect on the public mind. The Messrs. Dana, brothers, in 1818 made a detailed and valuable report on the mineralogy and geology of the vicinity of Boston, as M. Godon had done less extensively in 1807 and 1808. Prof. Denison Olmsted, under state authority, explored with signal success the mountains of North Carolina. Prof. F. Hall made early and valuable explorations in Vermont and the adjacent states. In New York, Dr. A. Bruce, in 1809, had instituted a journal of mineralogy and geology, and the connected arts, but the decline of his health suspended the work after the completion of the first volume, and the American Journal of Science and Arts, on a more extended plan, succeeded in 1818 to the journal of Dr. Bruce. Mr. Robert Gilmor, of Baltimore, formed a beautiful cabinet of the rarer minerals and gems, in which taste, science, and wealth, conspire to enrich the collection.

Dr. H. H. Hayden published an interesting volume on diluvial remains and diluvial action; and Prof. Amos Eaton, under the patronage and at the expense of the late Gen. Van. Rensselaer of

Albany, made an elaborate survey of the geology of the country on the Erie canal. Prof. Hitchcock described the valley of the Connecticut; Prof. Dewey the western part of Massachusetts, the memoirs of both being illustrated by geological maps and sections. Mr. James Pierce described parts of New Jersey, the Cattskill mountains, Maine and Florida, &c. &c. The Academy of Natural Sciences in Philadelphia, the New York Lyceum of Natural History, and the Albany Institute, formed valuable collections and published important memoirs; the American Journal of Science and the Boston Journal of Philosophy by Dr. Webster, recorded many of the geological observations of the day, either in the form of original papers or copied from the archives or publications of learned societies. In the American Journal of Science alone there are about four hundred memoirs and communications on geology and mineralogy; most of them are original papers and by far the greater part are accounts of American researches made in illustration of the mineralogy and geology of the United States, Canada and Nova Scotia. In Canada many British officers were very active and successful explorers in geology. Dr. Charles T. Jackson and Mr. Francis Alger of Boston, in 1828 and 1829, published in the American Journal of Science a full and able account of the mineralogy and geology of Nova Scotia, with a map and pictorial illustrations. In 1831, this memoir much enlarged and improved by a second visit to Nova Scotia appeared in the Transactions of the American Academy at Boston.

In the above enumeration, we have not included hundreds of miscellaneous notices, besides numerous communications published in the journals and transactions of our academies, and in various journals more or less scientific. Nor do we include many reports on geology and mineralogy made to the general government by their authorized scientific travellers, such as the journals of Lewis and Clark, Mr. Schoolcraft and Major Long; nor geological works relating to foreign countries although written here —as, for instance, the excellent account of the Azores or Western Islands, by Prof. J. W. Webster of Harvard University, who was one of our early and active geological explorers.

It is sufficiently apparent, that since the commencement of this century, and particularly within the last twenty-five or thirty years, geology has become in this country a favorite pursuit, and that now its dominion although not yet perfected is fully established.

In proof of this position, however, it is not possible to give any thing more than an outline of our earlier efforts for the promotion of geology, and we shall have little time to glance at the agency of individuals in the field within the later years, in which geology has flourished with vigor. During the last fifteen or twenty years, many of the local governments of the individual states have caused to be instituted geological surveys of their respective territories—all of them appropriating public money, and many of them with laudable liberality, to the great object in view.

Geological surveys have been ordered and are now in progress or are already accomplished in more than three fourths, and if we include *reconnaissances*, in four fifths of our states and territories. We trust that with the return of a more prosperous state of affairs, the rest will follow. The general government has caused geological *reconnaissances* to be made in the territories which are still unappropriated, as state domains, and the exploring naval expedition, charged with the collection of specimens in geology and mineralogy, as well as in other departments of natural history, has already sent to the city of Washington a valuable harvest of these objects, to be deposited in the museum of the National Institute. State collections, illustrating the geology and mineralogy, and in some instances the zoology and botany of their respective territories, are also formed and forming in the different local capitals. Whenever the general government shall perform its duty, by carrying into effect the Smithsonian bequest, (thus imitating the promptness and fidelity exhibited in Boston in a case quite parallel—that of the Lowell fund,) then we may hope to have established at Washington in the manner of the school of mines at Paris, a grand national collection, which shall present in a connected and yet independent view, a faithful representation of the geology of our continent. Our neighbors in Nova Scotia, New Brunswick and Canada, have been for some years and still are actively engaged in exploring those important countries, in some parts of which are found great treasures of coal, grit-sandstone,* iron ore and plaster of Paris.

* Grindstones of excellent quality.

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COMPARISON WITH EUROPEAN GEOLOGY.

In comparing our geology with that of Europe, we find the scientific table of geological formations regularly filled, with the following exceptions.

Within the United States proper, there are no volcanoes, either dormant or active. The numerous volcanic vents on the western side of both North and South America and the contiguous islands, and those in California, Mexico, Central America, and the West Indies, relieve the eastern or Atlantic sides from the necessity of providing such safety valves for the internal fire, which finds a ready exit along the coasts of the Pacific and among the West

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In the earlier records of fire our country abounds, and in no part of the world can the phenomena of igneous rocks be studied with more advantage than in New England, in parts of New York, and of many other states, especially those through whose territories run certain longitudinal divisions of the great Appalachian chain.

With respect to aqueous or stratified rocks, we are deficient only in those strata that lie below the chalk and above the new or saliferous red sandstone. The equivalent of the chalk we have indeed in a vast extent, with the appropriate fossils lying in beds of clay, ferruginous sand, marl, &c.; but we have not yet discovered the proper mineral chalk itself. Beneath the chalk, we miss the oolite, the Wealden, and the lias, with their astonishing reptilian remains. Oolite has indeed been announced, on high authority, as existing in the State of New York, and in due time we shall be made acquainted with the proofs from included fossils and from relative position; for, without these, we can hardly be sure that strata, although they may have the oolitic structure, do really belong to the true oolite which makes so great a figure in England, and in certain parts of the European continent. In some cases, as in that of the Jura limestone, formations are admitted by geologists into the oolitic group because the strata contain the fossils that are characteristic of oolite, although the rock is destitute of the oolitic structure, and as regards its merely mineral characters, would never be referred by the eye to that family. This statement, as we suppose, contains the entire list of our deficiencies, and it is by no means improbable, that it will yet be filled up, in the wide range of our territories and in those of our neighbors, in which many regions still remain to be thoroughly explored. As an example of the intercalation of deficient rocks or minerals, we may mention, that during the last year, mineral salt in regular and very thick strata

Lyceums.—Voluntary associations have been formed in great numbers in the United States, and are rapidly increasing, in which citizens and especially young people meet for instruction, chiefly by lectures; they form museums devoted to the collection of interesting objects, chiefly in natural history, and geology is a favorite subject of attention.

Geology is not confined to the learned. Popular lectures upon this science are now demanded in many of our cities, towns and villages, and with the aid of diagrams and specimens, the subject is rendered both intelligible and instructive to large and attentive audiences.

So highly and so justly is geological science appreciated among us, that a new order of professional talent is now called into action. Individuals, interested in exploring or in working useful minerals, no longer depend upon the decisions of the credulous, the ignorant, the superstitious, or the crafty; they invoke the aid of geologists conversant alike with theory and practice, and their opinions are usually regarded as final in questions of this nature, often involving heavy and it may be ruinous expenditures. The negative, which the geologist is often able to pronounce with perfect confidence in regard to a proposed mineral enterprise, is frequently of the most momentous interest to the parties, and may save them from destruction; while the affirmative will be presented with guarded caution by every geologist who regards his duty or his honor.

RECENT STATE OF GEOLOGY IN THE UNITED STATES, WITH SOME PRACTICAL RESULTS.

The results obtained in the United States for scientific geology have been highly satisfactory. For their details we must refer to the various reports of the state geologists, of which even a summary would occupy more time than we have at our command; and it is the less necessary as Prof. Hitchcock in his excellent address pronounced last year before this Association at Philadelphia, presented a lucid synopsis of American geology. On reviewing that abstract, I perceive very little to add.

Frequent notices, abstracts and reviews of the reports of the state geologists, often furnished by correspondents, have been published from year to year in the American Journal of Science, and the editors have had only to regret their inability, on account of the number and frequency of the reports, to notice them all; especially as it was an agreeable duty to remark upon such valuable labors, where there was so much to commend and so little that merited criticism.

Foreign geologists may not be aware, that frequent reports, usually annual, on the geology of those states that are under survey, are either prescribed by their respective legislatures, or are deemed necessary by the geologists, to sustain the popular confidence and public spirit until a long continued labor, perhaps of several years, shall have been consummated; otherwise, there might be danger that the necessary annual appropriations of money would be withheld, and that thus an important enterprise might be defeated; this danger has been encountered in several cases, and has been realized, we trust only temporarily, in more than one.

We confide however in the intelligence and patriotism of our citizens ultimately to carry out these great undertakings, even in those states whose resources are the most embarrassed; and we have already expressed our confidence, that sooner or later every state and territory will be faithful to itself, in exploring its own resources by geological surveys, under public authority.

We can readily believe, that it might have been more agreeable to the state geologists to hold back their annual reports, until their entire labor should have been accomplished; for, a mature view of the whole ground might, very possibly, modify early and partial conclusions. For these ultimate results, we must patiently wait until the final reports in the different states are made. That of Prof. Hitchcock on the geology of Massachusetts, is already before the public in a third edition, revised and enlarged by the author, under the authority of the state, and the last edition is in two large quartos, expensively illustrated by numerous plates and figures. Distinct reports have also been made in the state of Massachusetts on all the departments of natural history.

It was stated last year by Prof. Hitchcock, that the final report on New Jersey, by Prof. H. D. Rogers, with a geological map and sections of the state, was published in 1840. In the same year Dr. Jackson's final report on Rhode Island appeared, including agriculture, with a geological map and sections.

Prof. Charles U. Shepard in 1839, published a report upon the economical mineralogy of Connecticut, and his colleague, Dr.

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—fifty or sixty feet—has been discovered, *in situ*, near Abingdon in Virginia, along with gypsum shale, and probably sandstone. There are abundant salt fountains at the same place, and the mineral salt was discovered in boring for salt water.

This is an interesting feature, added to our geology. We had before vast numbers of salt springs, but no solid mineral salt short of the Rocky Mountains. There, in a mountain on the Salmon River, it was observed some years ago, by the Rev. Mr. Parker, a missionary, who reports it to be floored and roofed by sandstone. (This Jour. Vol. XLI, p. 214.)

The tin ore, (oxide of tin,) reported last year, as discovered by Dr. Jackson in the White Mountains, has been found by him in increasing quantity, and small bars or ingots of the metal have been extracted by the discoverer. This is an important addition to our metallic resources; and the extraction of metallic zinc from blende (the sulphuret) by Dr. Jackson, from the ore found at Eaton, New Hampshire, agreeably to the practice now adopted in Germany, is a happy beginning upon an ore heretofore regarded as of little value, but existing in great quantities in the United States.

We forbear to dilate upon the simplicity and immensity of many of our geological formations—a vast country constructed upon one great model, with such unity of design and with such persistence in the plan, that particular formations are found associated and running longitudinally northerly and southerly, through the entire continent.

The best architectural materials, granites, traps, porphyries, sienites, serpentines, soapstones, limestones, primary slates, and slaty rocks of every geological age, sandstones and conglomerates, abound. The most useful minerals are found also in large quantity—ores of iron, copper and lead, gold and silver, the latter especially as it exists in argentiferous galenas. Above all, coal-fields of unequalled magnitude, thickness, extent, and richness, with clays, marls, and sands, and soils, of every variety, furnish to our population all the means of national wealth and individual prosperity. Over vast regions, there has been no serious disturbance of the strata; they have been gently lifted from the waves, often without a fracture, dislocation, or an intrusion of an igneous rock, for hundreds of miles. This geological quietude affords vast advantage in working our coal-fields, especially the trans-

Alleghany deposits, where the "*troubles*" of the European mines are, in a great measure, unknown. At the same time, the disturbed anthracite region of central Pennsylvania, contains in its fractured and folded mountains and strata, a lucid record of the operations of fire, both in its mechanical effects and in the debituminization of the coal, which, without any material difference in its geological relations compared with those of the bituminous coal into which it insensibly graduates as we proceed westward, has yielded up its bitumen by expulsion or decomposition, urged by invasions of heat from below.

The Silurian formation of Mr. Murchison, so well described by him as it exists in Wales, is developed on an amazing scale, and with strongly marked features, in western New York, and generally in the Western States, while the tertiary, which, in other countries, Mr. Lyell has illustrated with unequalled copiousness and discrimination, extends along the Atlantic border of the United States—in some places far into the interior—and appears besides in many isolated positions, covering an extent of area probably not equalled in any other part of the world.

Our tertiary and upper secondary have been successfully examined by Dr. Morton, Mr. Vanuxem, Mr. Conrad, Mr. Lea, Mr. Nicollet, and others; but this field is far from being exhausted.

It is worthy of remark, that the trifid tracks and impressions on the new red sandstone of the valley of the Connecticut, so zealously explored by Dr. James Dean of Greenfield, and both explored, and figured and described by Prof. Hitchcock, leave no reasonable doubt, that they are, at least in part, due to the feet of birds*—some of them of colossal dimensions. It is certainly possible, that among the impressions of this period, if not among those already observed, may be found some of the batracians or chirotheria of the strata of England and Germany. The doubts concerning the latter having been cleared up by the discovery of bones, by the aid of which Mr. Owen, the great comparative anatomist of London, has ventured to restore the form of batracian reptiles as large as a bull or an elephant, we may hope that a fortunate development of the bones of these ancient birds may

* **Reptiles would seem more probable, but many of the tracks appear decidedly those of birds.**

enable us, in like manner, to restore their skeletons—when, without doubt, they will be found to be appropriate companions of the gigantic frogs of their day—not more acceptable however, we may presume, in their regal sway, than were the storks of fabulous narrative, when appointed by Jupiter to reign over the frogs of that epoch of comparative pigmies. We want nothing but the fossilized bones of these primeval birds, to establish their existence ages before the earliest period heretofore assigned to them in the tertiary, or very recently in the Wealden, above the oolite and below the chalk, by Dr. Mantell.

The gigantic birds and frogs would be also in perfect keeping with the colossal reptiles, the Ichthyosauri, Plesiosauri, Megalosauri and Iguanodons of that middle reign, the fit successors of the great Saurian fishes below the coal, as they were, in their turn, successors or companions of the carnivorous cephalopods of the Silurian rocks.

DESIDERATA AND DIFFICULTIES.

In speaking of the desiderata of American geology, I have only to refer to the mention already made of the deficiencies in our geological table. If those members of the geological series, in which we are deficient, do really exist within our territories, (giving them their widest range to the Pacific Ocean,) or, if they exist even in any part of North America, it is most desirable that they should be discovered, for our boundaries in science are not limited by political divisions. There is much remaining yet to be done in this country, and in all countries, even those that have been most explored; and the number of well instructed geologists is now so considerable in all enlightened communities, that the great work will assuredly go forward with ceaseless effort and with increasing success, presenting rich additions to our knowledge and giving still greater precision and extension to our scientific views.

Geology has now survived most of its difficulties. To examine the structure of this earth is no longer regarded as a vain, idle, or presumptuous pursuit. Its economical utility is admitted by multitudes in our public counsels, who neither perceive nor appreciate its high intellectual and moral interest, while the polemical opposition is gradually yielding to the force of truth and to more reasonable modes of criticism and interpretation.

Astronomy demands space, geology time; the former has long been conceded, and the latter will not be long withheld.

It is already admitted by multitudes, that the chronology of the Scriptures is, in strictness, applied only to the history of our race, the sole moral beings whom God has placed in this world; while all that precedes man in the creation, is limited, in duration backwards, only by that beginning, whose date is known to no being but the infinite Creator, and which certainly precedes, by many ages, the creation of man; how long, it is neither important nor possible to determine; long enough however to admit of the arrangement, consolidation and elevation by natural laws, of the crust of the earth and of all its wonderful, mineral, and organic contents.

The records inscribed upon the volumes of the earth's solid strata, and often buried beneath the mountains, are more copious, more legible, and more authentic, than historical medals, than Arundelian marbles, than Egyptian hieroglyphics, or Persepolitan characters. They cannot be falsified, corrupted or suppressed, and will remain, while the earth shall endure, a visible, tangible history, written by the finger of God upon the work of his own hands. Only a small portion of these volumes has yet been perused, but enough has been deciphered to prove, that the work has immense antiquity, and was compiled in successive epochs, during a series of ages—the inscriptions being, *like those of the holy mount, on tables of stone.*

OF THE POWERS OR DYNAMICS BY WHICH ITS RESULTS ARE PRODUCED.

IGNEOUS CAUSES.

On this wide topic, our time will permit us to say but little. It embraces all physical and chemical laws, and includes the entire philosophy of geology.

As the phenomena of the planet, belonging to past ages and recorded in its structure, conspire with the events still occurring under our eyes, to prove that no portion of this earth is now in the condition in which it was originally formed, we seek in vain for a goal of departure, from which to date the series of geological events. As the only direct revelation which we possess concerning the origin of the earth, and of the universe of which it is a part, is silent as to the condition in which the materials were brought into existence, we are at liberty, on this topic, to make any supposition not inconsistent with physical and chemical laws. If we admit then, that the elements of matter were created in their simple or uncombined condition, (a supposition which is in no degree improbable,) then it is obvious, that a mutual and energetic action would be the immediate result of their first contact; intense ignition and general combustion would follow, attended by fusion, volatilization, and all the concomitants of a powerful chemical conflict. The action would relent as the combinations proceeded, as incombustible compounds resulted from the union of the elements, and as radiation into space cooled the surface. Thus, an oxydized crust would be formed around the nucleus of the earth, and similar incombustible compounds would be produced by all the agents that excite combustion—chlorine, iodine, bromine, fluorine, and other similar elements, if such there be. Water would of course be formed from the union of its elements, and as it obtained access through the fissured crust to the still combustible interior of the planet, violent phenomena of combustion and explosive eruption would follow, until the combustibles to which the water obtained access had been thoroughly burned. The heat evolved by the energetic chemical action, whether induced by combustion or by any other mode of chemical action, might ignite, to a great depth, the combustible materials lying beneath the crust; *thermo* and *galvanic* electricity would propagate the ignition to a profound depth, and the power thus evolved as an effect, might, in its turn, operate as a cause, until the entire interior became ignited, softened, or even fused, more or less extensively.

Such agencies would, of course, be attended by various and powerful chemical effects; combinations and decompositions would result in the augmentation of heat, which again acting thermo-electrically, would tend to perpetuate and augment its own energy. Our recent experience proves, that heat may be long given out by the so called perpetual batteries, so that arrangements may be imagined among the elements or compound materials in the earth, by which a perpetual evolution of heat may be produced, and this again in its turn may excite a perpetual flow of electricity, and thus the ignition, at first produced in the crust of the earth by combustion, may be made perpetual by thermo- and galvano-electricity.

Should we admit that the agents of combustion, which have been supposed in this statement to act first upon the combustible elements at the surface, exist also in the profound interior, so as to produce combustion there; or to combine in any other manner, so as to evolve heat, then we are supplied with another igniting power in the interior, in addition to the thermo and voltaic electrical. Nor need we suppose either of these powers ever to become extinct. Electricity, excited as suggested above, may flow on, without limit of time, and occasionally with paroxysmal intensity; the combustible elements, which, by burning or by other similar chemical action, have lost their combustibility may, by the power of galvanic decomposition and the chemical agency of hydrogen, be evolved again and be thus restored to their original combustibility. In this manner, the elements of water may be combined by combustion to produce that fluid, and this may be decomposed anew, so as to evolve the elements again in pristine energy. So, potassium and sodium and the metallic bases of the earths may be evolved, and the chlorides, iodides, bromides, and fluorides, may be alternately decomposed and recomposed, and the more combustible elements brought into combustion by contact with water or with oxygen in a state of freedom or with chlorine, or other similar agents, may serve as matches or as kindlers to ignite those that are more tardy in burning, until the most energetic effects of combustion are added to those of electricity, and thus an eternal circle of causes is established—causes whose existence and operation are experimentally proved, since they are now always at our command, to produce on the surface of the earth exactly such effects as we have supposed it possible that they may produce in the interior of the planet.

As a thermo and galvano-electric power is a permanent principle in nature, ever active and ceaselessly regenerated, with its attendant decompositions and combustions, we can no longer hesitate to admit its agency as the great cause of the internal heat of our planet; nor is it improbable, that the solar orb and all the central suns of other worlds derive their perpetual radiance of heat and light from a similar cause, although that cause, like all other final causes in our philosophy, is inscrutible to our minds, and must be referred ultimately to the agency of the Creator, in immediate and energetic action.

May we not suppose, that we now understand why the heat of the earth regularly increases as we descend, one degree of Fahrenheit for every forty five or fifty feet of descent; eighty two to eighty three degrees of Fahrenheit having been recently obtained in a spouting fountain of an Artesian boring at Paris, sunk to the depth of more than eighteen hundred feet, or over one third of a mile; the heat of a hot summer's day is thus obtained, unaffected by the atmosphere above, even when at zero.

The conclusion to which this regular progressive increase of heat, supposing it to continue, conducts us, is obvious, and is familiar to geologists—boiling water at the depth of two miles, ignited rock at ten miles, melted rocks at one hundred. Who can say that it is really so, and who can say that it is not? Are we then walking upon a shell—a frozen crust? If this cannot be certainly affirmed, neither can it be positively denied; while the actual eruption of molten rock through the ruptured crust of the earth, many times in a year, from some of its hundreds of ignivomous mouths, demonstrates that rocks are indeed melted in amazing quantities and at profound depths in the interior; while innumerable thermal and boiling fountains in all parts of the world, prove the elevated temperature of the interior.

It is not necessary to suppose with Mr. Lyell, that there are internal igneous tides of extensive prevalence that by their afflux will melt down the crust of the earth; for, from the analogy of volcanoes, we may suppose that the interior of the earth, may be in general only in an ignited or softened or pasty condition—tenacious but not flowing liquid, like water or melted iron; except that occasional accumulations of heat in particular regions, arising from local thermo or galvanic or chemical action might, in those places, impart unusual fluidity; and joined with explosive power from steam and imprisoned gases, as well as from expansion, and (it may be admitted also from local igneous tides) the result would or might be a rupture of the crust, and an outbreak or overflow of lava—in a word, a volcano; the explosion occurring where the force was the greatest and the resistance the least.

Those who adopt the theory of nebular condensation, and suppose the earth to have been formed by accumulation of such expanded materials, evolving heat as they became solid, will find no difficulty in admitting also the agency of the causes that have been suggested; for, as regards the reality and continued operation of the causes upon which our induction is erected, it is quite unimportant when or how the solid materials of the earth were formed; because, commencing however or whenever they might, they would be governed by the same chemical and physical laws as now.

AQUEOUS CAUSES.

If the internal heat of the earth, with its permanent and efficient causes, be admitted, we have solved the most difficult problems in geology; for, immensely the greater part of our planet is of igneous origin, and all that is due to water, if thrown like a covering evenly around the globe, would form but a very thin film—scarcely, in a section of a globe of four feet in diameter, forming a visible line. The power of water is to dissolve, to crystallize, to lacerate, to wear down, to transport and to deposit the materials in new situations.

In estimating the chemical effects of water, we must endow it with all the solvent power which heat, under enormous pressure under miles of ocean or of incumbent land, would give it; and then we must regard it not simply as water, but as a compound fluid composed of all that water, in such circumstances, can dissolve; when perhaps red hot, a condition which it may well attain, it might acquire new and remarkable energy—softening or dissolving materials which might otherwise be unaffected by it. These views would appear particularly important to any metamorphic theory of rocks, the changes of which it would seem more reasonable to attribute to a conjoined operation of fire and water than (as regards their crystallization) to impute them to fire alone.

Gentlemen, after having detained you so long, I am not disposed to occupy any more of your time by discussing any peculiar theories of the operation of water. Its effects, both mechanical and chemical, are extensive and manifest to all. In the Wernerian school, the solvent powers of water were exaggerated beyond all credibility; and at this day, no geologist would venture to suggest that the mountains and the entire crust of the earth have ever been dissolved in its waters. While in later times the operations of fire have been, on substantial proof, (as on theory alone they were formerly by Leibnitz,) prodigiously extended, those of water have not been cancelled, although they have been greatly circumscribed, and restricted within the limits which science and sound reason prescribe. Happily, it is the less necessary for me, on the present occasion, to trace the effects of water, since they have been, along with the general powers of geology, so ably elucidated by our distinguished foreign guest,* in his learned, elegant, and instructive works. In regard to our scientific and social relations, we will not however view him as a foreigner, while we salute him as our associate and friend. For to him, more than to any other or all other writers on geology, we owe our recovery from the illusions of dreams and visions, regarding imaginary powers supposed formerly to exist, but to have become exhausted or greatly enfeebled or even extinct, in modern times. He has proved to us, that the powers of nature are the same now that they have ever been; that except the act of creation and the first outbreak of the new-born elements and energies, there was nothing in the geological laws of former ages different from the present; and that the causes now in operation, acting with greater or less intensity, are sufficient to produce the effects of earlier epochs.

These positions are sustained by an ample train of induction from facts, drawn from a wide range of geological history, as well as of laborious, exact, and acute personal observation, carried on through many countries and through a long series of years. We account it therefore a privilege to have made his personal acquaintance, and many of us have been favored with opportunities of witnessing his methods of illustrating, in public lectures, the science which he has so successfully cultivated. Our fine packet ships, and still more the winged Atlantic steamers, have so much diminished the difficulties and delays of the passage, that we may expect a more frequent renewal of the visits of enlightened and cultivated individuals from Europe.

In 1839, Dr. Daubeny took a rapid survey of our country, and after his return, favored us with an interesting summary of our geology. We believe that no gentlemen from the scientific faculties of the English universities had ever before examined the United States.

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* Charles Lyell, Esq., was in the United States from the first week in August, 1841, to July 16, 1842, and being present in the Association of American Geologists at Boston in the last week of April, 1842, took part in their debates. See abstract of their proceedings in the first number of this volume.

With the exception of Dr. Daubeny, the visit of Mr. Lyell is perhaps the first that we have received from a distinguished European geologist. To us, it is an important advantage to compare our views with his, and thus to be assured, by visible symbols, that we do indeed understand each other's language. The kind and respectful manner in which, in his public lectures, he has treated the labors of our geologists—the prominence which he has given to their observations, and the gratifying coincidence between his views and theirs in relation to our geology, afford us satisfactory proof that the geologists of the old and of the new world do indeed observe and think alike.

But, gentlemen, allow me to observe, that American geologists have important duties to discharge towards each other—duties of justice, honor, fidelity and delicacy. Cultivating a field of vast extent and surpassing richness, separated by distance from each other, and laboring often alone, we cannot always be early informed of our respective observations and discoveries. In accordance therefore with the best feelings, and with the strictest rules of geological courtesy, while we maintain with good temper and dignity our own personal claims, it will I trust be our pleasure to place in prominent relief, the claims of our fellow laborers, to do full justice to their observations and discoveries, and to find more satisfaction in the advancement of science by our common efforts, than in any partial or personal acquisition of fame. The harmony and unity of effort which have thus far been happily maintained among us, will thus be perpetuated; and our annual meetings, (always, we trust, to be in future honored by the attendance and coöperation of our foreign friends, actuated by, and received in, the same spirit,) will then be equally instructive and delightful; they will become both focal and radiant points of intellectual light and moral influence, to the honor of our country and the common benefit of mankind.

Gentlemen—pardon me, if in my honest zeal for our noble cause, I have presumed to speak as a Mentor; or, if in giving historical notices of the shooting of American geology, as an offset from the European stock, I have ventured also to speak of my own humble participation in this arduous enterprise. As an original witness, I hope I have not transgressed the proprieties of the occasion, while I have frankly and honestly told the things I knew. Thirty five years ago, some eight or ten* individuals began to labor in this country in the great cause in which we are engaged. It has flourished beyond our most sanguine expectations, and we now behold around us, or we recognize in all our states, a numerous corps of well instructed, zealous and active geologists.

Upon this happy result, while I congratulate the Association, my emotions of pleasure are chastened by the recollection that among our attending members on the present occasion, I stand in this place almost the sole representative of the original corps of American geologists—one half of whom are gone to that land from whose bourne no traveller returns. MACLURE, MITCHILL, GIBBS, BRUCE, and SEYBERT are among the dead.

Gentlemen, let us not forget that *our* labors must also have an end; and when *we* too shall have reached our goal, may we be cheered onward by a well founded hope, that this tangible earth which we now see and explore, may be exchanged for the heaven of our faith and hope—that glorious world whose very atmosphere is moral purity and love, and whose cloudless firmament glows with the light of eternal truth.

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* Maclure, Gibbs, Mitchill, Bruce, Cleaveland, Gilmer, Hayden, Hall, (Fred.), Silliman.

*Proceedings of the Third Annual Meeting of the Association of American Geologists and Naturalists.**

Monday, April 25th, 1842, 9 o'clock, A. M.—Association met at Boston, pursuant to adjournment of last meeting.

Dr. Morton (the chairman) not having arrived, *Prof. Locke* was called to the chair. *Dr. C. T. Jackson*, secretary. *Mr. Josiah D. Whitney* and *Mr. Moses B. Williams* were appointed assistant secretaries.

Letters were then read by the secretary from *Messrs. W. W. Mather*, *Robert Gilmore*, *H. H. Hayden*, *Baron Lederer*, *Francis Markoe, Jr.*, *R. Harlan.* An extract from a letter received from *Dr. Douglas Houghton*, was read by *Prof. Beck.* It was then

Resolved, That all those gentlemen, whether of this or any other country, who are interested in geology and the allied branches of science, and who may be present on this occasion, be invited to unite with the Association in its deliberations.

A letter being read by the secretary from *Prof. Silliman*, stating his readiness to comply with the wishes of the Association, either to deliver his address before the Association alone or before the public:—It was

Resolved, That the address of Prof. Silliman be delivered to the Association in presence of the public.

Resolved, That the local committee be authorized to make all necessary arrangements for the accommodation of the audience during the delivery of this address.

Resolved, That any gentleman requesting permission to read a paper, on condition that it be returned to him without an abstract of its contents having been entered on the minutes, may have the privilege, on merely allowing its title to be recorded.

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* As a rule of the Association excludes mere oral remarks from the records on account of the difficulty of reporting them correctly, but sanctions the subsequent communication of them by their authors, and as these minutes were thus furnished by some gentlemen and not by others, this will account for the very disproportionate space occupied by the remarks of different individuals, as published in the annexed abstract of the proceedings. Many valuable observations have thus been lost which there is much occasion to regret, and particularly those of Mr. Lyell, of which no minutes were communicated, although the Association listened to him with much satisfaction during the several periods when he favored them with his views.

Provided only, that in all cases where the paper is to be withdrawn, as above, there shall be no discussion on the subject.

The Association then adjourned until 3½ o'clock, P. M.

Monday, April 25th, 3½ o'clock, P.M.—*Prof. Locke* in the chair.

Prof. Locke exhibited sections of the rocks of the lead regions of the Upper Mississippi, with remarks on the geology of the west.

Prof. L. proceeded to state as follows:—I present to-day some geological sections of the lead region of the Upper Mississippi. These were made by myself during the survey of the Mineral Lands ordered by Congress, and by Dr. Owen and myself with numerous assistants in 1839. A detailed report of that survey was made to the Department of the Land Office early in 1840, but owing to some mismanagement at Washington, it was published without the illustrations, which were numerous, and so connected with the text that the document became nearly unintelligible without them. As this paper, imperfect as it is, has been seen by few of our geologists, and as the sections before us are chiefly in connection with what I have denominated the cliff limestone of the west, I will ask leave to read from my printed report some remarks upon that rock. This I do more especially as it appears not to be known or recollected that I have a claim to the discovery that the metalliferous rock of the Mississippi is identical with the cliff limestone of Ohio, and that the same rock wherever it has been found is more or less metalliferous. [Here was read part of the report of Prof. L. to Dr. Owen, referred to as published in Document 239, 26th Congress, United States.—The following sections were also exhibited and explained.]

" I. A section from the heights of Little Mahoqueta through Dubuque Mines to Sinsinawa Mound, fifteen miles. This section exhibited,

1. The cliff limestone, containing in its middle and lower portions the lead veins.
2. The blue limestone (Trenton limestone).
3. Presumptively, the lower magnesian underlying the blue.

" II. A section at Prairie du Chien exhibiting the following rocks, descending series:

1.	Soil and cliff limestone, - - - - - -	60 feet.
2.	Blue fossiliferous limestone, - - - - - -	115 "
3.	Buff colored limestone, - - - - - -	20 "
4.	Soft saccharoid sandstone, - - - - - -	40 "
5.	A portion covered by soil, - - - - - -	40 "
6.	Lower magnesian limestone resembling the cliff lithologically, but is nearly destitute of fossils, - -	190 "
7.	Saccharoid sandstone, - - - - - - - -	30 "
	This last is exposed only at low water.	——
	Total, - - - - - - - - -	495 feet.

"III. A section from Blue Mounds to Wiskonsin River, exhibiting the following descending series of rocks:

1.	Beds of siliceous chert, containing the fossils of the cliff and forming the peaks of the mounds, - - -	410 feet.
2.	The cliff limestone, containing in its lower portion lead ore, - - - - - - - - - -	169 "
3.	The blue fossiliferous limestone, very thin, and in some places wanting, - - - - - - - -	00 "
4.	Saccharoid sandstone, - - - - - - - -	40 "
5.	Alternations of saccharoid sandstone and lower magnesian limestone, - - - - - - - -	188 "
6.	Sandstone, - - - - - - - - - -	3 "
7.	Lower magnesian, - - - - - - -	190 "
	Total, - - - - - - - - -	1000 feet.

By lower magnesian limestone is not meant the magnesian limestone of Europe. The name was given by Dr. Owen in contradistinction to the cliff limestone, (which is the upper magnesian,) both containing magnesia. What has been denominated by me the cliff limestone,—a name adopted by Dr. Owen,—is properly divided into three portions, which other geologists may consider three distinct formations.

The following is Dr. Owen's subdivision of the cliff series: p. 24, Document 239, 26th Congress.

"*Upper beds.*—More regularly stratified, and less frequently vertically fissured than the middle and lower. Also, more rich in siliceous fossils, containing layers of chert, and indeed passing wholly into masses of flinty rocks, containing also good iron ore, and much crystallized carbonate of lime; but lead rarely, and in unprofitable quantities.

"*Middle beds.*—Aspect more arenaceous, though it contains but a small per centage of sand. Cherty masses are rare. Stratification imperfect, with numerous vertical fissures. Rich in ores of lead and zinc, associated with iron in small quantities.

"*Lower beds.*—Also of arenaceous appearance; rather more distinctly stratified than the middle beds, and imbedding more frequently than these siliceous cherty masses. They contain the same ores as the middle beds, with the addition of copper ore and sulphuret of zinc."

These several beds are distinguished by their fossils. The several fossils enumerated by Dr. Owen are:

"*Upper beds.*—*Terebratulæ*, several species of *Catenapora*, *Calamipora*, *Columnaria tubipora*, *Aulopora*, *Sarcissula*, *Astrea*, *Cyathophylla*, *Caryophylla* and *Orthocerites*.

"*Middle and lower beds.*—*Coscinipora* (*sulcata?* Gr.), the only coralline, a *Cirrus* resembling *perspectious; Ampularia*, in perfect impressions of a long, spiral univalve, resembling the genus *Vivipara.* It seems by the above, that there was no absolute zoological distinction between the middle and lower beds."

Permit me here to add as a claim of the western geologists, rather strangely overlooked by some *eastern* writers on *western* geology,—that besides these all the other western rocks yet made known, have been described by western geologists. Especially the bed of mountain or carboniferous limestone, superimposed on the cliff at the upper rapids of Mississippi, underlying the great Illinois coal basin, cropping out at St. Louis, and forming the bluffs at and above Alton, Illinois, with its characteristic fossil, the *Archimedes* of Le Seuer, was well known to Messrs. Troost, Owen and myself. The same rock occurs within the limits of the survey of the Professors Rogers, who belong, in part at least, to the western corps. In 1839, I had the pleasure of comparing notes with Prof. James Rogers, on the characters of this very rock as it occurs in Indiana and Illinois on the one part, and in Western Virginia on the other. I hope yet more specifically to settle the claims of the various *laborers* in our western geology. At the same time I would observe that it is impossible for an eastern geologist, without visiting the west, or even by a post-haste journey over the trans-Appalachian world, to write upon its geology without committing errors injurious to his own reputation, the publication of which, he would of course, gladly recall.

Remarks were offered and facts stated on the above subject by *Dr. King*, *Mr. Haldeman*, *Mr. Teschemacher*, *Prof. Henry D. Rogers*, *Dr. C. T. Jackson*, *Prof. Vanuxem*, *Prof. Hitchcock*, *Prof. Beck*, and *Dr. Dana*.

Mr. Haldeman laid on the table, at the request of Dr. Morton, some copies of a work on cretaceous fossils, bringing our knowledge of this subject near the present day, most of these being from the researches of Prof. Nicollet.

A letter was read from *Prof. Park* of Philadelphia, regretting his inability to attend the present meeting. The Association adjourned to—

Tuesday, April 26th, 9 o'clock, A. M.—*Prof. Locke* in the chair. The committee on the constitution and by-laws was called upon for report. *Dr. Jackson* read the rules, as submitted by this committee.

*Constitution and By-Laws of the Association of American Geologists and Naturalists.**

Art. I. The Society shall be called "The Association of American Geologists and Naturalists."

* The constitution and by-laws as here printed, were in fact adopted at the session of Wednesday, but it is thought expedient to insert them here, as they embrace all the rules which were adopted on Tuesday and thus to avoid repetition.

Art. II. The objects of this Association are the advancement of geology and the collateral branches of natural science, and the promotion of intercourse between those who cultivate them.

Art. III. All those persons whose names have already been enrolled in the published proceedings of the Association, and those who have been invited to attend the meetings, shall be considered members on signing the Constitution and By-Laws.

Art. IV. Members of societies having in view the same objects as this Association and publishing transactions, shall be considered members upon subscribing to the Constitution and By-Laws.

Art. V. Persons not embraced in the above provisions may become members of the Association, upon nomination by the standing committee, and by concurrence of two thirds of the members present.

Art. VI. The officers of the Association shall be a chairman, a secretary, and a treasurer, who shall be elected at each annual meeting.

Art. VII. The secretary may appoint two assistant secretaries to aid him in the discharge of his duties.

Art. VIII. The Association shall meet annually for one week—the time and place of each meeting being determined by a vote of the Association at the previous meeting, and the arrangements for it shall be entrusted to the officers and the local committee.

Art. IX. The standing committee shall consist of the chairman, secretary, and treasurer, with nine other members present who have attended the previous meetings.

Art. X. It shall be the duty of the standing committee to nominate members for admission, and to manage the affairs of the Association.

Art. XI. The local committee shall be appointed by the standing committee from among members residing at or near the place of meeting, and it shall be the duty of said committee to make arrangements for the meeting.

Art. XII. The expenses of each meeting shall be defrayed by an equal assessment on the members present.

Art. XIII. All communications to the Association shall be presented in writing, and upon them discussions may take place which shall not be reported, but the facts presented in such discussions may be reduced to writing by the persons communicating them, and they may then be handed in at a subsequent session, when they may be entered on the records.

Art. XIV. If communications are made, and notice is given that they are to be withdrawn for publication elsewhere, they may be read, but no discussion shall take place on them.

Art. XV. No article of this Constitution shall be altered or amended without the concurrence of three fourths of the members present, nor unless notice of the proposed amendment or alteration shall have been given at the preceding annual meeting.

Dr. Morton having arrived, took the chair as president of the meeting.

Resolved, That *Prof. Locke*, *Dr. Jackson*, and *Prof. Hitchcock*, be appointed a committee to prepare business for the Association.

Prof. Hitchcock then read a paper "on the Phenomena of Drift in this country," which was illustrated by numerous drawings, and a map of the United States, on which were drawn lines representing the course of the striæ, and lines of dispersion of bowlders. In the course of his paper Prof. H. called on *Mr. Gray* to describe a remarkable moraine in Andover, Mass. Mr. Gray stated this moraine to be one mile long and fifteen or twenty feet in height. At the close of this paper, an animated and extended discussion arose on the subject of drift.

Dr. Jackson objected to the views of Prof. Hitchcock, as published in a recent report on the Geology of Massachusetts, but having had an opportunity, since those views were published, of conversing freely with Prof. H. he found but little real difference in their present opinions. He would, however, by no means consider that we could yet form an unobjectionable theory on the subject of drift, polished grooves, and the transportation of erratic blocks of stone. If we admit several different causes, how remarkable would it be should they be found to have acted in nearly the same direction! Yet we cannot agree upon any known cause, as sufficient to explain all the facts. This country exhibits no proofs of the glacial theory as taught by Agassiz, but on the contrary the general bearing of the facts is against that theory; for we observe nowhere in this country a general radiation of detritus from the principal mountain ranges, although, as in Rhode Island, there is a divergence from the point whence the bowlders were derived. This divergence is however merely a spreading of fifteen miles for forty in extent, and it is in the usual general direction of North American drift to the southward; none of the bowlders having been drifted to the north of their parent bed.

Mr. Lyell offered some remarks on the subject of the distribution of bowlders and of the furrows in the rocks, citing the result of many observations in Europe.

Mr. Redfield had from his limited observations been led to infer that the drift of the region near New York was the joint result of glacial and aqueous action, and was mainly deposited during a period of increasing submergence. Mr. Redfield also alluded to the agreement of the striæ of the polished rocks, and of the transported bowlders and drift, with the known course of the existing polar currents of the ocean, in the northern hemisphere; and suggested that this system of currents, being essentially the same in both hemispheres and having its cause in the dynamics of the solar system, must have operated through all time, and over extensive regions, but varying in locality and direction with the changes of outline and relative levels of seas and continents, during successive geological periods.

Some discussion then ensued on the question whether the mounds of the western United States were the result of natural diluvial causes or the work of the Indians.

Mr. Lyell cited an instance where the inhabitants of Scandinavia, had taken advantage of a long and very high natural ridge, to form three separate mounds, which they afterwards considered as the burial places of their fabulous deities.

Prof. Silliman remarked with respect to the genuineness of mounds, as works of man, in contradistinction from those natural piles, that have been cut out of the strata of clay, sand, gravel, loam, &c., and rounded and shaped by water so as to resemble works of art—that artificial mounds (found in many and distant countries, both on the eastern and western continent) appear to have been characteristic of a particular state of society advanced beyond barbarism, but not yet sufficiently civilized for the construction of massy sepulchres of solid stone, sarcophagi, pyramids and temples. He appealed to those numerous mounds which form a most impressive feature of the scenery on Salisbury plain in Wiltshire, in the southwest of England. Prof. S. had counted seventy of these mounds in one view, while sitting upon his horse upon the top of a low one, and from the same place Dr. Stukeley says that he enumerated one hundred and twenty eight. These mounds are rarely less than thirty feet in diameter; they are generally surrounded by a broad ditch, enclosed by a circular or oblong parapet or embankment. Near Overton in the west of England, Prof. S. ascended one which was one hundred and seventy feet high and whose base covered about an acre of ground, its form being that of the lower segment of a cone.

The void, from which the earth was taken, remains to this day, and is as evidently an artificial excavation, to form an artificial hill, as any modern fortification with its ditch and glacis. There remains not the smallest doubt, that these mounds were erected both as sepulchres, for distinguished individuals, and as monuments of victories. The remains of the dead have been often found in them, either skeletons or ashes—with heads of spears, swords, bones of horses, dogs and other domestic animals, sometimes beads, trinkets, and female ornaments, articles dear to the departed while living and which were believed to be important to them in another world.

Prof. H. D. Rogers remarked in relation to Mr. Lyell's opinion of the gradual rising of the North American terraces, that if such was the case, fossil shells or marine sedimentary accumulations, should be found at all elevations on the mountain slopes, which are covered with marks of diluvial action, at every height. It has not been shown by examination that such is the case, hence he infers that the cause which produced the elevation was paroxysmal in its operation and effects, and not secular, or gradual, and uninterrupted. In order to explain the theory of diluvial phenomena, he would suppose with Mr. Lyell, and others, that the region around the north pole was capped with ice, in immense masses, and that by a sudden outburst of volcanic action, this was dispersed, and sent in a quaquaversal direction towards the equator. But if we suppose that this was accompanied by an earthquake, rocking, or wave-like motion, of the bed of the ocean, the whole mass of torn-up strata would be shoved violently from N. to S., and at every heaving of the earth, a mass of water would be thrown forward, like the rolling in of a tremendous surf. Mr. Couthouy's observations among the coral islands, would go to strengthen this theory, while the rocking movement of the earth's surface during an earthquake, had been long ago admitted.

Mr. Couthouy remarked in relation to the paroxysmal rise of the land at intervals, that on one island which he had visited, which was about two hundred feet in elevation; about one half way from the base to the summit, the face of the cliff was deeply sea-worn and indented; as its present base would appear should it be at this moment raised above the ocean level, when it would present similar marks of powerful and long continued action of water, at the part which was before on a line with the sea. In regard to the bowl-shaped cavities, encircled on all sides by regular hills, he suggested that they might have been worn by the rotary motion of icebergs; this rotary, or semi-rotary motion of the icebergs, he had noticed both in those which were and were not stranded. They become gradually worn away on one side by the action of the water, when they turn over with a displacement of the sea, and violent upheaving of the mud and sand, rendering the water turbid to a great distance.

The discussion was continued by *Mr. Lyell* and *Mr. Couthouy*, on the probable agency of icebergs in diluvial phenomena, and especially in regard to the water-worn cavities or pot holes.

Dr. C. T. Jackson described the pot holes which occur in Orange, near Canaan, in the elevated land between the Connecticut and Merrimack rivers in N. Hampshire. They are worn in a hard granite-gneiss, in a line following the general N. and S. direction of the diluvial or drift current. One which had been cleared of the round smooth stones which formerly filled it, and which is known to the inhabitants as "the well," is eleven feet deep, four and a quarter feet wide at the top, and two feet at the bottom. These pot holes could not be referred to the action of any existing current of water, as they are on the water-shed line, between the two rivers, and more than one thousand feet above the sea level.

Mr. John H. Blake was requested to prepare a paper on the tertiary and drift of the Andes.

Prof. H. D. Rogers remarked in relation to stranded icebergs, that coming from the north, loaded with bowlders, and stranded far above the sea level, they would, while melting, produce all the phenomena of the glaciers of the Alps.

Mr. Couthouy was requested to draw up a paper, embracing the facts which he had collected in regard to icebergs, to lay before the Association. Mr. C. having, in accordance with this request, prepared the following summary of his observations and the remarks he had made concerning them, at the present session, it is here inserted.

Mr. C. premised that in order to give the remarks he was about to submit, their full weight, it might be proper for him to state, that he had no preconceived opinion—no hypothesis of his own upon this question, to sustain. His intention was simply to offer a few facts which had fallen under his personal observation, with the inferences to which they had led his own mind, leaving abler judges to decide upon the value of such facts and the correctness of the inferences. He remarked that the opportunity of witnessing the actual operation of the huge bodies of drifting ice, known as Bergs or Islands, was of so rare occurrence that its true character appeared to him not clearly understood, and consequently geologists were liable to overlook or err in judgement upon some important points in the dynamics of aqueo-glacial agency. Mr. C. then proceeded to a statement of the geographical position of a number of icebergs, as determined by reference to his journals. The first noted was observed on the 28th of May, 1822, during a passage from Havana to Rotterdam, and was in 42° 10′ N. lat., 44° 50′ West from Greenwich. Its size must have been very considerable, as it was visible from the deck of a vessel of two hundred tons, for eighteen miles. Numerous small streams of water were pouring down its sides, and a boat was sent with a view to obtain a supply, but on approaching it, the swell, notwithstanding its being quite calm, was found to dash against its face with such force, and the lower portions were so worn and ragged, as to render it inaccessible. Although the weather was so serene, and the sea so tranquil, yet the berg was constantly turning slowly round as the swell struck its many promontoriform projections. It appeared to have lost little of its primal magnitude, the summits retaining a conical or rounded form, instead of being worn like others he had seen, into sharp pinnacles and acicular ridges by the action of the atmosphere and rain.

The next observed by Mr. C., was on the return passage in September of the same year. It was aground on the eastern edge of the great Bank of Newfoundland, in 43° 18′ N. lat., 48° 30′ W. long. Sounding three miles inside of it, the depth was found to be one hundred and five fathoms, and as the water deepens rapidly toward the edge of the bank, the berg must have been in at least one hundred and twenty or one hundred and thirty fathoms. There was a heavy sea running at the time, causing it to rock, and oscillate horizontally to and fro, with a heavy grinding noise distinctly audible to all on board. A fresh wind from the east was continually forcing it farther up on the bank, but in the event of a contrary gale springing up, it would doubtless have been driven off again into deep water to pursue its course to a milder clime, loaded with materials ground into its base while stranded.

Between this period and the summer of 1827, several icebergs were seen by Mr. C., but not being able at present to lay hand on his journals of that interval, he could enter into no particulars, farther than to state that as with a few exceptions, his voyages were between the United States or West Indies and Great Britain or the Mediterranean, it was probable that they were chiefly met between the 36th and 42d parallels of north latitude. He remembered however, having encountered in November, 1825, off the entrance to the Rio de la Plata, in latitude 35° south, longitude 49° west, or thereabouts, a number of icebergs, some of which were of large magnitude ; a reference to the chart would, he observed, show to what a vast distance from their birth-place these floating masses had been driven by wind and current.

In the month of August, 1827, while crossing the Grand Banks, in latitude 46° 30′ north, longitude 48° west, Mr. C. passed within less than a mile of a large berg which was stranded in between eighty and ninety fathoms water. The wind was light, but a heavy swell was running from the westward, and the huge pile could be distinctly seen to rock and shake violently as it ground heavily down into its bed with every surge. Owing to its longest diameter facing the swell, the mass had an oscillatory or semi-rotary back and forward motion upon its vertical axis, according as the sea broke upon one or the other extremity, which it did with so much force at times as to turn the berg apparently full half round; in this situation it would remain till another heavy surge striking the opposite end would force it back and round in the other direction. The vessel was sufficiently near for Mr. C. to perceive distinctly, large fragments of rock and quantities of earthy matter imbedded in the sides of the iceberg, and to see from the fore yard, that the water for at least a quarter of a mile round it, was full of mud, stirred up from the bottom by the violent rolling and crushing of the mass. This movement was accompanied by a harsh grating noise, with occasional cracking reports, resembling those produced by blasting rocks, which might have been heard ten or twelve miles. The height of this berg was estimated by Mr. C., at from fifty to seventy feet, and its length at four hundred yards. While examining it through the glass, it was observed to incline suddenly more than usual, and in the next moment, with a crash and roar that were truly fearful, and amid a whirlwind of spray and foam, the whole enormous pile rolled over on its side, tearing up with it, no doubt, large quantities of matter from the bottom, and loading the sea with mud and sand for more than a mile in all directions from its bed. On the 27th of April, 1829, Mr. C. passed, in latitude 36° 10′ north, longitude 39° west, near the middle of the Gulf Stream, which there set in an east-south-easterly direction, an iceberg estimated to be a quarter of a mile long, and from eighty to one hundred feet high. It was much wasted in its upper portion, which was worn and broken into the most fanciful shapes, forming resemblances of minarets, spires, pyramids and castellated ridges, whose character was momentarily changing by reason of the berg moving backward and forward horizontally with great quickness. A strong breeze, and numerous smaller fragments of ice floating in its vicinity, prevented a very near approach, but on one side, a large earthy colored patch was seen, having numerous blacker spots, which Mr. C. had no doubt were bowlders, scattered over it. Some of these presented a surface of two or three hundred square feet.

In 1831, on a passage from Boston to Mobile, at daylight of 17th August, in latitude 36° 20′ north, longitude 67° 45′ west, upon the southern edge of the Gulf Stream, Mr. C. fell in with several small bergs in such proximity to each other, as to leave little doubt of their being fragments of a large one, which weakened by the high temperature of the surrounding water, had fallen asunder during a strong gale which for several days previous had prevailed from the southeast. The natural tendency of this would be to force the berg into the warm northeast current of the stream, where, already much worn by its prior sojourn there while crossing from the north, its separation soon took place. The strong northwest wind immediately following the southeast gale, probably drove the fragments out of the Gulf again, to where they were seen in the eddy current, which Mr. C. found to set in that place southwest, at the rate of half a mile per hour. And here, said he, a suggestion of much geological interest presented itself to his mind. Supposing an iceberg of the present day to break loose from the northern polar regions, loaded with blocks of stone and gravel, and drifting southward, to strand upon the Banks of Newfoundland, or George's bank near our own shores, and there remain for a considerable period grinding themselves upon the ocean's bed, thereby incorporating into their mass, portions of it, such as shells, gravel, sand, clay or stones. Owing to the unequal action of the weather upon its surface, and water on its submerged portion, it might as has been shown, turn partially or even entirely over, thus placing the newly gathered matter above water, and if the old were at the bottom previously to the overturn, mixing together the rocks from both localities. Loaded with this additional material, it might float off and resume its southerly course, till accidentally forced into the Gulf Stream and carried eastward at the rate of 24′ a day, (the mean velocity of the Stream in the meridian referred to,) till it was melted away. To affect this dissolution would require three or four months, during which time, the berg would be carried six or seven hundred miles in a direction nearly at right angles with its primary drift, depositing a greater or less quantity of transported material along its entire track. Mr. Couthouy remarked that the instance just cited, was one of peculiar interest, from its illustrating the manner in which rocky materials imbedded in icebergs, may through the devious course of these latter, be deposited along a wide range of longitude as well as latitude. He called attention to the fact that this berg was to the southward of the Gulf Stream, and about 18° or seven hundred and fifty miles west of a meridional line, passing through the centre of the grand Bank of Newfoundland. It was the only case within his knowledge, of an iceberg being seen so near our continent in this parallel. He shewed by reference to a chart of the Atlantic, that in all probability this one entered the Gulf Stream at least as far eastward as the 48th deg. of west longitude, and in the 42d or 43d parallel of north latitude. It was his opinion that this occurred in the spring of the year, when the prevalent strong northeast winds would drive it southerly across the stream with nearly as much rapidity as the latter would carry it forward in an easterly direction. To exemplify this, said Mr. C., we should work out the drift, and true course of this berg, precisely as a seaman would do that of a ship hove to the wind for the same length of time, and under like circumstances. Assuming then that the berg in question, had impinged upon the Gulf Stream in the latitude and longitude above given, and there encountered one of the northeast gales, so frequent, and of such long continuance on our coast in the spring;—half a mile per hour would be a moderate allowance for its set southwestward by the wind and heave of the sea. In forty days, (and it is well known that easterly gales often prevail over this part of the Atlantic during the spring months, for even a longer period;) in forty days, it would, were there no opposing agency at work, be propelled three hundred and forty miles west, and the same distance south of its point of entrance into the Gulf Stream. But as in this parallel, there is a current setting in an east by south direction, with a mean velocity of three quarters of a mile per hour, this would during the assumed period, not only counteract the wasting caused by the swell, but carry the berg three hundred and sixty-eight miles east, and one hundred and twenty miles farther south, making its true line of drift up to the close of the forty days, to be south 38° east, and the distance traversed four hundred and seventy miles. This would place it in latitude 34° 50′ north, longitude 38° 30′ west, or about across the Stream, here not far from four hundred and fifty miles wide. From this point to the locality in which the fragments were seen, its course would be about south 84° west, and the distance one thousand four hundred and seventy miles. Assuming that the eddy current and heave of the sea combined, were equal to impelling it westward at the rate of three quarters of a mile an hour, it would require about eighty days to transport it to the locality in question. But as the wind although acting upon it generally from the eastward, cannot be supposed to have done so constantly, it might be a considerably longer time in performing the voyage.

Mr. Couthouy exhibited a chart of the Atlantic, with the assumed track of the iceberg met by him, marked upon it, and pointed out that its drift westward must have been at least as great as he had there represented; since it could not, owing to the trend of the coast of Newfoundland, have entered the Gulf to the westward of the point designated, but on the contrary was likely to have done so farther eastward. Moreover, as it could by no possibility have reached the spot where he fell in with it, without having been driven across the Gulf Stream into the westerly eddy, it was obvious that unless the heave southwestward by the northeasterly wind and swell were admitted, it must have been for a much longer period in the Stream and finally emerged to the southward of it, at a point much farther south and east than he had assumed in his calculation of its course.

That a mass of ice so considerable should remain after so long a sojourn amid the warm waters of the Stream, would not, he observed, appear surprising, when the enormous magnitude of some of the masses that have been encountered by voyagers in these seas was taken into account; together with the fact that they produce by their dissolution, carry about with them, and occasion to a great distance around them, a very material decrease of temperature, both in the air and ocean, which tended to render the operation a much more gradual one than we might at the first glance imagine. From the record of a journal kept by Francis D. Mason, Esq., in June, 1810, on a passage from New York to Halifax, N. S., and published in Blunt's American Coast Pilot, edit. 1827, it appears that the water at seven miles from some icebergs was from 12° to 15° below the average temperature where it was not affected by the presence of such bodies. One of these islands is represented as having been one hundred and fifty feet in height, and a mile in extent. It was easy to conceive of masses like this, resisting the action of air and water for a much longer period than would suffice to place the berg, whose course has just been described, so far from the point of its northern entrance into the Gulf Stream.

The last iceberg of which Mr. C. was prepared to speak from personal observation, was encountered by him on the 4th of March, 1841, in the Pacific Ocean, during a passage from the Hawaiian islands to Boston. It was of great magnitude. Its height could not have been less than two hundred and eighty or three hundred feet, and its longest diameter two thirds of a mile. The ship sailing at the rate of seven miles an hour, was two hours and three quarters in coming up with it after it was first seen from the deck, when it already loomed up like a large islet. Immediately on its discovery the ship was headed directly for it, till within half a mile of the berg, at which distance it was passed. Without the aid of a glass Mr. C. distinctly saw enormous masses of rock projecting from different parts of this ice mountain, some of them apparently having a surface of at least twenty feet square. The swell, which was very heavy from the westward, washed up the sloping sides to the height of eighty or one hundred feet, recoiling in vast sheets resembling cataracts; and where the face of the berg was perpendicular, the surf broke against it as if it had been a wall of rock, with tremendous force, and a booming roar like that of distant heavy thunder. There appeared to have been a recent overturn of the berg, inasmuch as the water for a mile's distance from it was full of fragments, some of them sufficiently large to endanger a vessel. One of the most remarkable phenomena observed by Mr. C., was the almost incredibly rapid revolution of this huge body on its vertical axis, in consequence of which, it did not present the same aspect for two minutes together. One moment it was a pyramid, the next barn-shaped, and in another a glittering pile of peaks and serrated crests, or battlements, like those of some ancient castellated citadel, was exhibited. Scarcely was there time to sketch the rudest outline of one configuration, ere it gave place to another totally dissimilar. This melting away of the various figures, could be compared to nothing better than the sudden and fanciful changes we see in turning a kaleidoscope. Mr. Couthouy here exhibited to the Association a series of sketches taken at the time as illustrative of the variety of form spoken of. The following statement of the temperature of the air and ocean at various distances from the berg, was given as evidence of the great extent to which they were affected by its presence, and the influence which, as before mentioned, this circumstance exerted on the retardation of the dissolution of similar masses:

	Noon.	2 P.M.	3 P.M.	3 30 P.M.	4 P.M.	4 30 P.M.	5 P.M.	5 30 P.M.
Air,	54°	53°	50°	46°	42°	37°	35°	37°
Water,	50°	50°	48°	44°	43°	36°	36°	40°
Distance of berg,	33′	19′ (visible,)	12′	8′	4½′	1′	3′	6′

When nearest the iceberg, (which was within a short half mile,) the water was at a little below 34° Fahr., and the air at 35°. After passing the island, when about two miles to leeward, a smart fall of hail was experienced, which lasted about ten minutes. By this statement it appears, that the water three miles to leeward of the island was 7° Fahr. colder than that four and a half miles to windward, and at six miles, 3° colder than at four and a half and 4° colder than at eight miles to windward, owing probably to a surface current carrying the cold water from it in the direction the wind was blowing. The latitude of this ice island was 53° 20′ S., and its longitude 104° 50′ W., making its distance from Terra del Fuégo, the nearest eastern land, one thousand four hundred and fifty miles, and one thousand from St. Peter's and Alexander's Islands, the proximate southern land from which it could have been detached. From its great magnitude, it was the opinion of Mr. C. that should this berg have been driven by the westerly gales which prevail in that region of the Pacific during so large a portion of the year, into the current setting constantly to the northward along the whole west coast of South America, it might have floated to the verge of the tropics ere it dissolved entirely, or perhaps been stranded somewhere about the shores of the Chiloan Archipelago.

The attention of the Association was called to the fact of such large masses of rock, which were undoubtedly once at the bottom of the berg, being exposed on its face or sides. Mr. Couthouy conceived that the dissolution below the surface by the action of the water, and above it by that of the weather, being unequal in different portions of the berg, especially when it was aground, and consequently one side more constantly exposed to the sun's rays than the other; the equilibrium would be occasionally destroyed, the result of which would be an overturn, like that witnessed upon the Grand Banks, bringing to the surface portions of the mass containing rocks and earth. The U. S. ship Peacock, during her last cruise of discovery in the Antarctic Ocean, while attempting to penetrate the great barrier of ice, was seriously injured, and narrowly escaped utter destruction, from the separation and toppling down of a huge fragment of an iceberg. Had not this latter been still attached to the main body, there can be no question but that one of the violent overturns referred to, would have followed such a change in the proportions of the berg. Again, in the case of a drifting island, where from its rotary motion it is probable the waste from exposure would be nearly equal on all sides, it is evident that the side in which the rocks were imbedded, would, owing to their specific gravity being much greater than that of the ice, gradually preponderate, and either produce a sudden and violent change of axis, or slowly settle down once more, according as circumstances varied. In smooth, still water, the latter would probably occur, while the former might be expected to happen in a tempest or a heavy sea. In connection with these facts, Mr. C. submitted the following supposititious case, as one by no means of improbable actual occurrence, the first portion of which, indeed, was merely a statement of what had really taken place in the great iceberg last described. Suppose an island of ice to be detached from the great southern barrier, having its base loaded with rocks, &c., and after drifting several hundred miles northward, to experience an overturn bringing these rocks to the surface. It then floats on for a considerable distance farther, till from the equilibrium being again destroyed, the rocky portion settles down and resumes its original position. These alternations may occur several times. Driven landward by the heavy westerly swell into the continental northern current, it is at length stranded on the coast of South America, and undergoes one or more overturns, bringing up at each time an additional amount of material. It then is forced off by a strong off-shore wind, and after drifting still farther north is stranded again, perhaps at a long distance from its first anchorage. New overturns follow, fresh materials are accumulated, but from waste, the whole mass becoming lighter, it is once more floated off, and pursuing a somewhat devious course toward the tropics, is gradually melted away. Could that part of the ocean's bed over which such an iceberg has passed be laid bare for our inspection, what would be the appearances presented? The early progress of the mass would be marked by a deposition of large angular fragments of polar rocks. Subsequent to the overturn there would be an interval with few or no traces of its path, till the rocky portion of the berg had resumed its original situation, when the deposition would be continued, and these alternations would evidently correspond to the number of overturns. The larger masses of rock would for the most part be the first to drop out, and latterly the majority of matter might consist of smaller and more rounded fragments, such as had been worn by the grinding of the ice on the beach or bottom. Prior to the last, or even the first stranding, all, or nearly all the rock and earth originally contained in it might be deposited, when the latter portion of its track would be marked by a comparatively scanty amount of material from its more recent halting places, perhaps confusedly mixed, and affording here and there some slight indications of the birth-place of the berg, in the occasional presence of a fragment of the remote Antarctic soil.

Was there aught, asked Mr. C., in the evidences of ancient aqueo-glacial action, analogous to such a mixed deposition, and irregular distribution of materials from widely separated localities, as would result from the conjectural case here presented, or the actual one of the iceberg previously cited as fallen in with on the southern margin of the Gulf Stream? Did they explain any of the obstacles and apparent anomalies presented by the aqueo-glacial theory of the drift formation? These were questions which he submitted for the decision of those whose attention had been more specially directed to this subject.

In reference to the advance and northern limits of icebergs from the Antarctic in the eastern hemisphere, Mr. C. could state nothing from his personal knowledge, farther than that they frequently occur at least as low as the thirty-fifth parallel of latitude. During his residence in New South Wales, in the summer and autumn of 1839–40, (December to March,) several ships arriving at Sydney from England, reported having fallen in with large icebergs in the vicinity of the Cape of Good Hope, at least 1800 miles from the nearest southern land; along the whole of which distance they possibly deposited material from their polar starting point.

Mr. C. stated that he would here offer a few brief remarks upon the bearing of the facts he had submitted upon the question of the results of aqueo-glacial action in past times, and especially in the effects produced upon subjacent rocks by the stranding of icebergs. It was with much diffidence that he dissented from the opinion entertained by some eminent geologists, that this circumstance had any agency in producing the parallel grooves constituting so remarkable a feature in the rocks of New England. Even assuming that in a former era the drifting masses of ice had pursued an uniformly direct course from north to south, though this might explain the general distribution of erratic blocks and bowlders, yet it appeared to him highly improbable that their grounding, and then being driven forward by the combined forces of wind and sea, could ever have produced the furrows in question. There is no reason why the oscillatory or semi-gyratory movement, should not then have followed such an accident as it does now, in which case, as at present, the tendency would be rather to obliterate all such marks, (had they previously existed,) and form a deep hollow if passing over a yielding surface, or a confused scratching and grinding down of a rocky one. It had been shown, however, that the icebergs of the present day pursue a very irregular course, and although their general progress is truly from north to south, or the reverse, yet impelled by varying winds and currents, they deviate widely both east and west of a meridional line. Did not this fact in some measure explain the difference pointed out by Prof. Hitchcock as apparently existing between the line of direction observable in the distribution of bowlders, and that of the diluvial scratches? It had been suggested, that at the period when the drift was deposited there was no Gulf Stream to affect the course of floating ice, but while this may be very true, it does not follow that there were no currents whatever. It struck him that to assume the production of our parallel grooves by the action of stranded ice, was to presuppose a state of things, a combination of circumstances amounting to a physical impossibility.

Not only must it be taken for granted that there were no currents, or at least but one from the pole to the equator, and only one perennial wind blowing in the same direction, but the floating masses must either have been of such nicely balanced proportions, and melted with such uniform regularity, and the waves must have struck them so exactly from the same quarter, as to have prevented any change of position; or they must have been in such numbers and so closely packed as to preclude any oscillatory movement.

Was it essential to the explanation of the phenomena of drift, to assume that the distribution of bowlders, and the production of our so-called diluvial scratches, were entirely the result of contemporaneous action? Might there not have been a period when the northern portion of our hemisphere was covered with glaciers resembling those of the Alps, during which the furrows were produced by their gradual and radiolinear advance, followed by one of drifting ice, (whether borne along with a sudden rush of waters, caused by a paroxysmal elevation of land in the vicinity of the pole, or floods resulting from a gradual melting away of the mass, he would not now pause to inquire,) depositing bowlders through its course, and by the stranding and grinding of large masses into beds of sedimentary matter or drift, have occasioned the singular contortions visible in portions of the clay strata?

If it could be shown that a sudden and violent rush of waters from the polar region had taken place, sweeping over the whole northern portion of this hemisphere, bearing along with it large islands of ice, denuding the hills and filling the valleys with drift, and eventually subsiding almost as rapidly as it poured southward,—would not this induce a belief that the remarkable, large bowl-shaped cavities described in Prof. Hitchcock's able memoir on the drift of New England, as existing on Cape Cod and elsewhere, might have been formed by the stranding and grinding of large islands of ice down into the recently deposited drift? It occurred to Mr. C. at once, when these excavations were alluded to by Prof. Hitchcock, in connection with ice, that they might have originated in this manner, rather than from the deposition of matter round the melting ice, as suggested by that gentleman,—or they may have been produced by a combination of these two operations; the grinding and settling down of the stranded berg, excavating a hollow, while the earthy materials contained in it would be piled up round the sides as it dissolved. If we supposed a very large berg of the pinnacled character, to have been left aground by the subsidence of the paroxysmal flood, and divided into several smaller ones, each forming a separate crateriform bed for itself, we should then readily comprehend the production of such a group of these cavities as was described by Prof. H. Whether these suggestions were borne out by the geological features of the drift in general, was left for those to determine whose observation had been more specially directed to a study of these phenomena. Mr. Couthouy observed that he would merely repeat that in relation to the production of diluvial, or to speak more correctly, glacial furrows, he had no preconceived views of his own to support, but that when he first heard them attributed to the grating along the bottom of icebergs, he was convinced by the recollection of what he had personally witnessed of the action of ice under such circumstances at the present day, that this never would have produced such results. The parallelism and uniform direction of the striæ, appeared to him conclusive of a different agency in their formation. He felt persuaded that no person who had once seen the actual movements of a stranded iceberg, would ever afterwards entertain for a moment the idea that such a cause would produce the furrows under consideration. He also thought it very problematical whether icebergs would by their stranding, and being irregularly pushed forward by wind and wave, produce moraines, having much if any affinity with those resulting from the slow, regular advance of the Alpine glaciers.

He offered these suggestions with no small hesitation, fully sensible how presumptuous it might seem in him to venture a difference in opinion with those eminently distinguished geologists who had addressed the Association on this topic. They were, however, such as arose naturally in his mind while reflecting on what had passed under his own observation. The facts on which they rested were before the members, and so little was really known, so few had an opportunity of witnessing this part of the aqueo-glacial agency now going forward, he felt sure that they would excuse his having trespassed on so much of their time in submitting at least these facts for their consideration.

In conclusion, Mr. Couthouy remarked, that he had in this paper used the term *aqueo-glacial* to express the nature of the action of water and ice, in connection with the deposition of drift, rather than that of *glacio-aqueous*, proposed by Prof. Hitchcock in his memoir, not merely for its greater euphony, but because he thought it more expressive of the relations of the transporting media, of which water rather than ice was the predominant, or at least the active agent, and therefore entitled to precedence in a descriptive phrase like this.

A communication was then read from *Dr. Hale*, inviting the Association to make use of the library and rooms of the American Academy. The Association adjourned to

Tuesday, 3½ o'clock, P. M.—*Prof. Wm. B. Rogers* was called to the chair in consequence of the indisposition of the president.

Dr. Jackson exhibited a drawing of the pot holes described by him in the morning, and gave a farther description of the same, and the discussion of the morning was carried on by *Prof. Henry D. Rogers*, *Prof. Emmons*, *Prof. Hitchcock*, *Mr. Redfield*, and the chair.

Prof. Beck read a paper "on certain pseudomorphous or parasitic minerals in the State of New York," on which remarks were offered by *B. Silliman, Jr.*, *Dr. Jackson*, and *Prof. Emmons.*

Mr. Vanuxem read a paper "on the Origin generally of Mineral Springs," which he followed by some remarks on the metalliferous ores found by himself in the State of New York, together with some observations in regard to the fissures in rocks.

Association adjourned to Wednesday, 9 o'clock, A. M.

In the evening *Prof. Silliman* delivered a most interesting address on the "Progress of Geological Science in this country," to the Association, in presence of the public, who had been invited to attend.

Wednesday, April 27th, 9 o'clock, A. M.—Association met pursuant to adjournment, *Dr. Morton* in the chair. A letter was read by the secretary from *Mr. Richard C. Taylor.*

The constitution, as reported by the committee on the constitution and by-laws, was then read by the secretary. Articles I, III, and IV, were carried with amendments; the other articles were carried as reported.*

Resolved, That an additional article be prepared by the committee, providing for the future alteration or amendment of the constitution and by-laws.

Resolved, That Prof. Silliman be requested to publish his address before this Association in the American Journal of Science as one of its articles.†

After some remarks on the subject of drift, *Prof. Emmons* offered the following resolution on the subject of drift, which was carried.

Resolved, That the subject of drift in our country receive still farther examination from the committee, and that a farther report be made at the next meeting of the Association. Objections to the views presented and as it has been treated by geologists in general are, that many phenomena are confounded together: as, 1st, the washing up of ridges along the shores of lakes; 2d, those of glaciers; 3d, of icebergs; 4th, alluvial beds; 5th, the accumulation of bowlders along what were ancient coasts; and 6th and 7th, pot holes and slickensides. Icebergs do not necessarily act upon rocks when borne along, inasmuch as they are supposed to be defended by soft materials, as gravel, sand, and mud; and that they explain merely the *distribution of bowlders*, and their peculiar movements when grounded are not likely to form parallel grooves or scratches. The theory of an hemisphere of ice

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* The Constitution will be found under Tuesday's proceedings.

† This address will form the leading article in our next number.—Eds.

capping the whole at least of the northern region is objectionable from the utter extinction of life, especially of molluscous animals, which does not appear to have been the case, as there is an uninterrupted or unbroken series from the eocene to the present.

Resolved, That a committee of three or more be appointed, each to make a distinct report on the subject of drift.

Prof. Emmons, *Prof. Wm. B. Rogers*, *Mr. Vanuxem*, *Mr. Nicollet*, and *Dr. Jackson*, were appointed on the above committee.

Resolved, That all committees which have not reported this year, be instructed to report at the next meeting.

Resolved, That a committee of one be appointed to inquire through all available sources in regard to the influence of icebergs on drift. *Mr. Couthouy* was appointed on the above committee.

Prof. Locke read a paper on the ancient earthworks of Ohio. A discussion followed some remarks of the chairman (Dr. Morton) on this subject, between *Prof. Locke*, *Mr. Nicollet*, *Dr. King*, *Mr. Haldeman*, *Prof. Silliman*, *Prof. Hitchcock*, and *Prof. Bailey.* Mr. Nicollet related several observations relative to the manners and customs of the Indians, made during a long residence in their country, having a bearing on the construction and age of these mounds.

Resolved, That a committee be appointed to examine and report on the subject of western mounds. The following gentlemen were appointed on this committee.

Prof. Locke, *Mr. Nicollet*, *Mr. John H. Blake*, *Dr. Engelman*, *Mr. S. P. Hildreth*, *Prof. Troost*, and *Dr. B. B. Brown.*

Adjourned to Thursday at 9, A. M., the afternoon being appropriated to the delivery of an address before the Boston Society of Natural History, by the chairman of this Association.

Thursday, April 28th, 9 o'clock, A. M.—The Association met according to adjournment, *Prof. Silliman* in the chair. Proceedings of the former meetings were read and accepted.

Resolved, That *Mr. John L. Hayes* be added to the committee on the subject of icebergs, and that he be requested to prepare a separate report.

The committee appointed reported an article relative to amendments of the constitution, which was adopted as a part of the constitution.

Resolved, That on Friday at 9, A. M. the Association proceed to the choice of officers for the next annual meeting, and also to fix upon a place for the same.

Prof. Locke read a paper describing a new instrument invented by himself, and which he called a *Reflecting Level and Goniometer;* he described a reflecting compass of his invention, and read a paper "on a Prostrate Forest under the Diluvium of Ohio."

Prof. Hall made some remarks on the wood found underneath the drift in Washington.

Prof. Hubbard offered some remarks on the drift of New Hampshire, exhibiting a remarkable specimen of a bowlder of smoky quartz containing acicular crystals of rutile.

Resolved, That Prof. Hubbard be added to the committee on drift.

Dr. C. T. Jackson read a paper "on the Tin Veins of New Hampshire," exhibiting specimens of the ore both crystallized and compact, and an ingot weighing three ounces of the reduced metal obtained from five ounces of the ore, the accompanying minerals of the vein at Jackson, also specimens of the yellow blende of Eaton and the black blende of Shelburne, with a specimen of the reduced metal from each, and a specimen of the associated lead ore.

Prof. W. B. Rogers adverted to the occurrence of oxide of tin in Virginia, associated with the auriferous quartz and other minerals of some of the gold mines. As yet he had discovered it at only a few localities. It is in the form of very small crystals scattered at wide intervals, and even where it occurs is perhaps the rarest of all the metallic minerals found in and contiguous to the gold veins. In the two or three instances in which it was found in place, it was imbedded in a talco-micaceous slate, near its junction with the auriferous quartz. The minerals met with in the talcose and micaceous slates, which usually include the veins and beds of auriferous quartz, are auriferous, common, arsenical and cupreous sulphurets of iron, sulphuret of copper, carbonate of copper, sulphuret of zinc, sulphuret of lead, sulphur in minute crystals lining the cavities of cellular quartz, metallic gold, peroxide of iron, phosphate of lead beautifully crystalline, oxide of tin and oxide of bismuth, both exceeding rare.

In connection with Dr. C. T. Jackson's remarks on the occurrence of sulphuret and other ores of zinc in New Hampshire, *Prof. W. B. Rogers* mentioned that he had found the sulphuret of zinc sometimes, and the silicate (electric calamine) generally and very abundantly in the lead mines of Wythe Co., Virginia. The *latter mineral* often occupies a great part of the breadth of the vein, lying for the most part beneath the lead ore, sometimes as a sub-crystalline mass and sometimes in groups of small radiating crystals. The *sulphuret* is chiefly met in nests and thin veins, in the sparry and magnesian limestone adjoining the lead ore, and is intermixed with crystals and small seams of galena.

Prof. Rogers added, as a fact of mineralogical interest, that besides the *sulphuret of lead*, these mines yield in some instances quite a large proportion of *carbonate*, of which beautifully pure crystalline specimens are by no means uncommon; and what is still more interesting, they furnish a very considerable amount of *red oxide* or *native minium*, with a small proportion of *yellow oxide*, both of which have hitherto been regarded as very rare minerals. From its resemblance to ferruginous earth or clay, this red oxide was until lately regarded at the mines as worthless, but is now highly valued for its productiveness in metal.

Dr. C. T. Jackson exhibited a specimen of meteoric iron from Claiborne County, Alabama, in which he discovered chlorine in the form of chloride of iron and nickel, in 1834. (See this Journal, Vol. xxxiv, p. 332.)

Prof. J. B. Rogers referred to some analyses of meteoric iron and meteorites recently made by him. A specimen of meteoric iron taken from a mass of many pounds weight in Grayson Co. Virginia, was found to contain 6.15 per cent. of nickel, and gave a very slight trace of chlorine. A meteoric stone from Georgia, made up of shot-like grains of nickeliferous iron with slender flattened threads of the same mineral imbedded in a paste composed chiefly of silicate of magnesia and alumina, gave no indications of chlorine. The grains yielded 7 per cent. of nickel.

Prof. W. B. Rogers stated that he had examined a mass of meteoric iron from Roanoke County, Virginia, and was unable to detect in it the slightest trace of chlorine. A fragment of meteoric stone from Ashe County, North Carolina, examined at the same time, was found to contain a marked quantity of this principle, the presence of which, however, was accounted for by the fragment having been in contact with a bag of salt, as it was carried home by the person who found it.

Prof. Hitchcock read a paper "on a new species of Ornithichnite from the valley of the Connecticut river, and on the raindrop impressions from the same locality."

After Prof. Hitchcock's observations respecting the bird tracks of the Connecticut valley, *Mr. Lyell* alluded to the subject of the cause of the present dip of the formation, expressing the opinion that it is due, in part at least, to an uplifting of the strata.

Prof. H. D. Rogers mentioned the reasons which had induced him to attribute the dip of the beds in the other great tract of this new red sandstone, or that which ranges southwestward from the Hudson, to oblique deposition. A uniform northerly dip of about fifteen degrees prevails entirely across the basin, even where it is twelve or twenty miles in breadth, and coëxists with a manifest shallowness of the deposit. This want of vertical depth is seen in several places in Pennsylvania, where denudation has exposed, in the interior of the tract, large patches of the older Appalachian strata, upon which this new red formation rests unconformably. No traces of dislocation occur to lead to the inference that the shallowness of the basin is deceptive, and that the present want of depth in the deposit has been caused by a succession of upthrows with denudation. The steady northerly dip is very rarely influenced, either in amount or in direction, by any of the numerous dykes of trap which penetrate the formation.

Prof. Rogers next mentioned facts which go to shew that the formation of the Connecticut valley and the equivalent one of the Middle States, are in all probability, accumulations in two originally distinct estuaries. He mentioned as one evidence, the independent direction of the dip in the two basins, and stated that the absence of a parallel order of succession in the members of the two formations, tends likewise to strengthen this opinion.

Mr. Lyell conceived the steepness of the dip, which sometimes amounts to twenty degrees, but more especially its direction,—transverse to the course of the ancient estuary, to present a difficulty. Prof. R. endeavored however to shew that the present dip might have been the original one, by suggesting, first, that there is evidence in the nature of the materials of the great southern basin for believing that they entered the estuary *laterally* on the outcrop side, by streams flowing from a country of decomposing, talcose, chloritic and hornblende rocks; secondly, that if the channel was near the same shore, the velocity of the tide might have prevented any horizontal deposition far out from the margin; and thirdly, that a gentle and steady *rising* of the region would, in conjunction with the proximity of the channel, tend to maintain both the slope of the sediment and the lateral advance of the shore which the hypothesis requires.

Mr. Benjamin Silliman, Jr., referring to the formation of the Connecticut valley only, considered a part of the present inclination of the beds to be the result of upheaval, connected with the outbursting of the trap.

Prof. W. B. Rogers made some remarks corroborating the views of Prof. H. D. Rogers in their application to the middle secondary or new red sandstone strata of Virginia and North Carolina. He described this group of rocks, consisting of shales, slates, sandstones and conglomerates of various tints of red and gray, as extending with some considerable interruptions in a nearly S. S. W. direction, entirely across the State of Virginia, and for some distance into North Carolina. With but a few local exceptions he had found the dip throughout this belt to be N. W. or N. N. W. Though destitute of the wide and prolonged ridges of trap met with in the corresponding districts of Pennsylvania and New Jersey, this region includes a great number of small dykes and knobs of trappean rock, penetrating the sedimentary strata, but in no instance causing any well marked change of dip in the adjacent beds. The materials of these strata Prof. R. stated to be very clearly traceable to the region of gneissoid and schistose rocks lying to the southeast of the tract, and in some cases, as in the limestone pebbles included in the conglomerate, could even be referred to the individual beds from which they had been torn.

He supported the opinion maintained for some years past by Prof. H. D. Rogers, that the inclination of the strata is not due to a tilting action subsequent to their deposition, but is the simple consequence of the influx of detrital matter from the southeast, and its deposition in a series of northwest-dipping planes. As greatly favoring this view he mentioned the fact generally observed in this belt throughout Virginia, that the strata become steeper in their inclination as we proceed towards the northwest; whereas the reverse should have been expected from a force tilting them from a horizontal or gently inclined position into the present northwestern dips. This opinion he conceived, was still further confirmed by the appearance of the strata in some parts of the district, where in consequence of the removal of the sedimentary rocks from a narrow space entirely across the tract, he was able to trace the beds from their outcrop nearly to the bottom of the trough in which they were deposited. In this case, he found the inclination of the beds to continue unchanged downwards, instead of becoming more gently inclined towards the bottom, as might be expected on the hypothesis of an originally horizontal position with a subsequent uptilting movement.

Mr. Redfield spoke of fossil rain-marks of a very perfect character which he had observed with Mr. Lyell, at the quarries of new red sandstone near Newark, N. J. He also gave notice of the discovery of a new species of fossil footmark in the new red sandstone of Connecticut. The specimen which he had seen was found in the well known quarries at Portland, (formerly Chatham,) by Mr. Russell, one of the proprietors, and is now in the possession of Dr. Barratt of Middletown. These footmarks are wholly unlike the Ornithichnites described by Prof. Hitchcock, some of which have been found in the same quarries; but they have some little resemblance to the *Cheirotherium minus*, which is figured in the Bulletin of the Geological Society of France.

Mr. Redfield also exhibited a new species of fossil fish from Sunderland, Mass., which seems referrible to the genus *Palæoniscus;* and also called the attention of the Association to a difference of structure in the *Palæonisci* of the Sunderland locality from those of Connecticut in the same formation; while the latter have a perfect resemblance to the fossil fishes of New Jersey. He had also discovered an apparent error in his own printed notice of American fossil fishes, in having named Sunderland as one of the localities of the genus *Catopterus*, as further examinations had led him to doubt on this point; although this genus is more common than *Palæoniscus* in the new red formation, both in Connecticut and New Jersey.

Mr. Lyell and *Mr. B. Silliman, Jr.* offered some remarks on Mr. Redfield's observations.

Mr. John S. Hayes, in explanation of the fossil footmarks in the sandstone of Connecticut river valley, gave some account of the existing species of birds most nearly resembling those supposed to have made those tracks.

As going to show the inclined position of the strata at the time when these impressions were made, *Prof. W. B. Rogers* called attention to a peculiarity in the form of many of these impressions, noticed by himself and Prof. H. D. Rogers in company with Prof. Hitchcock, during the last summer, and often remarked by Prof. Hitchcock on previous occasions. The feature referred to resembles the effect of a slight sliding of the foot in soft clay. It is seen in some of the larger footsteps, both those which point upwards and downwards in reference to the present slope of the rocks, and is even more conspicuous where the animal has been walking horizontally along the inclined surface, in which case there is a protuberance on the downhill side of each impression, as if in virtue of the slope the pressure of the foot had accumulated the soft clay in that direction. Adjourned to

Thursday, 3½ o'clock, P. M.—*Prof. W. B. Rogers* in the chair. A communication from *Prof. Chester Dewey* on the polished rocks of Rochester, N. Y.

Dr. Locke exhibited about eighty colored casts of the fossils found in the western rocks, with explanatory remarks, and upon the advantages to be derived to geological science from the distribution of similar copies.

Mr. James Hall and *Prof. H. D. Rogers* offered some remarks on observations made in connection with Dr. Locke on the same subject.

Dr. King expressed the opinion that the fossils exhibited by Dr. Locke, were not generally the same as those common to the lead-bearing series of the upper Mississippi, and that from his investigations, which had been pretty extensive, he believed that the portion of the formation of that region in which the lead is found, overlies, and is very distinct from what is considered by Dr. Locke to be the *cliff* formation of Ohio. To this *Prof. Locke* replied that the fossils presented by him, were not presented as the fossils of that part of the cliff limestone, containing the lead ore; some of them were actually from the stratum overlying that ore.

Resolved, That the attention of the meeting be strictly confined to the reading of papers, during the remainder of the present session, and that no discussion be allowed thereon.

Mr. James Hall read a paper in connection with a section which he exhibited, of the rocks extending from Cleveland, Ohio, southwesterly to the Mississippi.

Prof. Locke offered some remarks, explanatory of Mr. Hall's opinion on the equivalency of the western formations.

Prof. Hitchcock read a paper on the determination of the silicified trunk of a tree found in the new red sandstone of Connecticut.

The Association then proceeded to the election of a standing committee.

Resolved, That this committee consist of the following gentlemen: *Prof. Edward Hitchcock*, *Dr. Ducatel*, *Dr. C. T. Jackson*, *Prof. Lewis C. Beck*, *Mr. Lardner Vanuxem*, *Dr. J. B. Rogers*, *Prof. J. W. Bailey*, *Prof. John Locke*, and *Prof. B. Silliman.*

Resolved, That *Dr. King* and *Dr. David Dale Owen*, be added to the committee on the western mounds. Adjourned to

Friday, *April* 29, 9 o'clock, A. M.—Association met pursuant to adjournment, *Prof. Beck* in the chair; minutes of the last meeting read; proceeded to the choice of officers for the ensuing year, according to the resolve of yesterday. The following gentlemen were unanimously elected: *Prof. Henry D. Rogers*, Chairman; *Prof. John Locke*, Treasurer; *Prof. Oliver P. Hubbard*, Secretary.

Resolved, That the next meeting of this Association be held in Albany, N. Y.

The secretary was requested to answer the communication from the National Institute at Washington, inviting the Association to meet in that city.

In consequence of the election of *Prof. Locke* to the office of treasurer, a vacancy was left in the standing committee, he being *ex-officio* a member of that committee. *Mr. John L. Hayes* was elected in his place.

Prof. Wm. B. Rogers, *Prof. Locke* and *Prof. Hitchcock*, were appointed a committee to confer on the subject of the time of the next meeting.

Resolved, That the subject of publication of the abstract of the proceedings of this meeting of the Association, be placed at the disposal of the chairman and secretaries of the present meeting.

A communication was read from *Mr. J. E. Teschemacher*, containing "a description of the oxide of Tin, found at the Tourmalin locality of Chesterfield, Mass."

Prof. Beck read the title of a paper "on some Trappean minerals and the general geological conclusions to be drawn from their history."

The committee on the time of meeting for 1843, reported the fourth Wednesday of April next, which was accepted.

Prof. W. B. Rogers read a paper "on the Age of the Coal Rocks of eastern Virginia." He described these strata as occupying parts of Chesterfield, Powhatan, Amelia, Henrico, and Goochland counties, and lying in basins of granite, the principal coal seam being separated by only a few feet from the floor of primary rock. In some places near the margin of the field, where alone they have been explored, the thickness of these coal rocks is upwards of eight hundred feet, but towards the centre of the principal basin it is probably somewhat greater. Throughout much of this depth they consist of coarse grits, often composed of the materials of granite so little worn as to present the aspect of this rock in a decomposing state. In this paper Prof. R. shows, on the testimony of fossils, and especially the vegetable impressions found in the grits and slates associated with the coal, that these rocks instead of being as had been hitherto supposed of even older date than the great carboniferous formation of the west and of Europe, belong in fact to a much later period and correspond nearly if not accurately with *the bottom of the oolite formation of Europe.* The prevailing fossils are of the genera *Equisetum*, *Tæniopteus*, and *Cycadites* or *Pterophyllum*, and either agree specifically or correspond nearly with those of the *oolite coal of Brora* and the equivalent beds at Whitby and other places. Prof. R. laid much stress on this determination as supplying one of the links in the geological series not hitherto discovered in this country, and as presenting a striking analogy with the abnormal development of the lower oolite in certain parts of Europe. At the conclusion of the paper, Prof. R. stated that from the fossils he has discovered in a particular division of the new red sandstone of Virginia, he expects ere long to be able confidently to announce the existence of beds in that formation corresponding to the *Keuper in Europe.*

Prof. Wm. B. Rogers communicated a paper "on the Porous Anthracite or Natural Coke of Eastern Virginia." In this paper Prof. R. investigates the cause of the peculiar texture and composition of this material, and points out the forms of vegetation from which both it and the neighboring bituminous coal have been chiefly derived. From the position of the coke beds, as compared with those of the bituminous coal, and the frequent interlamination of the two, he proves that the non-bituminous character of the former could not have arisen from the effects of heat on a seam of bituminous coal, but must be ascribed to the thorough carbonization and desiccation of the vegetable matter before it was *sealed in* by the overlying strata.

Prof. W. B. Rogers communicated a paper "on the Connection of Thermal Springs in Virginia with Anticlinal Axes and Faults." In this paper he gives a list of more than thirty thermal springs, having an excess of temperature over the ordinary constant springs of the neighborhood of from two to nearly sixty degrees, comprising all the distinctly thermal waters which he has thus far met with in Virginia. These are all situated in the Appalachian belt, and *without an exception issue on or near the line of an anticlinal axis or a fault—or near the contact of the Appalachian with the Hypogene rocks.* Prof. R. laid much stress on the fact that the warmest of these springs were generally those which issued from the lowest formations. Accompanying the paper were a series of short sections, illustrating the geological position of a number of the most interesting of these springs.

Prof. W. B. Rogers communicated a paper entitled "Observations on Subterranean Temperature made in the mines of eastern Virginia." In this paper Prof. R. gives the results of observations with the thermometer at depths varying from one hundred to nearly eight hundred feet, all indicating an increase of temperature downwards. Some of these results procured under favorable circumstances, he considers sufficiently accurate to warrant an inference as to the rate of increase of the temperature with the depth in this region. These, it is believed, are the first observations of the kind made in the United States, and, if we except those of Humboldt in Mexico, the first in North America.

Prof. H. D. Rogers offered some remarks on the influence of pyrites on the heat of the strata.

Prof. Hitchcock read a paper entitled "Notes on the Geology of some parts of Western Asia, derived principally from the American Missionaries," and exhibited numerous specimens in illustration of his remarks.

Dr. Dana presented a copy of what was probably the first work on the geology of America, entitled "Beytrage zur mineralogepfer Keintre und des Cëstlicheu theils von Nord America und sum Gebürsge von D. Johamre David Schöpf," presented to the library of the Boston Society of Natural History. Mr. Teschemacher was requested to report on it.

Mr. Couthouy read a paper "on various icebergs as observed by him."*

Mr. James Hall read a paper "on wave lines and other markings on the surface of rocky strata in New York and other places." Association adjourned to 3½ o'clock, P. M.

Friday, 3½ o'clock, P. M.—*Prof. Silliman* in the chair. The following gentlemen were announced by the standing committee as the local committee for next year. *Dr. T. Romeyn Beck*, *Prof. E. Emmons*, Albany, and *Mr. W. C. Redfield*, New York.

A letter from *Mr. James T. Hodge*, relative to the distribution of State Reports, was read by the secretary.

A paper was read "on the Structure of the Appalachian chain, as exemplifying the laws which have regulated the elevation of great mountain chains generally;" by *Prof. Henry D. Rogers*, and *Prof. William B. Rogers.*

The authors divide their papers into two parts; Part I, being a description of the phenomena; Part II, a theory of the flexure and elevation, of the strata deduced from the preceding features of structure.

Part. I, embraces the following heads:

1st. A sketch of the physical features of the Appalachian chain, from New England to Alabama.

2nd. Predominance of southeastern dips, with an historical sketch of the previous explanations offered by other geologists.

3rd. Of the character of the flexures of the strata, and the law of their gradation in crossing the chain northwestward. Two or three new terms are here proposed for designating conditions of structure. The several prevailing forms of structure are then exemplified: (*a*,) normal flexures; (*b*,) folded flexures and inversions; (*c*,) flexures broken on passing into faults.

4th. Of the distribution of the axes in groups; remarkable parallelism of the axes in each group; great length of some axes; bending of

* Mr. Couthouy's remarks have been already given, p. 154–165.

axes; increasing interval between the axes as we advance towards the northwest.

5th. Descriptions of a series of sections across the chain, with a table of the northwest and southeast dips which they disclose.

Part II, treats of the following theoretical topics:

1st. The force producing the flexure and elevation of the strata, was compounded of a wave-like oscillation of the crust, and a tangential pressure towards the northwest.

2nd. Theory of the origin of the supposed subterranean undulations, and of the manner in which the strata became permanently bent.

3rd. Identity of the undulations of the crust with the wave-like motion of the earth in earthquakes. This latter shown to result from an actual billowy oscillation of the surface of the subterranean fluid lava.

4th. Of the geological era of the elevation of the Appalachian chain.

5th. Analogous phenomena of flexures; axes in other countries.

A paper was next read by *Prof. Henry D. Rogers*, entitled "an Inquiry into the Origin of the Appalachian coal strata, bituminous and anthracite." It embraces the following subjects:

1st. A brief introductory sketch of the researches of other geologists in the same region.

2nd. The extent and physical features of the Appalachian coal region.

3rd. The character of the strata; (*a*,) rocks of mechanical or terrestrial origin; the laws of their gradation and distribution; (*b*,) rocks of chemical or marine origin, as limestones, &c.; the law of their distribution; inferences respecting the position of the ancient carboniferous sea and its coast.

4th. Of the coal seams, and the phenomena immediately connected with them; wide range of some of the beds; identified from basin to basin; ancient limits of the coal much more extensive; area of the great Pittsburgh seam, and law of its distribution; present and former areas of the coal strata computed.

5th. Of the intimate mechanical structure of the coal; inferences; persistency of the minor subdivisions of the coal beds inconsistent with the doctrine that the vegetable matter was drifted.

6th. Character of the strata which immediately accompany the beds of coal; prevailing nature of the under stratum, Stigmaria; different composition of the overlying rocks; these latter indicate a rapid motion of the waters, the under clay on the contrary a quiet subsidence of sediment.

7th. Beds of marine limestone in contact with the seams of coal.

8th. Theory of the origin of the coal strata; sketch of the discoveries and opinions of preceding writers; deficiencies in the hypotheses hitherto presented; condition under which the vegetable matter of the coal seams was accumulated; of the part performed by earthquake inundations in producing the mechanical strata; evidences of gradual depressions and risings of the coast of the carboniferous sea; indications of similar alternations of secular and paroxysmal movements of the earth's crust at all geological periods.

9th. Regular gradation in the proportion of volatile matter in the coal as we cross the Appalachian basins northwestward; phenomena connected with it; theory of the debituminization of the coal, and conversion into anthracite.

Prof. W. B. Rogers made a few remarks on thermal springs, as relating to the foregoing subject.

Dr. A. A. Gould, Dr. Amos Binney and *Mr. Haldeman*, were appointed a committee to report on the distribution of shells.

Some discussion on the subject of the publication of the Transactions of the Association followed.

Resolved, That *Prof. H. D. Rogers, Mr. B. Silliman, Jr.* and *Prof. L. C. Beck*, be appointed a committee to take charge of the whole matter.

The following gentlemen were invited to become members of this Association: *Prof. Johnston*, of the Wesleyan University, *Dr. Barratt*, Middletown, Ct., *Dr. James Deane*, Greenfield, Mass., *Prof. Nichols*, Union College.

Resolved, That the thanks of this Association be tendered to our distinguished chairman, *Dr. Morton*, for his services at the present meeting.

Resolved, That an invitation be given to European societies who may have the same objects in view as our Association, to send delegates to our next meeting.

Prof. Wm. B. Rogers expressed his feeling of great satisfaction at the unanimity and good feeling which had pervaded the present meeting, as well as at the straightforward devotion to science which had marked so strongly all the proceedings of its members. The Association adjourned to

Saturday, April 30th, 9 o'clock, A. M.—Association met pursuant to adjournment, *Dr. Morton* in the chair. Minutes of the last meeting were read.

Prof. H. D. Rogers presented some details in relation to the striated surfaces of the northeastern counties of Pennsylvania, and the adjacent districts of New York, proving that while the scratches which abound on the summits of all the mountain ridges in that part of the Appalachian chain observe a nearly north and south direction, answering to their prevailing course throughout New England and the country of the lakes, those on the sides and bottoms of the valleys, obey with remarkable fidelity all the local deflections which a body of moving waters would encounter among the ridges and valleys of this entangled range. In the neighborhood of the Wyoming valley, the summits of the mountains, elevated about two thousand feet above the sea, and one thousand five hundred above the valley, are covered with nearly parallel striæ, pointing a little west of south, but on their slopes, in the bed of the valley, these lines follow other directions conforming to the course which any obstructed inundation would pursue. Thus, near Wilkesbarre, the northern flank of the southern mountain, which was here exposed to the full brunt of the inundation, exhibits the grooves with a direction compounded of the general meridional one, and that of the deflecting mountain wall. High on the side of the ridge, the striæ ascend the slope obliquely, but nearer the base they are parallel to the medial axes of the valley. Near the lateral notch, in the northern mountain at Nanticoke, they point *toward* the gorge, showing that a portion of the current here came from a quarter south of east. A great northern wave would, so long as it submersed in its first impetuous rush the summits of the mountains, move forward regardless of the local inequalities of the surface, but after it had partially subsided, the long parallel ridges would present so many barriers to divide and locally deflect the now feeble remnant of the drainage. Reviewing the phenomena which he has observed, Prof. Rogers concludes that the striæ were produced by the friction of the overlying stratum of drift itself, urged into rapid motion from the north by one or more sudden inundations. From the absence near the southern border of the striated region of granitic, or other far transported northern bowlders, he infers that floating ice, while it may have been concerned in dispersing the detrital matter from the north, has had no agency in furrowing and smoothing the surfaces of the strata.

The same gentleman next adverted to the origin of conglomerates and other coarse mechanical strata, attributing them in many instances to the similar agency of the sea-wave produced by earthquakes. The wide and uniform distribution of some of the coarser rocks of the Appalachian basin, was appealed to in proof that they could have been spread out as we find them only by a sheet of water as broad as the entire margin of an ocean, breaking in successive sea-waves upon the land, and abrading and dispersing the fragmentary matter during repeated oscillations of the crust.

Prof. Rogers then added some remarks respecting grooved and polished surfaces at the contact of ancient secondary strata. He thinks he has seen unequivocal instances of these in Pennsylvania. Their production at periods when the earth's temperature was manifestly incompatible with the existence of ice, would seem to demonstrate that angular detrital matter, urged by water, is able of itself to score and polish the surfaces of rocks.

Prof. W. B. Rogers continued the illustration of this subject, by calling attention particularly to the evidences of ancient denudation and drifting action, so strikingly displayed along the place of junction of the Oriskany sandstone, (Formation VII, of the Pa. and Va. Reports,) and the subjacent limestones, (Formation VI.) In many districts the limestone has been irregularly denuded, and even to a great extent removed, and at the same time fragments of the limestone and fossils, water-worn and blended with coarse sand and gravel, have been accumulated to form the lower beds of the Oriskany rock. The rapid fluctuation in thickness of the upper limestones, as witnessed in Virginia, Pennsylvania and western New York, (near Black Rock, for example,) Prof. R. ascribed rather to the irregular force of the denudation, than to irregularity of thickness in the original deposit. He dwelt upon the epoch of the close of this limestone series, and the commencement of the overlying sandstone, as one of great interest in the history of our Appalachian rocks, marked as it is, throughout a great part of the Appalachian belt, by evidences of a sudden and great change in the physical conditions of the ancient sea, and by the proofs of attendant drifting and denuding action of extraordinary energy.

He contended that the grooved and worn surfaces of the limestone which mark the abrading action of a drift at this ancient period, together with the same phenomena observed in the rocks of other portions of the Appalachian series, as described by Prof. H. D. Rogers and Mr. Hall, bear so striking a resemblance to those more recent effects, which have given rise of late to such deeply interesting speculations, that it would seem unphilosophical to refer the two to *different* mechanical causes. He therefore maintained, that as in the production of these ancient phenomena of diluvium or drift, it can hardly be supposed that *ice*, either floating or in the form of glaciers, could have performed any part, since the existence of ice in the ocean at that period is scarcely conceivable, we are under no necessity of resorting to the glacial, or even the glacio-aqueous theory, in explanation of the more modern phenomena of grooved and striated rocks.

Resolved, That *Mr. J. D. Whitney, Jr.* be appointed a committee to be charged with the letters from the secretary to the various foreign societies inviting their coöperation.

The standing committee nominated *Mr. N. Appleton*, of Boston, and *Prof. E. Emmet*, of the University of Virginia, as members of the Association, and they were unanimously elected.

Resolved, That the thanks of this Association be presented to the secretary and assistant secretaries for the performance of the arduous duties assigned them during the present meeting of the Association.

Resolved, That the different state geologists be requested to apply to the legislature of the states with which they are connected, for a number of copies of their reports for the use of the Association.

Resolved, That *Mr. James Hall* be added to the local committee of next year.

Resolved, That the thanks of this Association be presented to the Boston Society of Natural History for the use of their hall as a place of meeting, and for the kind attention shown to the Association by its individual members.

Mr. Couthouy read some extracts from his journal, "on the wave-like undulations of the earth's crust at all periods of disturbance from the most ancient date to the present time," instancing some modern volcanoes.

Dr. Morton, on resigning the chair during the remainder of the meeting, then addressed the Association as follows:

GENTLEMEN—Before we part, permit me to thank you in the most sincere and grateful terms for the honor you have done me in permitting me to preside on the present occasion. I can assure you that I have listened with entire satisfaction and instruction to the proceedings of this body, which will fully sustain the high reputation of those gentlemen who have favored us with their communications, and at the same time establish the character of the Association at home and abroad. I look forward with confidence to its widely increasing utility, and with the most earnest desire to coöperate in your future labors, and confident of your success, I again thank you for the distinction you have thus kindly conferred upon me.

Prof. Locke was chosen chairman during the remaining part of the session.

Mr. Couthouy continued his remarks on the range of the volcanoes of the South Sea islands, and in regard to the progressive movement of volcanic action in a fixed direction.

Prof. Locke offered some remarks in regard to the Oulophyllites found on the Wabash river; also on the diamond found in Indiana on ground near and below the coal.

Dr. Amos Binney and *Dr. A. A. Gould* were added to the committee on publication.

Mr. James Hall exhibited sections on Lake Erie, showing broken strata with intermingled drift; he also spoke in regard to wood and bones found in the drift of various parts of the State of New York, particularly in the Genesee river, and in regard to the change which has there taken place in the channel of the river.

James D. Dana, A. M., of the U. S. exploring expedition, was invited to become a member of this Association.

Prof. Locke in resigning the chair remarked:—In parting with the members of the Association, I cannot refrain from adverting to the fine spirit of harmony and cordiality which has characterized the present meeting throughout all of its transactions. To preserve so desirable a condition, it is of the utmost importance that we observe, in all our communications, the most delicate principles of justice to the previous labors and publications of others. It is not sufficient that we may plead that we have not read their productions; we *must* read them, and give credit in order to preserve each his own reputation. To give credit is to acquire credit, and to withhold it is to sink ourselves into disgrace.

I will only add, that my happiness has been vastly increased by the multiplied social attachments which I have here formed. And in this I presume I express the sentiments of all who have here had the privilege of taking each other by the hand, and of reflecting mutually that look of cordiality which is to be warmly cherished in memory's cabinet until we meet again.

Association adjourned to meet at Albany on the fourth Wednesday in April, 1843. Signed,

SAMUEL G. MORTON, *Chairman.*

CHARLES T. JACKSON, *Secretary.*

JOSIAH D. WHITNEY, Jr. } *Assistant Secretaries.*
MOSES B. WILLIAMS, }

Names and Addresses of Members of the Association of American Geologists present at the Third Annual Meeting in Boston, April 25–30, 1842.

Lewis C. Beck, *New Brunswick, N. J.*
J. T. Ducatel, *Baltimore, Md.*
Lardner Vanuxem, *Bristol, Pa.*
J. N. Nicollet, *Baltimore, Md.*
H. King, *Washington City.*
Henry D. Rogers, *Philadelphia, Pa.*
John Locke, *Cincinnati, Ohio.*
E. N. Horsford, *Albany, N. Y.*
F. Hall, *Washington, D. C.*
Oliver P. Hubbard, *Hanover, N. H.*
Charles T. Jackson, *Boston, Mass.*
J. W. Bailey, *West Point, N. Y.*
Abraham Jenkins, Jr., *Barre, Mass.*
Wm. C. Redfield, *New York City.*
Moses B. Williams, *Boston, Mass.*
James Hall, *Albany, N. Y.*
Josiah D. Whitney, *Northampton, Mass.*
Samuel L. Dana, *Lowell, Mass.*
S. S. Haldeman, *Columbia, Pa.*
H. C. Perkins, *Newburyport, Mass.*
Enoch Hale, *Boston, Mass.*
B. Silliman, *Yale Coll., New Haven, Ct.*
Robert W. Forbes, *New Haven, Ct.*
B. Silliman, Jr., *Yale Coll., New Haven, Ct.*
Charles Lyell, *London.*
Joseph P. Couthouy, *Boston, Mass.*
John L. Hayes, *Portsmouth, N. H.*
John H. Blake, *Boston, Mass.*
Augustus A. Gould, *Boston, Mass.*
Charles H. Olmsted, *Hartford, Ct.*
John Lewis Russell, *Salem, Mass.*
Francis Alger, *Boston, Mass.*
Edward Hitchcock, *Amherst, Mass.*
Ebenezer Emmons, *Albany, N. Y.*
R. M. S. Jackson, *Alexandria, Hunt. Co., Pa.*
Wm. B. Rogers, *University of Virginia.*
James B. Rogers, *Philadelphia, Pa.*
Henry Colman, *Rochester, N. Y.*
Owen Mason, *Providence, R. I.*
Amos Binney, *Boston, Mass.*
Martin Gay, *Boston, Mass.*
J. B. S. Jackson, *Boston, Mass.*