OUTLINE

OF THE

COURSE OF GEOLOGICAL LECTURES,

GIVEN IN

YALE COLLEGE.

NEW HAVEN:

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1829.

DISTRICT OF CONNECTICUT, ss.

L. S.

BE IT REMEMBERED, That on the eighth day of January, in the fifty third year of the Independence of the United States of America, HEZEKIAH HOWE, of the said District, hath deposited in this office, the title of a Book, the right whereof he claims as Proprietor, in the words following, to wit:

"Outline of the Course of Geological Lectures, given in Yale College."

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CHARLES A. INGERSOLL,
Clerk of the District of Connecticut.

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CHARLES A. INGERSOLL,
Clerk of the District of Connecticut.

PREFACE.

This outline of my course of geological lectures, is to be regarded, as a skeleton, furnished indeed with some of the principle muscles; but, destitute of the color and finish, of a perfect form. To my pupils, to whom it has particular reference, it may serve both as a guide and a review, and should it prove, in any degree, useful to others, I shall be gratified. It is intended as an outline of the *philosophy of geology*; according to the best views, which I have been able to take of the suoject. Those who may peruse it, will, however, do me the justice to believe, that in the progress of the lectures, full details are given, and numerous specimens of rocks exhibited. both Foreign and American, in the order proposed, with ample descriptions of their mechanical and chemical constitution—their organized remains, and the order of their arrangement and connexion, and some subjects are discussed which are not even mentioned in this general sketch. As it is the *fashion* of the day, to attribute almost every thing in the earth to igneous agency, I shall probably be thought to be behind the present state of opinion, while I maintain, that the chemical affinities, through the medium of aqueous solutions of the great chemical agents—as well as of water itself, have also produced important effects in the early arrangements of the planet.

If Werner attributed too much to these causes, may there not be danger, at this day, of vibrating to the opposite extreme? It is indeed already proved, that igneous agency has been vastly more extensive than was formerly believed, and it is probable that evidence of this kind will accumulate, as the researches of well instructed geologists are directed, more and more, to this important topic. But, why exclude any of the great powers, which we

find in actual operation; or, of whose ancient activity there appears probable evidence?

In the absence of positive evidence, it is perfectly justifiable to reason, analogically, upon facts and principles, well ascertained by experiment and observation; always bearing in mind, however, that there are probably many agents and agencies, of which we are still ignorant, and that the discovery of some new power, or of some new mode of operation in those already known, might, very materially alter, nay, perhaps entirely subvert conclusions, in which we have been accustomed to repose unlimited confidence. Such a train of thought is far from being agreeable, for we are always prone to reason, on every subject, as if we understood the whole matter; but, the history of science has abundantly proved that philosophy, after building splendid systems, has, in consequence of its own discoveries, been often obliged to return to the humble task of learning its elements anew.

The arrangement implied in the following sketch is, it will be perceived, founded upon the great outlines of the Wernerian plan. Whatever may be the errors and imperfections of that system, (for it undoubtedly has both,) its great outlines still appear to be founded in truth, and to present the best clew to conduct the young pupil through the labyrinths of geology. It has become fashionable to decry Werner; but, without being his blind admirer, I may be permitted to ask, who has done more for geology, and who has done it better?

The author of this sketch begs leave to add, that, desirous of following truth only, he has kept himself disentangled from the prevailing geological systems; and, although trained in geology principally at Edinburgh, in the schools both of *fire* and *water*,* he is neither Wernerian nor Huttonian, Neptunian nor Plutonist; but simply a student of facts—a learner, from those who certainly know more, and a teacher to those who may possibly

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* Hope, Playfair, Murray, Hall, Jameson, Seymour, &c. were the active men of that place, and period, (1805–6,) and several of them were then, and some are still, public instructors, or distinguished writers in geology.

know less. Being habituully occupied, as a part of his public duties, in presenting to his pupils, the great *facts* of geology, and in reasoning upon them; he accepts, with equal readiness, the agency of fire or water, or other agents, as they may appear best adapted to explain a given effect, and he has no hesitation in calling in the aid of all the great natural powers, whether mechanical or chemical, as there may be occasion.

So far as the following arrangement is founded upon the Wernerian plan, it is one of convenience merely, and therefore there is no hesitation in deviating from it, or in substituting other views, when they appear preferable.

Had Werner lived till this time, he would probably have admitted that the differences between the trap rocks and the lavas have become evanescent, and that it is certainly possible, if not probable, that they may have had a similar origin.

On the other hand, those authors who banish the transition class of rocks, being still obliged to describe such rocks, (because they exist, and cannot be annihilated by the stroke of the pen, which erases them from an artificial system) are compelled to divide them between the primitive and secondary rocks, which produces confusion and inconvenience, and destroys the distinctness, which, to a great degree, marks the three great divisions of primitive, transition and secondary. The rocks of North America, as far as they have been examined, correspond, in general, remarkably well with the great outlines of Werner; and who in North America has done so much to develop the grand features of our geology, as the AMERICAN WERNER, WILLIAM MACLURE, whose industry and acumen are equalled only by his candor and freedom from the bias of system.

The views presented in this sketch have not been adopted, without full consideration of the facts upon which they are founded.

The study of those facts seems necessarily to conduct us to the conclusion, that the proofs of both succession and revolution, connected with time, and with both order and disorder, which are so abundant and decisive in the crust of our planet, cannot

all be referred to the deluge. That great convulsion is indeed recorded on the surface of the earth in indelible characters, and it is impossible to weigh the evidence which geology presents in support of it, without admitting, independently of history or tradition, that it has happened. The facts that must be referred to it, are numerous, and highly important and interesting.

But it is impossible, upon any sound principles of philosophical reasoning, to refer to the same event—a still more extensive, various and interesting class of facts, relating chiefly to the rocks composed of ruins and fragments, and to those containing organized remains, in a mineralized and consolidated state, entombed in the solid strata and mountains. This is a vast field of observation and instruction, and it is less known even to the greater number of intelligent and educated persons, than almost any department of knowledge. None but geologists study it with diligence, and none who have not made themselves masters of the facts, are qualified to judge of their importance and of their bearing. The subject *requires*, for full illustration, the exhibition of a great many facts, either in the fields, mines and mountains, or, as an imperfect substitute, in the cabinet. Persons who are entirely destitute of this species of information, can never have formed the habit of comparing one fact in geology with another, and of thus estimating their relation to each other, and to the entire planet. It is very difficult to find access, on this subject, to many minds, otherwise enlightened, and habituated to receive and weigh evidence with candor and intelligence. The reason obviously is, that they are not in possession of the first elementary conceptions of the subject; if the facts are not denied, they are neglected, and fail to make the impression on the mind which they must always produce, when fully understood and realized. No well instructed geologist hesitates to refer them to an earlier period than the deluge, and to a widely different order of things.

This distinction, it will be seen, pervades the following sketch, and the writer believes that no consistent and rational account of the structure of the earth can be given upon any other plan.

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Are the discoveries of geology consistent with the history contained in the book of Genesis?

Respecting the deluge, there can be but one opinion, and that opinion has been already stated; geology fully confirms the scripture history of that event.

There is doubtless more difficulty as to the earlier periods; but the writer, after studying the subject for many years, has formed the opinion, that the geological facts are not only consistent with sacred history, but that their tendency is to illustrate and confirm it.

It is true, that the Bible is not a book of physical science, and that its allusions to physical subjects are, in the main, adapted to common apprehensions. Still, there are two great events recorded in it, which, although they have a momentous moral bearing, are, *in their nature*, entirely physical; we allude to the creation and arrangement of the planet, and to the deluge which was made to sweep over its surface. Why should any one refuse to attend to a history of these two stupendous events, merely because that history professes to have proceeded from the same author as the work itself; and why should we suppose that the brief notices of the great *physical* facts, connected with a *physical creation* and a *physical destruction*, are not correctly stated, in this earliest and most venerable of histories?

If all our discoveries regarding the surface and the interior of the planet tend, when properly understood, to confirm the credibility of both these events, and to enable us to discriminate between the circumstances and evidence which belong to them respectively—what moral consideration can, in this case, forbid a happy application of the discoveries of science, and why should science refuse to lend its aid to the support of moral truth!

YALE COLLEGE, January 12, 1829.

REMARK.

The succeeding sketch is not intended to contain minute descriptions of rocks, but is occupied, principally, with their general characters—their probable origin as regards the immediate physical agents, and the order of time in which they were deposited.

INTRODUCTORY VIEWS.

GENERAL OBJECT OF GEOLOGY.

The object of this science is to ascertain as far as possible, the structure of the earth; the nature of the mineral aggregates which it contains; the disposition, or arrangement of these aggregates, forming the great masses called rocks; the relative position and nature, of the rocks themselves; the useful substances which they contain; the common or natural associations of these with other substances; the proximate causes, which have, probably, given the mineral masses their present form and position; and those, which, operating upon them still, are causing them to undergo alterations, more or less considerable, and are even, in some instances, producing changes, which will ultimately give them new forms of existence.

POSITIVE AND SPECULATIVE GEOLOGY.

It is obvious, therefore, that geology is erected upon facts, and not upon mere speculation; yet, speculation is with propriety admitted, as a part of the means of advancing the science; in some cases it is an important part, but it is of no value if not founded upon facts, and facts must never be contradicted by it.

Positive geology is incomparably more important than speculative, and it proceeds, like the other natural sciences, upon a careful examination of particulars. From particulars, it ascends to generals, and upon these, builds legitimate conclusions. Thus, there is a clear distinction between geological theory and geological hypothesis. The former draws conclusions directly from facts, and follows strictly the inductive course. It has therefore the same foundation, as general physics; and its conclusions of-

ten approximate to demonstration. The latter also appeals to facts, but, in a manner less conclusive and it makes suppositions of facts, not actually proved to exist. For instance: when we observe, that vast quantities of aerial agents, especially of steam, are ejected from volcanos, we reason conclusively, that these agents are employed to raise the lava, and that they cause it to flow over the crater or to burst through the side of the mountain; for, we know, from familiar facts, and experiments, that these agents have power enough to produce such an effect; we know, that in the case supposed, they are present in sufficient quantities, and we are ignorant of any other causes, that might produce these effects, or that may be believed to exist in these circumstances. But, when we enquire for the causes of the heat that produces the steam, and evolves the other aerial agents, we are obliged to speculate. We may say, perhaps, that the voltaic or galvanic powers are the principal agents, and we may even render it highly probable, nay, quite credible; but, we cannot prove the fact, and therefore, our solution rests as an hypothesis; but, of that class of hypotheses which, being built upon analogous facts, approximate to legitimate theory.

If we reason concerning the cause of the magnetism of the earth, we may suppose, that there is a great mass of magnetic iron within the planet; but, this is an hypothesis of a lower order than the one just named; because, we have no analogies to support our conclusion, except that iron can become magnetic and that the mean specific gravity of the earth is about 5., water being 1.; and we invent the cause, on purpose to account for the effect.*

Positive geology is every day augmenting its already rich stores of facts; and speculative geology is building its conclusions upon a basis, which time is rendering more and more solid.

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* The beautiful fossil fish found in marly lime stone, in Mount Bolca, inform us that they were living and active beings, just before those hills were deposited, and when the waters stood over the place where they now are; this is a pregnant truth—but, if we say, with some, that they were overwhelmed by a volcanic eruption, we speculate, some would think plausibly, others fancifully.

LIMITS OF OUR KNOWLEDGE OF THE EARTH.

It is only the *crust* of our earth that we can examine; a few thousand feet, or, at the utmost, a few miles of its outer rind. We no longer attempt, by a brilliant excursion of the imagination, to account for its present form; poetry and fiction have ceased to perform the work of philosophy; those obsolete theories, or rather hypotheses—many of them adorned by the eloquence of powerful minds—which substituted waking dreams for the patient examination of facts, are no longer regarded, except as monuments of the restless activity of the human mind; which is inclined to repose on almost any hypothesis, however visionary, rather than to confess its weakness and ignorance. Buffon could believe, that the earth was struck off from the sun, by the tail of a comet, while it remains to be proved, that a comet has any palpable matter, where we observe that peculiar effulgence; or even if there is, that the firm globe of the sun, would receive injury from such a collision; any more than a cannon ball would be broken, by the stroke of an iron rod.*

A great number of highly qualified men are now occupied in geological researches; they bring to the investigation, all requisite science—the habit of careful induction, and the industry and patience, which are demanded; and the progress made in these enquiries, since the commencement of this century, is wonderful. Districts, provinces, countries and even continents are, more or less, extensively surveyed; and this kind of research, favored by the propensity for travelling, to which it affords both a high incitement and constant gratification, will, doubtless, continue to be extended, until there shall be no countries unexplored,

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*The geological student may find a spirited outline of the most prominent geological hypotheses in Cuvier's Introduction to Geology; they may be read as a matter of amusement; but it will be easily perceived, that they bear no closer analogy to modern geology, than the visions of Alchemy sustain to modern chemistry.

except those from which the *scientific* traveller is debarred, by insuperable moral or physical impediments.

Geology is, therefore, now entitled to a rank among the physical sciences, and is entirely worthy of the attention of the greatest minds.

In grandeur, it falls indeed short of astronomy; and what physical science does not; since, astronomy presents to our optics, or to our intellectual vision, the "great frame work" of the universe; we pass from the view of our own planet to the entire planetary system, of which our earth is a member; and from this system, to other and similar systems; and to the immense system of systems—of suns innumerable, with their attendant worlds, arranged and connected, in perfect harmony; performing all their revolutions without interference, or irregularity, and illustrating the power and wisdom and sustaining energy, of the omnipotent Creator and Governor. Still, the structure of a single planet is a subject of great interest and of no small grandeur; especially as we may reason from it *analogically*, although not indeed conclusively, respecting the structure of other planets.*

MODES OF INVESTIGATION AND SOURCES OF OUR KNOWLEDGE.

Our direct penetration into the earth, by mines, the deepest excavations of art, has scarcely exceeded three thousand feet or a little more than half a mile, not $\frac{1}{8}\frac{1}{0}\frac{1}{0}\frac{1}{0}$ part of the earth's diameter or $\frac{1}{4}\frac{1}{0}\frac{1}{0}\frac{1}{0}$ part of its radius.

It might therefore, at first view seem that we can attain only a very slight knowledge of the internal structure of the planet, and that it would be idle to attempt to reason respecting that of which we can see so little. Still, we are not without probable grounds of reasoning correctly upon this subject, for we have

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* The only positive knowledge which we possess on this subject is derived from the meteoric stones whose foreign origin cannot be reasonably doubted.

The observations made by telescopes, upon the moon, have discovered a surface similar to that of our earth, but vastly more mountainous and as it is now thought highly volcanic. See our author, Appendix, p. 386.

various sources of information and means of perusing the internal disposition of our globe; the most important are derived, from

1. *The obliquity of the strata.*

The strata or natural beds of rocks are found in all positions, from the perfectly vertical, to the perfectly horizontal. Were they all horizontal, it is obvious, that the edges could come into view, only on the sides of mountains, in the banks of rivers, in promontories, &c. and in artificial excavations; and that, in a tolerably level country, we might travel over many leagues, and see very little change in the rock formations.

But if, as happens in most countries, the strata are inclined to the horizon, then, their edges must of course, come into view, provided their obliquity does not change, and provided the rocks are not concealed by their own ruins, or by the general soil. Thus strata, that in a given situation are many miles below the surface, may, and necessarily, must, (under the limitations above specified) come into view, and *crop out*, as it is technically termed, in some place or another. Could we suppose, that for many leagues of surface, measured on a right line, the soil and diluvium were completely removed, from a series of rocks, inclined to the horizon, then, their edges would come fully into view, and we could have no reasonable doubt that we should see an adequate representation of the subterranean geography, as far as those strata extended; and probably for many leagues—it might be even for hundreds of miles beneath the surface. The same remark will of course apply to the strata that are vertical, and indeed to those in all positions, except the perfectly flat; and even then, we are not without means of studying them in the modes already suggested, or, which will be immediately indicated.

2. *Horizontal position of the strata.*

Strictly, this is a position parallel to the general curve of the earth's surface, considered without reference to its superficial in-

equalities; those inequalities themselves, that is the hills and mountains being supposed to have a similar structure. In that case, it is certain, that were this position strictly preserved and were there no perforations and ruptures of the strata, by artificial or natural causes, we should, except in the sides of hills and mountains, see only the upper stratum of rock, and our knowledge of the geology of the region in question, would be confined, very nearly, to the visible material beneath our feet.

We are not informed as to the figure of the nucleus of the earth, but, if it be irregular or even not globular, the strata deposited upon its different sides, or surfaces, may exhibit every degree and variety of obliquity; and the stratum, which, in a given situation, appears horizontal, may in fact, copy, not the great curve of the earth, but a plane, which if continued, would take off a segment of the globe, and thus the edges of the strata would, at their exit from the ground, come distinctly into view, although the surface of the country should be horizontal.

It is impossible to say whether the earth has a solid nucleus or not. If it has, and this nucleus is any thing but a sphere or a spheroidal figure, then the various faces which it would present, might cause the superposited strata to assume every position from flat to vertical, and there would be no occasion to admit that strata, originally arranged in one position, had been by force, elevated into another.

If we admit a nucleus having plane faces, or faces not spheroidal, and allow that the crust of the globe has been accumulated around the nucleus, then it would be possible, that planes of stratification might extend through a large portion of the planet, and might even jut out on opposite sides. If this suggestion were well founded, then the view of the crust might present a fair specimen of the interior, or at least to a considerable extent. The nucleus would however, by the supposition, be covered by the superimposed masses, which might, or might not correspond with it in their nature.

If there be no mistake in the conclusions of the British and French philosophers as to the high mean specific gravity of the

earth, the planet is, on an average, at least twice as heavy as the most common rocks and stones with which we are acquainted.

Does this discovery imply a prevalence of metals in the interior of the earth? Is the nucleus iron, or at least is iron diffused in great abundance in the interior of the earth, and does this account for the magnetism of the globe, although the magnetism of iron itself is still to be accounted for? Or does some other metal or do some other metals, of considerable specific gravity, prevail in the constitution of the earth? If there were known to be a nucleus of silver, gold or platina, there would soon be found adventurers hardy enough to attempt even the centre.

Where we are deficient in positive knowledge, we are at liberty to make suppositions, provided they are consistent with the known constitution of things.

It is then clearly possible, that matter, of the same kind as that which forms the rocky strata, on the surface, may exist below, in a degree of condensation, sufficient to account for the high specific gravity of the earth. We are not without examples in natural substances.

Carbon, in diamond, is three or four times as heavy as in the bitumens, and six or eight times as heavy as in charcoal; alumine in sapphire sustains a similar relation to the alumine of clays, and so does magnesia in the state of pulverulent native carbonat, or mountain cork, to magnesia in the boracite, or in the chrysolite, and silex in swimming flint, (quartz nectique) and in rock crystal, are in a similar situation.

It is possible, therefore, that the very minerals which we see on the surface, may, in the interior of the earth, have a double specific gravity.

It is a splendid conception, built upon the discoveries of Sir H. Davy and Prof. Berzelius, that the metals of the earths, and not merely the earths themselves may exist in the interior, and thus the nucleus of the planet may be principally a mass of metals, as its crust certainly is of metallic oxids.

All these views tend to shew, that it is possible, to reconcile the apparently contradictory specific gravity of the surface and of

the entire mass of the earth; and, were this the proper occasion, it might be easily proved, that these views are very interesting to general physics, and particularly to geology, in enabling us to understand the phenomena of earthquakes and volcanos.

But, for want of positive information as to the state of facts, it is impossible to reason conclusively on this subject, and the recent researches of Cordier tending to prove the existence of a state of igneous fusion in the interior of the earth and at no very profound depth, must, if confirmed, very materially influence our opinions. But philosophers will be slow to admit such appalling conclusions from the premises hitherto presented.

3. *Mines.*

The excavations made in mining are the greatest with which we are acquainted. The deepest mine in the world, that of Truttenberg in Bohemia, penetrates three thousand feet into the earth. In all mines, the strata are, of course, more or less perforated and broken, so that we obtain the most satisfactory information—as to the nature of the rocks and their disposition. Few of the mines of England are in perpendicular descent, deeper than twelve hundred feet (Dolgoath in Cornwall) and none in the United States exceed three or four hundred, (Richmond coal mines.)

4. *Wells.*

The evidence afforded by wells is of the same nature. The depth attained rarely equals one hundred feet, but in some instances it extends to two hundred, three hundred, four hundred, &c. as at Carisbrooke castle in the isle of Wight, on the plain or valley of London, &c. (Conybeare and Philips.)

5. *Boring for saltwater, salt mines, coal. &c.*

This is an operation of the same kind, and affords, as regards the rocks, similar evidence, although less distinct; because the

materials are brought up, in the state of powder, or at least of fragments, and a very imperfect idea is thus obtained of their original appearance; sufficient however to enable us to decide on their nature. These operations are often carried on to the depth of several hundred feet.

6. *Roads, canals,* tunnels.*

The two first rarely penetrate to any great depth, but sometimes there are deep cuts through diluvium, and even through solid rocks. The former is seen, very strikingly, on the Welland Canal, in Upper Canada; the cut through the diluvium being, in some places, more than fifty feet, in a stiff tenaceous clay, and the latter circumstance is particularly remarkable at Lockport on the Erie Canal, where for two miles or more, a very solid, subcrystaline limestone has been excavated by blasting in many places to the depth of thirty feet, disclosing not only the nature of the rock, but many beautiful imbedded minerals.

Tunnels are not numerous. Every one has heard of those of the Duke of Bridgewater, on the Canal leading from Liverpool to Manchester,† and of that now making under the Thames to serve as a substitute for a bridge.

It appears that they were not unknown to the ancients. From the Stadium near Athens, situated in a natural defile, the vanquished charioteers retired through a tunnel which perforated a neighboring hill, and thus those who had failed of victory were screened from the sneers and insults of the populace.‡ These and all other excavations into the earth add to our means of geological information.

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* The French, during their celebrated expedition to Egypt, under Bonaparte, traced and described the ancient and magnificent canal connecting the Mediterranean and the Red Sea, but which from the ignorance of locks in ancient times could be navigated only when the waters were high, and was therefore nearly useless.

† That stupendous work of art, the canal tunnel, under Standedge, between Huddersfield and Manchester, extends under ground upward of three miles, and is two hundred and twenty yards below the surface. The length of the voyage through the tunnel and back again is six miles and a half.—*English Newspaper*

‡ Dr. Howe's personal communications, Aug. 11. 1828

7. *Rivers and other water courses.*

From the humblest brook, that transports the gravel and sand along its current, to those stupendous rivers which force their way through mountain defiles, and appear as if they had burst the barriers that were once opposed to them, we derive geological instruction. The ruins which, in the form of sand and gravel and pebbles and sometimes even bowlder stones, they bear along in their course, or vex with incessant friction, till their angles are rounded or obliterated, afford us valuable information; and the sections of banks of gravel or of rocky strata which the waters expose, impart to us hints which we may turn to great account.

In many places, the rivers appear to have formerly flowed at a higher level, than at present, or to be the remnants of lakes whose barriers time has levelled or broken; and it is no uncommon circumstance to find water-worn ledges of rocks at elevations higher than any place where waters can flow at the present time. This is undeniably the fact in the vicinity of Bellows falls on Connecticut River, especially two or three miles below the falls, on the eastern side; here the primitive rocks shew the same water-rounded angles, furrowed lines and even pot holes, evidently, formed and polished by incessant friction, as are exhibited at the falls themselves, where these operations are now incessantly going forward. Similar facts are observable in the transition limestone near the head of lake George, at a considerable elevation above the lake, in ledges over which no water now flows but that of the atmosphere; "the angles are rounded and smoothed and there are numerous holes worn into the solid rock, sometimes shallow and irregular, but frequently deep and cylindrical, and bearing a very exact resemblance to those which are common in the ledges, upon which cataracts fall, and appearing to have been produced by the same cause, namely, the wearing agency of water, aided by small stones which it impels in incessant whirling revolutions."*

The passage of the Shenandoah through the blue ridge—of the Connecticut just below Middletown, through the Haddam

* American Journal, Vol. IV. p. 44.

hills, and of the river described by Lewis and Clark through the Rocky mountains, are a few among innumerable examples of this kind. It is very immaterial for geological purposes, whether the rivers have burst their barriers, or merely uncovered the rocks so that their characters can be observed; for, in either case they contribute to the mass of geological evidence.*

8. *Valleys and defiles.*

These are often deep cut and abrupt and of great extent, exposing the stratification on the sides of hills and mountains. The structure must in this manner, be more or less revealed, in every mountainous country, except so far as the sides are covered with soil and ruins. As a large part of the earth is mountainous, provision is thus made on a great scale for judging of the interior of the planet.

9. *Precipices, cliffs, promontories and abrupt banks.*

The shores of the seas and of the great lakes abound with such exhibitions, and all countries except those that are very low present them in great frequency. Many of them are inaccessible except in boats from the water side, but however viewed, they exhibit the stratification and structure more or less distinctly.

10. *Landslips, Slides and Avulsions.*

The peaceful dweller in the beautiful Isle of Wight, in the English channel, not unfrequently, sees the high chalky cliffs of that coast, that have been undermined by the sea, totter to their

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* Although it cannot be supposed that rivers have generally formed their own beds, there can be no doubt that these currents of water do often increase the depth and alter the form of their channels. The Genessee River and the Niagara River afford fine examples of the exhibition of stratification of river banks, by the wearing effects of water. The banks of these two rivers are often precipitous and of several hundred feet in elevation, giving very perfect sections of the strata.

fall, till they come thundering down; and even at some distance from the son, they occasionally slide or slip from their foundations, covering the plains below with ruins.

The mountaineers of the Alps witness still more stupendous catastrophes. Large mountain masses, and even considerable portions of mountains, fall into the valleys and plains, and choke them up, or fill the bosom of lakes, spreading desolation through villages—burying their inhabitants in the wreck, or sweeping them away by the overflowing of the waters.

Even the Green Mountains of Vermont, and the White Mountains of New Hampshire, have been the scenes of similar catastrophes, and the Notch in the White Mountains, will long record the desolations of July, 1826.*

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*The slides in the White Mountains of New Hampshire, and the Green Mountains of Vermont, have been recently very remarkable. (See Am. Journal, Vol. XV. Art. II.) There is a grand defile or pass in the White Mountains, called the Notch. The portion which is the grandest, is about five or six miles in length; it is composed of a double barrier of mountains, rising very abruptly from both sides of the wild roaring river Saco, which frequently washes the feet of both barriers; and sometimes there is not room for a single carriage to pass between the stream and the mountains; but the road is cut into the mountain itself. This double barrier, rises on each side, to the height of nearly half a mile in perpendicular altitude, often exceeding this height; and it is capped, here and there, by castellated turrets of rocks, standing high above the continued ridges; these are not straight, but are formed into numerous zigzag turns, which frequently cut off the view, and seem to imprison the observer in a vast, gloomy gulf.

The sides of these mountains are deeply furrowed and scarred, by the tremendous effects of the memorable deluge of August 28th, 1826, which, on the night succeeding that day, destroyed, in a moment, the Willey family, nine in number, and left not one to tell their story. They occupied a lonely house in the wildest part of the Notch, at the foot of the mountains; it was a resting place for travellers. For two seasons before, the mountains had been very dry, and on the morning of Aug. 28th, it commenced raining very hard, with strong tempestuous wind; the storm lasted through that day and the succeeding night, and when it ceased, the road was found obstructed by innumerable avalanches of mountain ruins, which rendered it impossible to pass, except on foot. The first person who came to the Willey house, found it empty of its inhabitants, and in the course of a few days the mangled bodies of seven out of nine, were discovered a short distance below, buried beneath the drift wood and mountain ruins, on the bank of the Saco, or rather in the midst of what was for the time, a vast raging torrent, uniting one mountain barrier to the

It is obvious therefore, that our means of perusing the structure of the interior of the earth are not so scanty, or so imperfect. as might at first view appear.

Thus at least may be said with truth, that, although we cannot prove what is the constitution of the earth one thousand, or even one hundred miles from its surface, we have means in our power of deciding upon the nature of the crust. Whether in one quarter of the world or in another, we ascend the loftiest mountains, and examine the awful peaks on which the sunbeams shine, first and last, as the sun rises and sets, and on which the storms of ages have spent their fury; or whether we descend into the deepest mines, and observe the strata uncovered, for the first time, since their formation; in whatever country; under whatever circumstances, we examine the earth, we are led to the important con-

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other. The effects of the torrents, which on that occasion descended from the mountains, now form a most conspicuous and interesting feature in the scenery.

The avalanches were very numerous; they were not, however, ruptures of the main foundation rock of the mountain, but *slides*, from very steep declivities; beginning, in many instances, at the very mountain top, and carrying down, in one promiscuous and frightful ruin, shrubs and forests, and the earth which sustained them; stones and rocks innumerable, and many of great size, such as would fill, each, a common apartment: the slide took every thing with it, down to the solid mountain rock, and being produced by torrents of water, which appear to have *burst*, like water spouts upon the mountains, after they had been thoroughly soaked with heavy rains, thus loosening all the materials that were not solid, and the trees pushed and wrung by fierce winds, acted as so many levers, and prepared every thing for the awful catastrophe. No tradition existed of any slide in former times, and such as are now discovered to have anciently happened, had been completely veiled by forest growth and shrubs. At length, on the 28th of June, two months before the painful event, there was an avalanche, not far from the Willey house, which so far alarmed the family, that they erected an encampment a little distance from their dwelling, intending it as a place of refuge. On the fatal night, it was impenetrably dark, and frightfully tempestuous: the solitary family had retired to rest, in their humble dwelling, six miles from the nearest human creature. The avalanches descended in every part of the gulf, for a distance of two miles; and a very heavy one began on the mountain top, immediately above the house, and took its course in a direct line towards it; the sweeping torrent, a river from the clouds, and a river full of earth, stones, trees, and rocks, rushed to the house, and marvellously divided within six feet of it, and just behind it, and passed on either side, sweeping away the stable and horses, and completely encircling the dwelling, but leaving it untouched. At

clusion, that the great features are drawn upon the same plan, and that similar laws have governed the whole series of formations.

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Fruits or results of the observations made on the structure of the crust, in consequence of the use of all the means in our power.

The earth is not (as ignorant persons usually suppose) rudis indigestaque moles, *a mere rude and unarranged heap of rocks*, and minerals, grouped together without order, without plan, and without a possibility of being rationally investigated.

Order, so distinctly observed in the mechanism of the universe; in the stellary and planetary systems; in the admirable

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this time, it is supposed the family issued from their door, and were swept away by the torrent.

Had they remained, they would have been entirely safe. They probably did remain amidst the war of wind and rain and mountain torrents, and the tremendous crash of the forests—earth and rocks, which for miles around them were rushing down in one wide scene of desolation, and with an astounding noise and concussion, of which, we can form no adequate conception; until the evident and near approach of the ruin immediately behind the house, left them, apparently, no alternative, but to fly from instant death. Even now (May 20, 1828,) almost two years after the event, there is a great rampart of earth—stones—rocks and trees, piled up within five feet of the house, and behind it and making a circuit round it, as if *repelled* by an invisible power. But the little green in front, and east of the house was undisturbed, and a flock of sheep, (a part of the possessions of the family) rested on this small spot of ground and were found there the next morning in safety—although the torrent which has been mentioned as dividing just above the house, and forming a curve on both sides, had swept completely around them, and again united below, and covered the meadows and orchard with ruins, which remain there to this hour. This catastrophe presents a very striking example of sudden diluvial action, and enables one to form some feeble conception of the universal effects of the vindictive deluge which once ravaged every plain and defile, and swept over every mountain. In the present instance, there was not one avalanche only, but there were many. The most extensive single one, was on the other side of the barrier which forms the northern boundary of the Notch. It is described as having slid, in the whole, three miles—with an average breadth of a quarter of a mile; it overwhelmed a bridge, and filled a river course, turning the stream, and now presents an unparalleled mass of ruins. There are places on the declivities of the mountains in the Notch, where acres of the steep sides were swept bare of their forests, and of every moveable thing, and the naked rock is now exposed to view

equilibrium of projection and gravitation; of cohesion and expansion; of cohesion and chemical affinity; in the beautiful structure and exact economy of animals and vegetables; and in the still more wonderful phenomena of mind, does not end there: it pervades all the other works of God; and in this rude, unconscious earth, is not less capable of proof, (although that proof is less obvious) than in the other departments of his universal dominion.

Still, while this regularity is thus manifest, and is the prevailing character, it must not be forgotten, that the earth exhibits, in every country, *decisive* proofs of violence, derangement and dislocation of strata; indicating the operation of various catastrophes. For example, in mines, strata are found, whose continuity is bro-

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In the greater number of instances however, the avalanches began almost at the mountain top, or high upon its slope. The excavation commenced, generally, as soon as there was any thing moveable—in a trench of a few yards in depth, and of a few rods in width, and descended down the mountains—widening and deepening—till it became a great chasm, like a vast irregular hollow cone, with its apex near the mountain top, and its base as its foot, and there spread out into a wide and deep mass of ruins, of transported earth, gravel stones, rocks and forest trees.—*Letter of the Editor, written on the spot, May* 20, 1828.

A party of gentlemen who ascended Mount Washington, the next day after the the storm, counted thirty slides on the western side of the mountain. They began near the line where the soil and vegetation terminate, and growing wider as they decended, were estimated to contain more than a hundred acres. These were all on the western side of the mountains. They were composed of the whole surface of the earth with all its growth of woods, and its loose rocks, to the depth of fifteen, twenty, and thirty feet. And wherever the slides of the two projecting mountains met forming a vast ravine, the depth was still greater. In some places the road was excavated to the depth of fifteen and twenty feet; and in others it was covered with earth, and rocks, and trees, to as great a height. In the Notch and along the deep defile below it, for a mile and a half, to the Notch House, and as far as could be seen beyond it, no appearance of the road, except in one place for two or three rods, could be discovered. The steep sides of the mountain, first on one hand, then on the other, and then on both, had slid down into this narrow passage, and formed a continued mass from one end to the other.—*Letter of Rev. Carlos Wilcox.*

The account of the slides in the Green Mountains will be quoted in connexion with the notice of diluvial action, in the latter part of this sketch

ken;—suddenly, at a particular depth, a certain rock, which is observed, on one side of a shaft or fissure, disappears on the other, and some different rock comes in its place; yet the first rock may be found again, either above or below the place where it disappeared, and with it all the attendant series of rocks, which in like manner were dislocated.

Again, a certain series of rocks may be cut across, by a different species of rock, which shall completely separate all the successive strata, and yet on both sides they may be found re-appearing either at the same elevation, or at a different one. The matter which fills the fissure is technically called a *dyke*.

Again, strata are sometimes found at particular places tortuous or winding, or angular; although they may, in general, be regular, thus indicating, as many suppose, the application of force to them, and their disturbance by a mechanical cause. Notwithstanding these and other similar irregularities,

A general regularity of arrangement has been observed in the structure of the globe.

The great mass of *the crust* of the earth, and probably of *its entire solidity*, is, in every country made up of rocks which have the following characteristics.

PRIMITIVE ROCKS.

1. *The most important fundamental rocks of our globe are composed, in general, of crystaline materials*, bearing every appearance of having been deposited, from a state of prevailing repose, and chiefly by the exertion of chemical affinities; they are made up principally of imperfect and confused crystals, or of parts, having more or less of a crystaline structure, adjusted to each other, either confusedly or by salient and re-entering angles, so as to form a mass of continuous matter; furnished however, sometimes with cavities, which are occasionally lined with large and beautiful crystals. Every thing in the appearance of these rocks implies a previous state of chemical mobility, (not of mechanical suspension) and the only powers with which we are acquainted, that are at all equal to the effect, are water and fire, aided by various saline, alkaline, acid, and other energetic chemical agents, which, in large quantities, we now find actually entering into the constitution of these rocks, and of other terrestrial masses, and which were therefore originally provided in the grand store-house of created materials.

Few of those who would employ fire to form the primitive, as well as the volcanic and trap rocks, go so far, as to exclude the operation of water, or of chemical agents, of which water may have been the basis and vehicle. Indeed, it is generally agreed, that, judging from the appearances of things, we must conclude, that the earth was originally, and for a long time, submerged, and that its crust at least, has been in a soft and impressible state, if not partially or wholly in solution.

Geology declares, that the original, or at least early state of the surface of the planet, was that of a watery abyss; and the book of Genesis, in the concise account which is there exhibited of the origin of things, reveals the same fact, as well as the recession of the waters, by which the dry land was made to appear.

We may therefore take it for granted, that the aqueous abyss preceded the habitable condition of the earth, and we are at liberty to reason upon its probable constitution and possible effects.

It was evidently a fluid of very different properties from mere water. It doubtless contained all the chemical agents, not only that are soluble in water, but also that are soluble in a compound fluid, consisting of water, and of other agents still more active. The acids alone would give it great solvent powers, particularly in relation to the alkalies—the metallic oxides, and several of the earths; the alkalies alone would impart a similar efficiency, especially with respect to silex, which is not readily soluble in any acid except one; acids may have prevailed at one time, and alkalies at another; and even if acids and alkalies, and acids and earths, and acids and metallic oxides, had been present at the same time, and had mutually combined, so as to form saline compounds, these compounds, as far as they remained in solution, would impart to the fluid peculiar and increased solvent powers: and those compounds which, from their insolubility, were precipitated, would be of course removed, and would not be in the way to impede other agencies. In the constitution of mineral bodies, we find the greater part of the most active chemical agents; the powerful acids, the sulphuric, the muriatic, the nitric, the phosphoric and the fluoric; and the carbonic, although not powerful, is abundant. The alkali soda exists in vast abundance, and often combined with no other acid than the carbonic; while potassa, as well as soda, is found in combination with other principles in a great many minerals, and lithia in several. The alkalies are largely, and the alkaline earths are considerably soluble in water; all the earths are easily soluble in acids, except silex, and even this is powerfully attacked by fluoric acid, and, under certain circumstances, is not unaffected by some other acids. All the metallic oxides are soluble, either in acids or alkalies; the metals combine readily with chlorine; carbon and the other combustibles become soluble by combination with each other, and with oxigen, or chlorine, or iodine; and we may reasonably presume, that as

these bodies came from the hand of the Creator, they were in a condition to act with intense energy, and that innumerable solutions, decompositions and precipitations, took place at a period when elementary action had full play, and the great agents, encountering each other at every turn, gradually developed the new order of things. It is of course difficult to say, precisely what was the condition, and what were the qualities of that early ocean, that primitive abyss, whose existence and sway it is impossible to deny; for while decisive facts declare it to the mere philosopher, revelation unfolds it to the believer, and both conspire to establish the truth in the minds of that large and respectable class of individuals, who combine both these characters in one.

It appears then that the solubility of all the existing materials that form the crust of the globe; their solubility either in their elementary forms, or in their proximate or complex combinations, is a truth clearly demonstrable, and actually demonstrated; and that the only serious difficulty is found, in attributing to the quantity of waters that now exist, *within our knowledge*, sufficient power to suspend all the materials of those rocks, that bear marks of deposition from a state of chemical solution.

On this point, perhaps nothing satisfactory can be said: but we may ask, who knows what were the depth and the quantity of the waters of the primitive abyss: how much water might (as the formations were going on) have been exhaled, even to other regions; how much might have been decomposed to afford the noble, and almost universally diffused elements, of this fluid, to the various nascent bodies, into whose constitution oxigen and hydrogen were destined to enter; and how much might have been received into cavities* in the earth, to await a future call, to deluge the surface anew.

* We may have occasion to mention again the idea of cavities in the earth, a supposition which some may think is excluded, by its high specific gravity. There is, however, no incompatibility in the two opinions. The amount of water requisite to cover, half a mile deep, all the existing mountains, would occupy

It is worthy of observation, that quartz, feldspar, and mica, the minerals which form the greater part of the three most important primitive rocks, namely, granite, gneiss, and mica slate, are composed mainly of silex and alumine. Now the silex, especially in a state of minute division, is entirely and readily soluble in the fixed alkalies, and so is alumine, with even greater facility: alumine is also very readily soluble in acids; silex is soluble in fluoric acid, and can become even gaseous in that acid, and, if minutely divided, it is soluble in some other acids. Modern analysis has discovered notable quantities of potash and soda in both feldspar and mica; and fluoric acid in the latter, so that it is proved that the necessary solvents were actually present at the time of the formation of these minerals, and therefore entered into their constitution. Alkali exists elsewhere also, in sufficient abundance for the solution of silex and alumine; for that portion of alkali, which is now in solid combination in the minerals, that enter into the constitution of the primitive rocks, would have done but little towards the solution of the earths in question.

The activity of most of the early chemical agents, and of all of them if subjected to pressure, would have been much increased by a high temperature. There can be no reason why we should suppose, that those causes* which now feed the fires of nearly two hundred active volcanos, were dormant in the youth of the planet. On the contrary, the numerous extinct or quiescent volcanos, of unquestionable character, record with irrefragable evidence, the energy and extent of primeval fire, operating both as an auxiliary to solution, and in its own proper agency by fusion; and that, without taking into view the trap rocks, whicl , if finally

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but a small fractional part of the cubical contents of the earth, (only $\frac{1}{2}\frac{1}{8}\frac{1}{5}$ part) and the remaining solid parts may still be sufficiently dense to give the required specific gravity. The supposition is more at war with the hypothesis of central igneous fluidity, but even these two suppositions are still reconcilable.

* Causes which will be considered under the head of volcanos.

admitted to have had an igneous origin, will greatly fortify this view of the subject.

When the planet was covered by an aqueous abyss, all volcanos must have been submarine, as many now are. They would all therefore act under vast pressure, a pressure incomparably transcending any thing effected by modern experiment, and the heat thus accumulated must have given any desired activity to water and to watery solutions of the great chemical agents.

While therefore provision is made, in this manner, upon established mechanical and chemical laws, for solution on the greatest scale of magnitude, and with the greatest possible energy of action, we may suppose chemical depositions to have been going on contemporaneously or subsequently, either confusedly, as in granite, or in successive layers, as in gneiss and mica slate; and the imbedded minerals of the primitive rocks, the garnets, the staurotides, the tourmalins, the beryls, and others, were doubtless, contemporaneous crystalizations; their elements being in solution in the same fluid, and uniting by the force of their peculiar affinities, formed the minute bodies, the integrant atoms, whose concretion ultimately produced the various crystaline solids, which adorn the early formations of the globe.

Water and fire and pressure and all the great chemical agents may thus have conspired, as means in his hands, to execute the great purposes of the Creator, in effecting the arrangement of the crust of the planet.

It becomes easy also to admit that all those catastrophes, which can reasonably be attributed to this period, may have happened.

Igneous agency, the parent of earthquakes, acting beneath the rocks already formed, and beneath the incumbent abyss, might produce fractures, heavings, dislocations and distortions, tortuous flexions, injections of veins and dykes, subsidence and elevation of strata, and all the irregularities technically called *faults* by the miners. Even the trap rocks themselves may have been thrown up beneath the primeval ocean; they may have broken through the strata and congealed above or between or among them, in ridges, peaks or flats; or they may have been injected in dykes or veins

or been driven, laterally, between the strata, rending them asunder, as if cleft by wedges.*

Although in giving this concise sketch of the possible and probable qualities, powers and effects of the primeval abyss, we have endeavored to adhere closely to acknowledged facts and principles as established by experience and sound reasoning, we do not pretend to claim for our speculations the verisimilitude of history. But, the only credible history which exists furnishes a record, important alike to philosophy and religion; we find in the planet itself, the proof that the record is true; we examine by the light of science the *modus operandi* and we think we can trace its development; although we do not confidently aver, that the events actually happened as we have supposed, we endeavor to prove, that the constitution of things and the records of evidence, which the planet affords, accord with our supposition. Thus we honor the Divine Author by tracing the operation of his laws; we would not slur them over under the vague term of *nature*, while we admit not only creative power, but arranging wisdom.†

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* These remarks have reference of course, to the trap rocks that appear in primitive regions, but it is obvious that a similar train of reasoning is applicable, *(mutatis mutandis)* to the trap rocks which are associated with the more recent formations. If these rocks are the offspring of subterranean fire, there appears no reason why their date should be restricted to any one series of rocks, and we actually find them associated with all.

† The author of this sketch is, in no degree, reluctant to avow his full adoption of the Baconian and Newtonian mode of reasoning on natural phenomena, as regards their ultimate connexion with the Creator and Governor of the universe. He would not force moral and religious topics into an unnatural association, with physical subjects, and he thinks it contrary both to good policy and good taste, to act the moralist on every occasion, and thus to render trite and perhaps offensive, ideas which, more cautiously and less frequently introduced, might have left a happy impression. But he holds, with Newton, that Natural Philosophy sustains an indissoluble connexion with the Deity, as the first cause of all things, and as the final cause which must forever terminate every series of secondary causes, by which we attempt to account for natural phenomena.

This reference is therefore not less proper on physical than on moral subjects, although the liberty should be more sparingly and cautiously used. Surely, if on any subject of natural science this course is proper, it is in relation to geology, one of whose primary objects, is to trace the operation of the Creator's laws, in the arrangement of the crust of the planet, which is our present abode.

II. *The rocks in question, namely, the primitive, lie below the others, and therefore were deposited first ;* they generally succeed each other, in a certain order, supporting the superincumbent rocks, but they still occasionally break through them all, and rise, so as form the highest peaks and ridges of our globe.

It is self-evident that the lower the rock, the older it must be, just as the foundations of a house must be deposited before the superstructure can be added.*

A miracle, it is true, could substitute one rock for another, but we are reasoning from established natural causes, and not from miracles, and we know not of any cause that would force one rock into a position beneath another, except volcanic or igneous agency, which, it is admitted might do it to a certain small extent, but never on a great scale. Circumstances would also indicate the catastrophe, such as the marks of violence and the altered appearance which the neighboring rocks would exhibit. Except the single case of intrusion by volcanic power, it would be equally true of deposition, from any cause whether aqueous, mechanical or igneous, that the upper rocks must be the most recent.

It is quite superfluous to say, that several rocks may have been deposited at once ; it is true that several may have been deposited from the same general agencies, constituting a suite or formation, but it would still be true that there would be succession, either tardy or rapid.

III. *The primitive rocks contain no organized bodies ;* not a fish or a shell, a plant or any thing ever endowed with life, or any fragment, relic or impress, of any such body is ever found

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* Contemporaneous crystalization might happen through large masses of the same species of rock, but is not credible with respect to successions of rocks of different kinds, as of saccharoidal limestone in gneiss, serpentine in clay slate, &c.

Even igneous depositions, it would seem, must require succession ; one igneous tide bursting through, after another had flowed and congealed ; and an igneous rock forcing its way, in fusion, through rocks of unquestionable aqueous or mechanical origin.

Who would believe, for instance, that the greenstone trap of Salisbury Craig at Edinburgh, or of the East and West rocks at New Haven, (Connecticut,) was not deposited after the sand stone and conglomerate rock upon which they repose !

in them; this fact, with others to be mentioned afterwards, evinces that the fundamental rocks were deposited before the creation of living beings, and that this substratum was laid for the purpose of preparing the globe for its great destination—that of becoming a suitable habitation for beings endowed with life.

This argument is of a negative character, but still it appears to be conclusive, and it would be conclusive to any extent; for, were all rocks destitute of organized remains, it would be equally fair to conclude, that they were all deposited before that interesting epoch in the creation, when life began to appear upon the planet.

The argument then, respecting the relative antiquity of the primitive rocks becomes still stronger, when we have ascertained that there are numerous rocks which contain organized remains both of animals and plants, but that they are never the lowest rocks, and that they are rarely highly crystaline in their structure, at least they are not often so in a degree to make them compare with the rocks that lie still lower.

But suppose that a rock having a constitution like that of the primitive, should be found lying upon another which is decidedly not primitive, for example granite on limestone containing organized remains; shall we continue to call this upper rock primitive? Certainly not. We must then either give it a new name and refer it to a new class, or allow that there are rocks of that particular name, which are not primitive but of a more recent date.

Such is the granite discovered by Von Buch in Norway near Christiania, provided there be no mistake. It is said to be a true granite reposing upon a limestone containing orthoceræ and other indubitable animals. Allowing the reality of this so called granite, it is a solitary case, and need not therefore disturb our general arrangement. If it be an exception it doubtless had a particular cause.

But should we find granite containing fish or shells or plants, would it be a primitive rock? Clearly not. We should then

as before, either conclude that it was not granite, or we should allow that it was a transition or secondary granite. No such granite has however been discovered and probably none ever will be.*

IV. *The fundamental rocks are rarely horizontal;* they are usually inclined more or less to the horizon, frequently at a high angle, and sometimes they are found vertical, that is, their strata are on edge; but the progress of research has evinced, that the rocks of the different classes are *occasionally* found in all positions.

It is no longer considered as true, that position, in relation to the angle formed with the horizon, is decisively characteristic of the different classes of rocks. Still the distinction is not entirely abolished, nor entirely without utility. Secondary rocks are usually horizontal, or not many degrees from that position; primitive rocks are perhaps always inclined, often highly so, and almost never quite flat, and the transition strata are generally in an intermediate position. In the formations of North America, it is however much more common to find primitive rocks at low levels, and at moderate angles of elevation, than in Europe.

In observing rocks, their position with regard to inclination, is always to be taken into view, but it would be unsafe to rely upon this character alone. The mineralogical constitution, geological connexion, and extraneous and other foreign contents of the rock, (if any are present,) must also be taken into account in judging of its geological character.

V. *The fundamental rocks are called primitive*, by some primary or primordial, in allusion to their relative antiquity; in ge-

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* Rocks consisting of the ruins of granite, are sometimes mistaken for true granite, and it requires some experience to avoid being deceived. A few years since, I received an account, from a remote interior state on this continent, of granite containing bituminous coal and fossil wood. I could not admit the correctness of the observation, and accordingly discovered, on receiving specimens of the so called granite, that the rock was a sand stone made up indeed of quartz, feldspar and mica, but merely in the state of loose and mechanical aggregation, constituting a genuine sand stone, which had probably been formed from the decomposition of granite

ology, this fact is always determined by .heir position and constitution.

The term is not intended to involve theoretical considerations, any further than it designates *order of time*; and whatever theoretical views we may adopt, we must admit not only time, but order of time. As to the amount of time, geology alone is not in a condition to decide absolutely; judging from phenomena alone, different events or effects would require periods of very different length.

If we could admit that granite, for instance, might crystalize through a very great space, in a short time; it would still be incredible, that granite and its cognate rocks, gneiss and mica slate, and clay slate; then graywacke and other early fragmented rocks; then anthracite coal, with transition slates, containing impressions of fern leaves and of trilobites; then transition limestones, with orthocerae; encrinites, and corals; then bituminous coal, with slates containing fish, and sandstones containing culmiferous plants; it would be quite incredible, that all these widely different deposits, should have been produced, by the same state of things, and laid down at the same time.

VI. *The principal primitive rocks are granite, gneiss and mica slate* and other slaty rocks, granular limestone, &c. and they generally occur in a particular order, granite being lowest.

It is not intended on this occasion, to enumerate all the rocks, or to describe any of them minutely. In studying geology, it will probably be found the most convenient and intelligible course, to pursue a particular rock through its entire history, and thus to present a connected view of it, rather than to mention it, in part, under the primitive, then again perhaps in the transition, and then again in the secondary and even in the tertiary.

Limestone is in this condition.

We find it indubitably primitive, then transition, then secondary and lastly tertiary, and its ruins are sometimes found even in alluvial or diluvial regions. Slate has similar characters. The

fragmented rocks are found in all the classes except the primitive,* and so of other rocks in a greater or less degree.

VII. *The epoch of the deposition of the primitive rocks appears to be coincident with that of the early prevalence of a primeval ocean.*

This abyss of waters which existed at an early unknown period, before the time of the final arrangement† of the surface, which preceded the creation of man, and continued, we may suppose for an unlimited time, is just such a state of things as is demanded for the deposition of the primitive rocks, and such an one as geologists‡ generally, both admit and require. In this period, the primitive rocks were probably deposited, and nothing appears to forbid the admission, that there was time enough for the formation of all their crystals, and for their regular arrangement.

The marks of disruption, dislocation and derangement, which the primitive, as well as other rocks present, justify us in the opinion, that there were occasional catastrophes, interrupting the general order of events, and producing local disorder; thus, *strata*, may have sunk by subsidence, for want of adequate support, or been torn asunder by earthquakes, or lifted by submarine volcanos; these are however subordinate events, and do not radically alter or subvert, although they may modify our general views.

Some however, imagine, that entire mountain ranges, and even entire continents, have been raised by the force of subterranean fire, and there seems, as already suggested, no inconsistency or improbability involved in the admission, that igneous and aqueous agency may have been concomitant and co-operative,

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* Dr. MacCulloch admits sandstone into the primitive. but in this he appears to be nearly or quite alone, and it is certainly very desirable, and also very practicable, to avoid so embarrassing an anomaly.

† Some prefer to consider it as a reformation from the wreck of a former world, or more correctly speaking, from the wreck of a former state of the present world.

‡ This statement requires but little qualification, even as regards the geologists who imagine a vast internal fire, by which the primitive rocks were deposited from a state of fusion, for they are obliged to call in the aid of water for the first deposition of the materials of the primitive rocks, and of course for the secondary.

and that, by their alternating, and conflicting, and modifying effects, they may have produced the actual state of things on the surface of the globe.

A vast mass of evidence has been accumulated, and is constantly increasing, which evinces that internal fire still prevails to a great extent in the interior of our planet, and its effects appear to have been the greatest, and the most extensive, in the earliest periods. Volcanic mountains are known to have risen, even in modern times, from the bosom of the ocean,* and permanent islands have been, and are still existing, where, in former ages, the sea raged uncontrolled. The first postulate of the philosophers of fire, is therefore proved to be possible, but, where mechanical causes are largely concerned, it does not follow, that, because an effect of a certain extent has taken place, that therefore one vastly greater has happened.

Trap rocks may have been produced by subterranean and submarine fire, but it does not, therefore follow, that a continent has risen from the deep. If so, either it was accumulated by successive submarine eruptions, or it was lifted, already formed, by subterranean expansion, and in either case, we may ask, whence were the materials supplied; and if supplied from the regions immediately beneath, what fills the void, and if not filled, what more than Roman or Gothic arches, are provided to sustain the enormous weight of a continent, and to prevent its plunging anew into the abyss, and carrying down, like a sinking ship, all that are embarked upon it. Is it arched over, from side to side, of the tremendous cavern, resting firmly upon the abutments of the solid earth! But what security is there, that subterranean fire will not melt these abutments down, and undermine the incumbent continent!

The primitive rocks present to the eye of one who has been accustomed to examine the results of chemical deposition, very decisive proofs of having been in that state of *mobility*, which leaves the particles at liberty, to unite according to the laws of corpuscular attraction; the heterogeneous particles being con-

* In the Grecian Archipelago, near the Azores, &c.—See Am. Jour. Vol. XIII.

nected by chemical, and the homogeneous by mechanical attraction. Thus, in felspar—the silex, composed of silicium, or silicon and oxigen—the alumine, of aluminum and oxigen—the potassa or soda, of potassium or sodium and oxigen—the lime, of calcium and oxigen, and the oxid of iron, of iron and oxigen, would be formed, supposing these to be the ultimate elements of the mineral, first by their uniting, chemically, to form these binary compounds; then these binary compounds would still further unite, but still chemically, to form the integrant particles of the mineral, and these particles united mechanically, by cohesion, would form the mineral itself.

The same reasoning may be applied to every variety of rocks and minerals. Limestone, consisting for its immediate principles, of lime, carbonic acid and water, contains, for its ultimate elements, according to the present state of our knowledge, calcium, carbon, hidrogen and oxigen; the latter principle being united with each of the former ones, so as to produce the lime, (oxigen and calcium,) the carbonic acid, (carbon and oxigen,) and the water, (oxigen and hidrogen.) If the limestone were a magnesian one, then we must add oxigen and magnesium, and so of other earths, as silex or alumine, if they were present.

How far back, and how near to the isolated, independent state, we are to trace each element, we cannot determine. Whether the elements were created, in the first place, in a state of perfect freedom, and their earliest movement was, not so much, that of elemental war, as of elemental combination; or whether, they were combined in pairs, and those pairs again combined, to form more complex results, we can never know with certainty; and all our suggestions on this subject being necessarily hypothetical, ought of course to be concisely stated.

But the discussion of these questions, which might easily be extended to the most complex rocks, and to all their imbedded minerals, however curious and even interesting, is, in no way material to our proceeding to reason intelligibly—may we not say plausibly, or even conclusively, upon the act or process, which must, according to physical laws, have preceded the concretion of the materials of the primitive rocks.

Suppose the elements which are to form granite, to have already united, and the previous fluidity, whether of solution or fusion, or both, to have established a state of things favorable to the grand result, the formation of the different minerals, a simultaneous deposition must of course happen ; the quartzy particles must find their fellows, those of feldspar will do the same, and those of mica the same, and the three minerals, born at the same moment, will find repose in the same cradle. In the same manner, their ornamental companions, (not essential to the rock, but often studding it, like gems set in royal robes)—the emeralds, the topazes, the garnets, the tourmalines, and the other crystalized minerals which sparkle in the bosom of the primitive rocks, declare a common birth. True it is, that creative power could call the rocks into being, without any arranging process in their parts, but no analogy countenances the truth of such a supposition, and neither moral nor physical reasons oblige us to admit so improbable a supposition.

Who has contemplated the stupendous garnets of Fahlun—the equally gigantic quartz and felspar crystals of the Alps—the more delicate emeralds of Brazil and Ethiopia—the variously colored tourmalines of Chesterfield, and Goshen, Mass., and of Paris in Maine—the fluor and calcareous spars, of Derbyshire and Cumberland—the idocrases of Vesuvius, and the rubies and sapphires of Ceylon and other regions of India, the bubbles of air included with water and other fluids in quartz—the fibres of amianthus—the crystals of titanium—the filaments of native copper and silver shut up in the same mineral—the successive crystalizations of galena—sulphate of barytes—calcareous spar—quartz and fluor spar, often included in the same group—the splendid amethystine and other geodes—little grottoes lined with polished and beautiful geometrical figures—who has seen all these things—the ornaments of our cabinets, and has doubted that they were as truly the results of crystalization, as any of the products of art, which are formed in our laboratories?

Crystalization is indeed not exclusively the attribute of primitive regions ; but in such regions it is eminently conspicuous, and

if we find crystals in the productions of every geological age, we are thus furnished with proof, that these agencies continued to operate, although with diminished frequency and energy, through all succeeding periods, and that they have not ceased even in our own times,* for mineral crystals are, every moment, forming around us.

Still no one finds in the upper secondary rocks—much less in the tertiary, the numerous and grand crystals that are common in the primitive, and even to a degree in the transition formations, and no one looks for those grand crystal cavities, *fours a cristaux*, as they have been fancifully called,† except in the ancient mountains, and in the veins and beds by which they are intersected.

No person who has been conversant with the effects of solution, and especially of solution, aided by heat and pressure, can easily confound them with those of mere mechanical deposition. Take a piece of the most beautiful granite—its quartz is translucent if not transparent—its feldspar is foliated in structure, presenting two regular cleavage planes, united at definite angles—its mica is perfectly foliated, and splits into innumerable thin lamina, each of which, is perfectly transparent and has a high lustre, and this last property is common (sometimes in a less degree,) to the quartz and the feldspar. Gneiss and mica slate and saccharoidal limestone are distinguished, in a greater or less degree by similar characteristics. Now, translucency—transparency—lustre—cleavage, planes and regular structure, are known and established results of chemical deposition, and are never the effect of mechanical aggregation. Compare the above proper-

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* I have obtained crystals of calcareous spar—of sulphate of barytes and of sulphate of lime and some of them repeatedly as accidental results in chemical processes: I have seen even quartz crystals form rapidly under my eye, and others have cited them as slowly produced with regularity and beauty, from the fluoric solution of silex. Crystals of pyroxene—specular iron, titanium and other minerals have been produced by volcanic and furnace heat; more than forty species of minerals have been observed in the slags of furnaces, and white pyroxene has been produced by the action of fire upon the constituents of this mineral, and after fusion, it has re-crystalized, in the same form.—*Am. Jour. Vol.* 10. *p.* 190

† Patrin's mineralogical travels.

tics, with those found in a piece of clay or chalk, and no person, however unskilled in physical characteristics, can possibly attribute them to a similar origin. The latter have as obviously sprung from mechanical as the former from chemical laws;—mechanical suspension must have preceded the one, and solution, fusion or sublimation the other.

Crystalization is the most exalted agency of the mineral kingdom and it answers to organization in the animal and vegetable; but it is entirely unconnected with the principle of life. It results in the production of regular solids—often of beautiful figures, bounded almost always, by plane faces and by right lines, which constitute the outline of beauty in the mineral kingdom, as the curve line does in the organized kingdoms. (Haüy.)

VIII. Geological research clearly proves, that *the earth was gradually redeemed from the universal and long continued dominion of water* under which it lay at its first creation. The appearance of the *dry land*, necessarily implies previous *entire* submersion, and taken in connexion with the existence of the universal watery abyss, before described, necessarily implies all that geology requires on this part of the subject.

The tops, the peaks and ridges of the highest mountains,* began then to appear, as they emerged from the universal primitive ocean, and as its waters gradually retired, the land became more and more denuded, and at this period and not before, it became possible, that vegetables should begin to exist, because they had now a place and soil on which to grow.

It is *possible* (but there is perhaps no positive evidence of the fact,) that some aquatic plants might have been created a little earlier, but the primitive ocean was evidently then too much charged with mineral matter to afford a proper medium, or a proper pabulum, for any considerable extent of animated exist-

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* It is not material here to discuss the origin of mountains—whether they were raised from below, or left prominent by the subsidence of the contiguous regions, or were reared by accumulation; it is agreed on all hands that they existed before the subsidence of the early ocean, whose retreat must of course have first exposed their summits.

ence, either vegetable or animal. As its waters were, gradually, more and more freed from foreign matter, by the progressive deposition of the rocks, it began to be fitted for the simpler forms of animal life, and its qualities might not have been inconsistent with the existence of some species of aquatic plants; still, we believe that the earliest impressions of vegetables, found in the transition strata, are generally those of land plants, or of those which might grow on shores or in swampy or marshy situations.

Plants are not numerous in the transition strata; as far as they were littoral, aquatic or marine, and therefore vegetating in or near the water, they would be found in the deposits of stony matter that were embosomed in it; as far as they were terrestrial, they might have been swept in by winds, storms, tides, and currents, and would thus become entombed. As to the animals, they, being altogether aquatic and marine, must necessarily live and die in the water, and their remains would be consolidated in the rocks whose deposition was then going on.

TRANSITION ROCKS.

IX. *The rocks deposited at and immediately after this period, are generally less crystaline and more compact in their structure than the primitive.*

The crystalization, although often conspicuous, is more confused; in the transition limestone, it sometimes appears only in minute plates and spangles, but the translucence is usually preserved, especially at the edges.

The number of foreign and imbedded crystals is less considerable than in the primitive rocks, and we begin to find the first proofs of certain modes of mechanical agency, indicating the commencement and earliest effects of attrition and violence upon the rocks already formed.

We must not confound these mechanical effects with those already mentioned in relation to the primitive rocks, among which we find so many proofs of sudden and great violence, causing ruptures, dislocations and injections of foreign matter; the rocks are elevated, contorted and fractured: veins and dykes are in-

troduced cutting the strata ; some of the strata are below and some above the common level or plane of the same strata continued, but the rocks are generally in or near their original geographical location, and pebbles, gravel and bowlders are rarely found.

Still, in our artificial arrangements in geology, we must remember, that near the dividing lines of contiguous departments, there are mixed characters. In rocks, decidedly primitive, we find (especially where a later formation is about to commence) marks of mechanical agencies, fragments of primitive rocks, and entire and sometimes large masses, imbedded in a basis of primitive rock.*

X. *In these rocks, we find (in general) for the first time, fragments both rounded and angular of all the previous rocks ;* sometimes these fragments are united by crystaline matter, forming the paste or cement, which holds them together ; at other times, the paste is composed of nearly or quite the same materials with the fragments, but in a state of much finer division, and at other times there is little interposed cement.

We must not confound the crystaline with the fragmentary or brecciated rocks, although some rocks of the transition class are almost entirely crystaline, and others are made up chiefly of ruins assembled and cemented.

In the formation of the transition rocks, chemical and mechanical action appear to have been sometimes concomitant, and at other times, alternating.

Among the transition marbles, which are decidedly crystaline, we may mention the limestone of the peak of Derbyshire, and the imbedded animals also, are often crystaline in their structure. Many of the transition limestones may be called at least sub-crystaline. The marbles of Bennington, Middlebury, and Swanton in Vermont—the latter on Lake Champlain, are translucent at the edges and evince a previous state of chemical solution ; those

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* The country about Northfield and Montague and Gill's falls in Massachusetts, presents remarkable examples of this nature, and they are the more interesting from the fact that we can, in the course of a few miles, trace a progress from rocks decidedly primitive, to conglomerate and even to graywacke and sand stone.

of Hudson, N. York, are similar and abound with encrinital remains.

But many of the rocks of this class are most palpably fragmentary, and the fragments are of all sizes, from those that are scarcely visible to the naked eye, to those whose dimensions are measured by inches and even by feet.

The graywackes of the Chaudière falls in Lower Canada, of Rhode Island, and of the Cattskill mountains, are striking examples.

The brecciated marble of the Potomac, employed in the public buildings at Washington, seems to belong to the transition class. It is a remarkably firm rock, composed of ovoidal and angular pebbles, which appear to have received their shape from friction in water. The cement is a more minutely divided substance of the same kind, but calcareous matter is not exclusively the material either of the pebbles or of the cement.

The fragmentary rocks of Rhode Island, extending by Providence to Boston, and which are very conspicuous in Dorchester, Roxbury, Brooklyn, and other neighboring towns, are fine examples of early formations of this kind. They are very interesting five miles east of Newport, at a place called Purgatory, where a large mass of the rock, separated by the natural seams which are found in it, running parallel for a great distance and cutting the pebbles in two, has fallen out, having been undermined by the sea, whose waves, when impelled by storms, break and roar, frightfully, in this deep chasm.

The pebbles are here chiefly quartz—they are ovoidal in form and of every size from that of a bird's egg to that of a common keg, and they lie generally with their transverse diameters parallel.

The pebbles of the fragmentary rocks about Boston are very various in their composition, obviously however the ruins chiefly of primitive rocks. The pebbles, which there lie in the roads and fields, have proceeded from the disintegration of this pudding stone. Although to estimate comprehensively, the extent and variety of fragmentary rocks, we must include in our view the vast deposits of the periods later than the transition; still we may pause a moment, at the geological period now before

us, and enquire whence arose the mighty masses of ruins which, of every shape and variety of composition, compose, not merely accidental fragments, or here or there a stratum or a hill, but which cover myriads of square miles, are sometimes the basis of countries, and rise occasionally even into mountains. The Cattskills are conspicuous monuments of geological revolutions. Not only at the base but at the summit, thousands of feet above the level of the Hudson river, we find these mountains composed extensively of fragmentary rocks, rounded and angular, and their rude piles inform us, that the materials of which they are built were once loose and rolling about, in the waves of the early ocean, encountering friction and violence, in their various modes of action.

If we call to mind the sketch recently presented to us of the effects and proofs of crystalization, as exhibited in the early primitive rocks, the contrast afforded by the fragmentary rocks, must appear very striking, and connected with their relative position, can leave no doubt on the mind, that they arose from a subsequent and totally different state of things.

What were the causes that broke up portions of the primitive rocks and left their ruins the sport of the waves, destined, in the progress of time, to be cemented again into firm masses!

Beyond the wearing effects of powers still in action, those of the weather and the seasons, and of the vicissitudes of temperature, we are at liberty to add the convulsions of earthquake, tempest, flood and fire, by which our planet is still agitated. Beyond these we are not at liberty to go, because we have no facts to form certain grounds of reasoning; but the causes that have been named would, in the course of ages, perform the work, great as its results may now appear.

XI. *The rocks of this class are rarely either quite vertical, or quite horizontal in their position*; their strata are inclined often at high angles from the horizon; where their strata come in contact with the primitive rocks, the former are found upon the latter, and when they touch primitive mountains, they generally slope down their flanks: always lying above them, but declining gradually towards the plain countries, and terminating commonly beneath them.

It has been proposed to limit their obliquity between certain degrees, for instance, 10° or 12°, and 45°. It is probable that these boundaries would, in fact, include most of the transition rocks; but it would be inconvenient to restrict ourselves within these limits, because, we do occasionally find transition rocks that range both below and above these degrees. Indeed, the progress of geological investigation has proved, that there is much less reliance to be placed upon the position of rocks in regard to obliquity, than was formerly imagined; although this distinction is not to be abandoned. Alone, it would perhaps rarely serve as a just ground of conclusion, but in connexion with other characters, it is a voluable auxiliary. As to elevation, transition mountains are not the highest, but they often attain a considerable altitude, as in the Cattskills—two, three and four thousand feet: and transition rocks sometimes occupy also low levels.

XII. *In these rocks, we find the first traces of organized beings*; the perfect impresses of plants, and both the impresses and the entire mineralized bodies of millions of animals; the deposition of these rocks was therefore cotemporary with, or subsequent to, the creation and propagation of the organized beings, whose impresses or whose bodies they contain, and it is self evident that these rocks could not have been deposited prior to the date of the animals included in them.

Both the plants and animals lived and died at or near the places where they are found entombed in the rocks; for they present, in many instances, few or no marks of violence, or of accident; their most delicate parts are, often, perfectly preserved; animals, with all their organs entire, and plants with their fibres and leaves in full expansion.

We must not, however, understand, with too much strictness, that every thing was always quiet in that ancient ocean. There is no reason to doubt that there were tides, as the laws of gravity were doubtless the same as now; there were probably storms, and tempests, and currents, and as the land came to be gradually uncovered, there would be rivers and torrents: there were also, we must believe, earthquakes and volcanos; hence, or from one or more of these causes, the marks of violence which we occa-

sionally find, one stratum having its included mineralized organic bodies entire, and a contiguous one having them more or less broken. (Our author, page 24.)

Both the plants and animals, generally belong to races which are no longer found alive, or if *analogous* races exist, they are related to the ancient ones, rather by generic than by specific characters. The animals are commonly either zoophites (belonging chiefly to the coral family) or shell fish, in many instances destitute, or nearly so, of locomotivity ; sometimes, however, they are furnished with organs for motion.* Sometimes they occupy great districts of country, and form almost the entire mass of marble, in the bowels of mountains, miles from day light, and they are so firmly united to the rock, as to form part of its substance. Many of the architectural marbles owe much of their beauty to imbedded animals, myriads of which lie almost in absolute contact, the matter of the rock only filling up the void between them, the void occasioned by their angular and confused positions.

There is no difficulty in understanding how the marine animals, the encrinites, for example, that fill the transition limestone of the Peak of Derbyshire, came to be thus entombed. We cannot doubt that the animals received their existence, and lived and died in an ocean full of carbonate of lime, in solution or in mechanical suspension, or both. When they died, they of course subsided to the bottom, and were surrounded, as they lay, by the concreting calcareous matter. Multitudes of them were present at the same time and place, in all the confusion of accidental position, and therefore were enveloped, just as we find them, in every imaginable posture ; the interstices were filled by the calcareous deposit, and this being more or less chemically dissolved, produced a firm sub-crystaline mass, a section of which shews us the animals sawn through, and admitting of a polish like the rest of the rock.

If we could suppose that our common clams and oysters, that lie in the mud of our harbors and inlets, were to become solidified

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* Madrepores and encrinites could move very little ; the echinus, found in secondary rocks, moved on his spine, which served him for a foot, and some of the early shell fish had organs to enable them to rise and fall in the water. (Our author.)

into one mass, along with the matter which envelops them, the case would not be dissimilar; only they would be enveloped in earthy, instead of crystaline matter, and the rock formed from it would be referred to the most recent secondary, or to the tertiary.

It is easily understood, also, how a new stratum, either of the same or of different constitution, may be deposited upon a previous one; and with it, the bodies of the animals that lived and died in the fluid; and these might be the same animals with those of a previous stratum, or of a different species or genus, it being understood that each successive stratum was, in its turn, the bottom of the then ocean, and also the upper or last consolidated layer of the crust of the earth, as it then was at that place.

As we have no direct historical evidence to the facts, it is impossible to say, precisely, what circumstances would determine such an ocean, to deposit, at a particular time, a stratum of limestone with madrepores and encrinites, and then one of slate with trilobites and fern leaves, and then one of breccia or sandstone with stems of reeds or palm leaves, or bodies of pectinites and anomiæ.

But it is easy to imagine, that if all the causes necessary to produce these events, were in successive operation, the events might succeed each other in the order supposed; and that they did in fact so succeed each other, cannot be reasonably doubted, any more than that an edifice, having trap rock for its foundation, and sandstone for its basement, and marble for its superstructure, and wood for its roof, and finished with sheet lead, zinc or iron, was actually constructed of these materials, connected by the builder in that order.

The great truths of geology are few, simple and intelligible; needing nothing but the application of a sound judgment, enlightened by science, to the accurate observation of facts. The facts can often be distinctly observed, and the order of their succession ascertained, whether the proximate causes and the immediate circumstances can be discovered or not. We then reason upon them, with the aid of the knowledge which we have acquired, and there can be no doubt that we often reason conclusively and correctly.

It is a supposition, altogether inadmissible, and unworthy of a serious answer, that the animal and vegetable races, entombed in such profusion, and buried often under entire mountain ranges, or firmly cemented into their very bosom, were created as we find them. On the contrary, there can be no doubt whatever, that they were once living beings, performing the part belonging to their respective races,* and that at their death, or soon after, they were consolidated, in the then concreting and forming rocky strata.

XIII. *The transition rocks are supposed to have been deposited, while the earth was passing from the state of a watery abyss to a habitable condition, and therefore they received the name which they bear.*

The leading rocks of this class are, most of the variegated, fragmentary, and petrifaction marbles, many pudding stones, breccias and sand stones, all the graywackes and many slates, especially those connected with the anthracite coal; such as that of Lehigh, that of Wilkesbarre, and that of Rhode Island, besides other strata.

Some geologists, instead of a transition class, prefer referring these rocks principally to those which we shall next describe, only considering a part of them as the older rocks of that class, and another part as newer members of the preceding.

It is less important which method is pursued, than that the characteristic distinctions of the rocks should be clearly pointed out.

The word transition is also partly descriptive of the characters as well as of the supposed age of these rocks: their characters are generally midway (*in transitu*) between those of the primitive and of the secondary rocks, and we slide down by a pleasing and instructive progression from the one to the other.

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*The trilobite, one of the early fossilized and imbedded animals, could bend his body double, like a lobster, having in his back, the same jointed articulation; we find him sometimes doubled, and sometimes expanded, as he lies in the rocks, and his eyes are often standing prominently out. Grand trilobites, of singular size and perfection, were shown me by the late Mr. John Sherman, at Trenton Falls, near Utica, (New York) where they were obtained. They seemed almost looking out of the black limestone rock, as if still animated

I am therefore inclined to retain the word and the class transition, although without confining it to the precise limits designated by Werner, who introduced this division.

It is seen at once, what inconvenience is experienced, when we attempt to dispense with the transition class of rocks. We either produce confusion in the primitive, by attaching to it the unnatural appendage of early fragmentary rocks, or we swell the secondary, already sufficiently full.

There is also this additional embarrassment in giving up the transition class. Either we throw into the primitive class, rocks containing organized remains, which creates a very unfortunate blending of formations extremely dissimilar, or we extend the secondary class still more, and group together organized remains of almost all ages, of all indeed, except of the tertiary and alluvial.*

Regarding therefore, for the present, Werner's theoretical ideas as to the *transit* of the earth from a chaotic to a habitable state, in no other light, than as the ground of a classification, we find that it is impossible, without great inconvenience, to neglect those peculiar characters and circumstances which denote an actual transition in the nature and position of the rocks, and which therefore sustain the propriety of this or of some analogous division.

XIV. *Not only the tops and ridges but the flanks of the highest Alpine chains were now, as we may presume, uncovered, and with them a portion of the highly elevated land was brought into view*; the valleys, basins, defiles and plains, with the moderately elevated regions, were probably still covered by the remains of the original ocean, and the waters appear to have been freed from a considerable portion of their chemically dissolved mineral contents; it would seem however that they still retained matter in

* The ingenious division of Messrs Conybeare and Philips, is not chargeable with these inconveniences, and is in many respects very good: but hitherto it is little known out of England, and perhaps it has a happier application in that country, where the coal strata hold so conspicuous a rank, than in most other countries.

chemical solution, and much that was in loose fragments or *mechanically* suspended; the latter state of things necessarily must have occurred, because there was now an extensive surface exposed to mechanical agencies. It would however appear that the waters had become much more fitted to support life, and the life of animals of more complex structure, and which demand a purer medium and a pabulum less mineral. Every thing seems now to have been prepared for the next grand epoch.

The creation of the vegetable and animal races appears to have gone on progressively with the deposition of the mineral strata and masses. It is impossible to form any other inference, if we examine the contents of the terrene crust. The only point that admits of discussion is, as to the amount of time employed. We shall be in the best situation to judge of this after having surveyed the entire subject, including the phenomena of the deluge, which, being the last grand catastrophe, that has happened upon the planet, has left, as might be supposed, its vestigia every where. These appearances and their causes must form a distinct subject of consideration, and no one can reason, correctly and conclusively, upon geology, who does not separate the events connected with the great catastrophe which destroyed nearly the whole human family, and most of the animals, from those events which belong to the earlier periods of the planet and preceded the creation of man.

The geological evidence that supports the history of the flood is most abundant and altogether satisfactory; but it is peculiar, and appropriate, and is very much confused and weakened, by being blended with the facts belonging to the primitive watery abyss, most of which have no connexion with or resemblance to the events, belonging to this period.

Before geology had become a science, it was very natural and perhaps unavoidable, that these effects should be, to a degree, confounded, but the discrimination which divides them and assigns to each the results that belong to it, is, in most cases, no longer difficult, and it is very unhappy, *in every view*, that mistakes should be committed on this subject.

SECONDARY ROCKS.

XV. From this period there is a progression in the position, constitution and contents of the rocks, which, although it sometimes presents only shades of difference, in contiguous members, is widely diverse in the extremes, and occasionally in deposits of nearly the same age.

In our artificial divisions of natural subjects, we are liable to do violence near the dividing lines. This is particularly true in geology. If we can hardly separate the later members of the primitive from the earlier members of the transition class of rocks, it is perhaps still more difficult to distinguish accurately between the borderers of the transition and the secondary.

Still, for the sake of perspicuity and for the assistance of the memory, it is necessary to fix the limits between the two.

But the truth is, that there is a gradual and instructive progression from the earliest primitive down through the transition, secondary and tertiary, to the diluvial and alluvial, including the undoubted but anomalous productions of fire, the lavas;—and the trap rocks and some of the porphyries, which, in the opinion of most geologists, had the same origin.

After the geological student has surveyed the whole, he will be little embarrassed by the artificial divisions which have aided him in his research. Having reached the top of the building, he will regard the stages and ladders by which he ascended, not as essential parts of the edifice, but merely as the means of his elevation.

XVI. *The position of the secondary rocks is generally horizontal or nearly so*, varying commonly, but a few degrees from that position. Sometimes however, they are found inclined at high angles, and even, as is asserted, in a few rare cases, in a vertical position.

The truth seems to be here also as with the primitive and transition, that position in regard to obliquity, is not a decisive indication of the character of a rock; still the positions of the rocks are generally those that have been described.

These rocks, where they are found in connexion with the classes before described, generally occupy the lower declivities of the mountains, reposing upon the transition rocks, or if these are wanting, upon the primitive, and they often slope gradually away into the plains of which (if they are present at all,) they form the upper surface; these rocks are not always found on the plains, whose immediate surface is sometimes formed by rocks of the transition or primitive class. But when the three are present at once (which frequently happens) those rocks now under consideration are on the top, the transition are next below and the primitive at the bottom. It is believed that in every country, by perforating to a certain depth, we should always arrive at primitive rocks, but in particular situations, those of either class may be occasionally found on the surface; the newer rocks when absent, either never having been deposited in that place, or having been removed by gradual or by violent operations.

The primitive rocks, form, by far, the greater part of the crust of the globe; they constute the firm basis of every country. Whether they appear at the surface or not, depends upon the presence or absence of the other classes of rocks.

Either of those classes may at particular places, cover the surface, and should the secondary alone appear, it may be impossible to know whether the rocks, intermediate in character between the secondary and the primitive, (the transition) exist below; but, in general, we may be sure of this fact, that a newer rock will not be found below an older one.

It may happen, as in Saxony, and many other countries, that the several classes of rocks may be exhibited in regular succession, the older rocks breaking through the newer and exposing portions of their masses uncovered.

It may, even happen, that the peaks and ridges may be primitive, the higher slopes and flanks transition, the lower secondary or tertiary, and the plains and hollows diluvial or alluvial, with perhaps an interlude of trap, or porphyry, or trachytic rocks, intruding among the rest, or crowning some of them: but this regularity of order is rarely found in full detail.

XVII. *The rocks of this class are called secondary, in relation to the supposed period of their deposition.* They occupy some entire countries, covering the primitive and transition classes. They are not always confined to plains and basins, but frequently rise into hills; sometimes even into mountains of moderate elevation, and frequently, they form what is called a rolling surface.

Secondary countries constitute a very considerable part of the earth's upper surface. A vast tract, mainly secondary—some of it perhaps mounting to the transition—extends from the western slopes of the Alleghany mountains to the Rocky mountains, forming one of the largest surfaces of derivative rocks in the world.

On the contrary, extensive ranges of the Alleghany mountains, running parallel with others of the secondary and transition class, are primitive, and primitive rocks occupy the surface of a very large part of the eastern or New England states.

Consequently, as in other regions, the scenery, the building materials, the soil, the agricultural processes and productions, and the very manners and modes of life of the inhabitants, vary with the physical features of the country. This is true also of the water courses and water power, the qualities of the water, and to some extent, of the very aspect of the sky.

XVIII. *Their constitution is progressively, less and less chemical, and more and more mechanical, in some degree, according to their age;* the older members of the series contain considerable traces of crystalization, but the newer are often quite earthy, and composed of finely divided parts, aggregated with little or no crystaline matter between the portions. The transparency, lustre and pure bright colors; the numerous aggregated and imbedded crystals, and the delicate structure of parts so conspicuous in the older rocks, are almost entirely wanting, in the most recent secondary. When crystals are found, they have generally resulted from the infiltration of fluids, subsequently to the formation of the rocks, and therefore the crystals occupy veins and cavities, and the mass of the rock is commonly destitute of them.

The agency of subterranean fire may have produced many crystalizations, especially in the igneigenous rocks, and we are not to suppose that all crystals have originated from aqueous solution. It has been proved, as well by the crystals produced by fire, in the case of volcanic eruptions, as by those which are occasionally found in the furnaces of the arts, and in heated and ignited vessels in our laboratories, that heat can form these beautiful solids; but, in general, there appears no reason to suppose that secondary rocks have been exposed to heat; and we look in vain for the splendid imbedded crystals, as well as for the general crystaline structure, by which the earlier primitive rocks are distinguished.

Who expects to see in the sandstones and shales, and in the compact limestones, that display of crystals, which is so common in the primitive?

We must not, however, attempt to limit natural operations too strictly. Every thing is not chemical that is early, nor every thing mechanical that is late. In the progressive development of the present order of things, there appear to have been alterations, and successions of periods characterized by chemical and mechanical deposits. The fragmentary rocks begin very early, immediately after the primitive, and even, perhaps, with the latest of that class, and they continue through all the formations, down to the alluvial and diluvial. Their deposits are, however, often interrupted by chemical formations, and therefore we still find chemical deposits, even among the secondary, and mechanical among the transition. This, however, does not seriously invalidate the truth of the general statement, that the higher we mount in the ages of rocks, the more chemical they are in their composition, and the lower we descend in time, the more mechanical.

It is generally true, that the lower the position of a rock, the deeper it lies in the earth, the more chemical is its constitution, and the more superficial, (provided the several classes of rocks be present at the same place) the more mechanical it will be found. These truths, originally developed by Werner, have

been, in part, questioned or denied by Dr. MacCulloch, upon the evidence of the strata, contained in a very limited, although a very interesting district, the West of Scotland; but the structure of the United States, and generally of North America, greatly confirms the original view of the geologist of Friburg.

There are splendid crystalizations in the transition and earlier secondary limestone, as in Derbyshire, and at Lockport and Niagara, in the State of New York. In the two latter places, although the rocks are usually called secondary, and lie very flat, there is a strong approximation to the transition character.

XIX. *The secondary rocks are often composed of palpable fragments, being the ruins of the preceding rocks.*

Many breccias and pudding stones, and a vast variety of sandstones, are of this description; and whether they are older or newer deposits of this kind, that is, whether they are referrible to the transition or secondary rocks, must be decided by their appearance, relative position, contents, &c. The most recent secondary deposits are scarcely to be distinguished, except by their stronger aggregation, from clays, soil and sand, and other merely earthy masses, of the tertiary or alluvial.

Indeed, the tertiary class, introduced within a few years, completes the connexion between the secondary and the most recent deposits.*

XX. *The secondary rocks, as a class, abound with organized bodies, and with their relics and impresses.*

It is not true, that *every* secondary rock contains such remains, nor that the same rock is always characterized either by their presence or absence; but, secondary rocks often contain organized remains, in astonishing quantities.

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* Some persons have urged that the term primary should be applied to the primitive rocks, secondary to the transition, and tertiary to the secondary. This would no doubt be, *numerically*, more correct, but it would not now be judicious to disturb the received acceptation of words, which really convey no false idea, and we should lose the advantage of the word transition, which is very significant, and in the sense which has been explained, its use is very just. Besides, a frequent change of terms is a great evil, and it is one of the vices of the science of this age.

The older rocks of this class, generally abound in shells of molluscous animals, principally of extinct genera, and there is a progression through the more recent strata, exhibiting a greater and greater approximation towards the more complicated structure of the most perfect animals; and the newer rocks of this class, and of the strata that lie upon them, including the tertiary, contain reptiles, fish, and even birds, and some terrestrial quadrupeds. Within a few years, however, the skeletons of some very large oviparous animals of the crocodile family, namely, the ichthyosaurus or fish lizard, the megalosaurus or great lizard, and the plesiosaurus, have been found in the lias limestone of England.

The secondary rocks abound with the impressions of plants, and there is, with respect both to them and the animals, a gradual progress from those which are unknown, or little known at the present day, up to those that are similar to, or identical with, the existing races. Many distinguished geologists entertain the opinion, which is sustained by numerous observations, although, perhaps, not absolutely confirmed in its fullest extent, that the same rocks, either of the transition or secondary kind, contain, when they have any such relics, organized remains of the same species or genera of plants and animals, so that a given rock, in the most remote countries, exhibits, as is supposed, substantially the same relics, and therefore it is inferred that the deposition of these rocks probably arose from the same causes, and was attended by similar circumstances. If this position is not fully established, so considerable an approximation has been made towards confirming it, that the fossil organic bodies contained in rocks, are now considered as good indicia of the geological age and character of the strata in which they occur.

It is to be observed, that, excepting in the coal formations, the remains of plants are much less numerous in the rocks, than those of animals; and among animals—until we arrive in the most superficial, and the most imperfectly consolidated rocks—the greater part, both in the transition and secondary formations, are marine or aquatic.

It is easy to understand why plants are less frequent than animals. Until the latest periods of the redemption of the earth

from the dominion of water, there must have been a much less perfect accommodation of things to vegetable, than to animal life, and therefore it might be expected that the impresses of plants should be more rare than those of animals.

They are few in the transition rocks, and, in that class, they are most frequent in the strata connected with the anthracite coal.

Among the secondary rocks also, they are most abundant in the bituminous coal formation, and they increase in quantity and variety, as we approach the tertiary, in which, and the most recent secondary, they are numerous; and we end by finding inhumed wood in the form of lignite, or bituminized wood, or wood slightly mineralized; and eventually we find wood unchanged; and thus we trace the vegetable families, from their commencement on the borders of the primitive, quite down to our own times.

The remarks that were made on the fossil animal remains of the transition class, are, in a great measure, applicable here. As the earlier animal races were evidently produced, lived, and died, in the water, and as even many of the more recent were amphibious, we cannot be surprised that their remains should have been deposited in the bottom of the then existing ocean, where they appear to have been consolidated, along with the matter of the rocks, which was in the course of deposition around them. Their deposition was evidently progressive; and successive generations, either of the same, or of different species and genera, were, in their turn, entombed and mineralized, and thus prepared for exhibition to the men of remote ages, who should chance to look into the natural mausoleums containing them.

The testaceous animals, being already protected by a natural calcareous covering, needed to be changed only in the interior or living part. Sometimes this is petrified with the same mineral matter as the shell; at other times, the shell is calcareous, and the animal is silicified; this is the fact, particularly with many of the chalk fossils; the echinus and the alcyonia are often masses

of flint, still, however, retaining the organized form, while every thing around them is calcareous.

It is scarcely possible to doubt, that the process of animal and mineral deposition, which has been thus concisely described, was that which really happened. Whatever may have been the operations of fire, at preceding or subsequent periods, it is impossible that it should have been concerned in the first deposition of the mineral strata, containing organized remains. Indeed, no geologist, however inclined to attribute as many things as possible, to igneous agency, has supposed that animal or vegetable life could ever be produced or sustained in the midst of fire; and indeed, it is quite incredible, that strata, containing distinct organized remains, were ever melted; nor is it easy to imagine that they could be even softened, in any great degree, without destroying or materially deranging the organized texture.*

XXI. *It appears evident that the mineralized plants and animals of the solid strata have not been collected in these situations, by any sudden and local, or even general catastrophe*, for as an author remarks, "among the immense number of fossil shells, many are remarkable for their extreme thinness, delicacy and minuteness of parts, none of which have been injured, but on the contrary are most perfectly preserved." Among the plants of the coal formation situated sometimes hundreds and thousands of feet below the surface, and covered by many beds of solid rocks, their leaves, many of which are of the most tender and delicate structure, are found fully expanded, and in their natural position, in regard to the rest of the plant and laid out, as it were, with as much care as in the *hortus siccus* of a botanist. The minutest parts do not appear to have suffered attrition or injury of any kind.†

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* Organized remains, or more strictly, petrifactions, have been beautifully named, the medals of the creation. Laid by, in ancient and progressive time, in the bosom of the deep, in which the rocks, containing them, were formed, they furnish a perpetual incentive and reward to investigation.

† To the truth of this remark, there are of course exceptions; there are disordered strata and aggregates, upon which are impressed marks of violence, exerted, ei-

It is evident therefore, that notwithstanding partial and local exceptions, the general state of things, at the time of these depositions, was favorable to the quietness of animal and vegetable life, and to the preservation of the remains of both kingdoms.

XXII. *Without excluding the possibility of transportation in particular cases, there can be little doubt, that in general these plants and animals lived and died at or near the places where their remains are found, and that at least those which are mineralized and entombed in the rocks, have no connexion with the deluge.* "Compare the calm deposit of shells and the appearance of the still calmer death of the antediluvian vegetable world with the bowlder stones, the gravel and the disjointed, dispersed and fractured osteology of the diluvial deposits, and it will be allowed that there is not the slightest analogy between these classes of events." (Sir A. Creighton in Annals of Philos. Feb. 1825.) We repeat, that it is a great error to attribute the remains and bodies of plants and animals, found usually in a mineralized condition in the mountains, and rock masses, often occupying extensive districts and sometimes whole countries, and unfathomable depths, to the punitive deluge. In past times, this error was quite universal, and it is not surprising that it was so, when we recollect that geology, as a regular and rational study, does not claim a date beyond the middle of the last century, and its more accurate researches and reasoning may be considered as almost exclusively the offspring of the present century.

One of the most important results obtained by modern geology is, that it has clearly distinguished between the circumstances, object and effects of the primitive abyss and of the diluvial ocean; and no two allied subjects in geology are capable of clearer and more satisfactory discrimination. It is true that the youth of geological *science* should make us cautious, but on this point our march cannot be backward; research can never weaken the

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ther at the time of, or subsequent to their formation. The general statement above is not meant to exclude local, occasional, or even general catastrophes, which are not inconsistent with long intermediate periods of prevailing quiet.

proofs already obtained, but will undoubtedly add constantly to their number and value.

TERTIARY, DILUVIAL AND ALLUVIAL.

XXIII. *The loose superficial masses of clay, sand, gravel, loam, pebbles and some of the superficial rocks appear to have been the last in the series of regular depositions ;* they are now included under the Tertiary and Diluvial and Alluvial*, properly so called.

The *tertiary* comprehends the most recent members of what was until within a few years, included under the *secondary*, and also the oldest members of the former *alluvial.*

The *diluvial* embraces what is conceived to belong to the deluge,† and the *alluvial* is now restricted to the deposits, chiefly mechanical, arising from agencies still in operation, and which have been always active, such as the weather, floods, rain, frost, electricity, &c. &c.

This threefold division has become necessary in consequence of the progress of discovery. The tertiary division sustains very nearly the same relation to the secondary, on the one hand, and the diluvial and alluvial on the other, as the transition does to the primitive and secondary. In either case, we may separate the subjects of the division referred to, and distribute the members between the two contiguous classes, but in both cases, a degree of confusion will be the result.

In colloquial language, it is not very important to distinguish between diluvial and alluvial. It may be sufficient, for the purposes of conversation, to speak of loose masses generally as alluvial ; but in accurate geological discussions, it is important to distinguish between the effects of causes now in operation and of those which belong to catastrophes, of which the occurrence of the

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* Always excepting of course, the volcanic and igneous formations, which are irregular and obey no settled law of succession.

† Or deluges, for there may have been repeated *physical* events of this kind, more or less extensive, although there has been only one general vindictive one and only one general deluge since the creation of man.

last is evinced, by the entire appearance of the surface of the earth, by the record of sacred history and the traditions, mythology, fables and poems of most heathen nations, ancient and modern, savage and civilized.*

It has been usual to speak of the great sandy, gravelly and clayey district of the southern American states, extending from the ocean to the high country, as alluvial; but in fact, a large part of it is tertiary and diluvial, and only a small part is strictly alluvial.

It is true, that in a scientific view, the production or preparation and transportation of the materials of the alluvial and diluvial, is due to the same general class of causes, but the scale of operations is widely different, and the diluvial are attributable to catastrophes, sudden, short, violent and occasional—the alluvial to causes comparatively or generally feeble, although sometimes violent, and always in operation.

XXIV. *In these looser superficial deposits, we find most of the remains of the larger and more perfect animals, and it is rare that trees† and their larger members are found in deposits of a more ancient date.* This epoch embraces the period of the very termination of the redemption of the earth from the first watery abyss.

It appears necessary here to remark that the last operations of the primitive ocean were, in all probability, similar to those of our present oceans. Indeed, had not the deluge supervened and introduced, along with these, a new set of effects, it might not perhaps have been possible to distinguish between the last operations of the first ocean and the daily effects of the present; or rather, the latter would, as far as we can understand, have been little else than a continuation of the former. Indeed, a certain part of the

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* See an abstract of these facts in the Edingurgh Encyclopedia, article Deluge.

† Trees and their branches and roots are sometimes found in the coal formations in the sand stones, in the lias limestone, &c. which proves that the gigantic vegetables were sometimes embraced in the depositions that were formed in the latter periods of the subsidence of the primitive ocean, as well as at epochs still more recent, some of which come down to our own time.

effects of the primitive ocean is liable to be confounded both with those of the present and of the diluvial ocean.

The discrimination is however not important, and these remarks are introduced merely to qualify the statements already made, respecting the general dissimilarity between the phenomena of these different periods.

The similar effects to which allusion is now made, are the general production of debris and wreck, but chiefly of rounded, water worn stones and bowlders.

There can be no doubt that these are now produced, or their forms modified by the moving waters of the surface of our planet.

No one who, on the sea shore, has observed the incessant lashing of the waves, and has listened to the hollow hum of the stones and pebbles rubbing against each other, with ceaseless friction, can doubt, that rounded, water worn pebbles are now every moment forming; and were they found no where else, except on the shores, and in moving waters, there would be no difficulty in assigning their origin generally to this cause. But rounded stones, water worn pebbles and bowlders are found, in every country, on the surface, and in the soil, and in regions the most remote from the ocean. This of course proves the universal prevalence of the waters.

Why not attribute the formation of the inland water worn stones to the *diluvial* ocean? The answer which must be returned is, that the time is too short for the process of grinding down, which would occupy a very long period. The deluge could, and evidently did transport and deposit immense masses of these ruins, where we now find them; but it was not possible that it could, in so limited a period, have effected much, in grinding down the angular fragments of quartz and of other hard stones, into ovoidal and globular pebbles, and bowlders. That effect appears to have been, principally, the work of the primitive ocean, which was not limited to a short time.

XXV. *Bones, single or connected, and even entire skeletons of the larger animals, (as the mammoth or mastodon, and other varieties of elephants, the rhinoceros, the hippopotamus, the tapir.*

elks, deer, bears, horses, oxen, whales, &c.) are found abundantly in many countries, buried in the upper and looser strata.*

Trees and their members, and even entire forests are found in similar situations.

In general, the bones and trees are not mineralized, but are rather, for the most part, in the condition of grave bones or ancient wood.

The bones could not be found in the older strata, if the animals were not in existence when those strata were deposited. Much less could we expect to find human bones in these strata, for man, evidently, was not created till the earth was reduced to complete order, and many generations of animals and plants, had lived and died; depositing their remains in the rocks, whose formation was contemporaneous with the existence of the animals or plants, or immediately subsequent to it, or whose materials were accumulated, by catastrophies that also overwhelmed the organized beings.

Few or no gigantic animals, of any description, are found in the solid strata, below the liast limestone. In that rock, and also in other strata, above and perhaps below, there have been found, within a few years, in England and elsewhere, gigantic oviparous animals of the saurian or lizard family: their remains indicate animals of twenty, forty, fifty, and seventy feet or more in length.‡ They were amphibious, and there is every reason to believe, that when only the mountains and higher hills of England, were redeemed from water, and stood out as islands, these enormous animals, closely allied to the crocodile and alligator, that is to say, being of the same genus, but of different species, swam and sported about, in the inter-insular waters of primitive Britain.

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* The cervus megaceros (Irish elk,) is probably extinct, and perhaps some other cotemporary species

‡ A local name, used in England. The hydraulic lime of New York, is a lias.

‡ In the interesting collection of G. W. Featherstonhaugh, Esq. in New York, there is a fine head of one of these ancient animals, and a very instructive series of specimens, illustrating the history of the bones found in the caverns, and in the diluvial formations of England.

Probably no land quadrupeds are found in any formation earlier than the tertiary.*

This is easily understood. Until this period, there was not dry land enough for terrestrial quadrupeds. It was evidently a period more advanced, than that which produced the ancient crocodiles; more land was uncovered, but a multitude of natural basins were still full of water, forming lakes, and as the strata which they now present, were in the course of being deposited, various quadrupeds, fortuitously conveyed into the water, or perhaps drowned by accident or by partial inundations, became solidified, and their remains are now found in the basins of Paris and London, and of the Isle of Wight. In general, their bones are not mineralized, or but partially so, and rarely are they perfectly changed. They are also much less frequent, than the marine animal remains of the earlier strata, probably, both because the animals were much less numerous, and because the circumstances attending their existence and death, were far less favorable to their inhumation.

It is worthy of remark also, that in the very strata in which they are contained, the relics of water-born animals are very numerous. It is believed, by Cuvier and Brongniart, whose elaborate investigation of the Paris strata, has been several years before the world, that there were successive periods, in which the waters produced, alternately and successively, marine and fresh-water shells, but perhaps our acquaintance with these ancient animals, does not enable us to decide positively on this point.

The most remarkable of the solid strata of the tertiary, are the *calcaire grossier* of the French, millstone, sandstones and gypsum; and among the materials that are not solidified, numerous beds of clay, marle and sand.

The tertiary formations having been distinguished only within a few years, have, as yet, been only partially examined, and almost exclusively, in France and England. There can be no

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* See a remarkable fact—American Journal of Science, Vol. II. p. 146.

doubt, as already observed, that much of the great alluvial, as it has been called, of the United States, is really tertiary.* The tertiary passes into the diluvial and alluvial, by almost imperceptible shades, and as it is not easy, perhaps it is not important, to draw the line of separation with perfect accuracy.

It has been generally admitted, that no viviparous quadrupeds, nor any vertebrated animals,† except amphibious ones, are found lower down than the chalk. Professor Buckland, has, however, discovered in the Stonesfield slate, near Oxford, the bones of birds‡ and of a species of opossum. Few large terrestrial quadrupeds are found in the strata beneath the diluvial and alluvial.

Of course these could not exist, in any great numbers, until the land was chiefly uncovered, and their inhumation is, we presume, to be ascribed, with few exceptions, to the deluge of Noah.

XXVI. *Many revolutions more or less extensive, the result of earthquakes, volcanos, tempests and even deluges, partial or general, and perhaps of other causes, now unknown, may have preceded the formation of man.* Of these revolutions, there is abundant evidence in the strata, which as already stated, are often contorted, elevated, depressed, dislocated and blended, and the same relics are asserted to be found in the strata of the same kind repeated at different depths, and separated by other intervening beds of rocks, containing also in many instances, their own peculiar remains. These facts if established by sufficient evidence, prove the existence of successive generations of these beings and their submersion and inhumation by the alternate and successive prevalence of the waters.

There is every reason to believe that the creation of animals and plants was successive; not by equivocal generation—not by atomic action, but by the fiat of the Almighty.

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* See two excellent papers on this subject, by Prof. Vanuxem and Dr. Morton, in the Journal of the Academy of Natural Sciences of Philadelphia, Vol. VI.

† For a notice of a vertebrated animal five feet long, found in old red sandstone, see American Journal, Vol. II. p. 146 and Vol. III. p. 247.

‡ Birds are supposed to have been found in the English lias.

The waters, at different periods, appear to have been adapted to the support of different races, and therefore, their remains were successively solidified. When this happened, it is not necessary to suppose that the animals of a particular race were all extinguished; a multitude of them were entombed, as is proved by their remains; but individuals probably survived, in sufficient numbers to continue the respective species; in the mean time, other animals were created, and new races were petrified in the forming rocks: again perhaps the diminished race prevailed anew, and becoming again the tenants of the waters, presented their relics to be solidified in a new deposition, and so on in succession.

As to plants, it has been already remarked that their relics (the coal formations excepted,) are far less numerous than those of animals. It is in no way surprising that their creation should have been successive, and associated with different rock formations, and if the same plants occur in successive repetitions of the same or of different formations, their seeds or roots might have been preserved in the waters or transported from other places.

It is in no way inconsistent with natural laws, that the particular state of things which attended a particular rocky deposition, should have been such also, when the same kind of rock came to be deposited again, as to favor the production of the same animal or vegetable races from the germs, seeds, roots or individuals that had been preserved. The temperature of the great waters under the same circumstances, is liable to little variation, which would greatly favor a similarity or identity of productions.

In the same latitudes there is now, on the earth, a great regularity in the vegetable species, and, in a less rigorous degree, in the animal races.

But the geologist is not obliged to remove or to solve every difficulty, however gratifying it may be to effect this object. His first duty is to ascertain correctly, and to describe faithfully, the great facts, and if they are inexplicable it is not his fault. Every thing in nature will not have been explained till time is no more.

In the present case however, we are quite sure that these interesting relics are not referrible to the deluge; that short, transient and violent catastrophe; and it is wholly incredible and inadmissible, that the plants and animals were made in the rocks. They are not a lusus naturæ, and no solution presents itself to the writer, but the one that has been given.

XXVII. *In most of the earlier strata that have been described, the animal remains are mineralized or petrified*, that is they are changed into rock or stone or other mineral matter, or at least enclosed in it; they form part of the solid strata; they are found at great depths, with vast piles of strata, and mountains, often of different kinds of rocks, lying over them; they extend in many instances, hundreds of miles in continuity; their number exceeds all estimation; and for all these reasons it is obvious, that their deposition and that of the rocks in which they are found must have occupied a great length of time.

The creation of the planet was no doubt instantaneous, as regards the materials, but the arrangement, at least of the crust, appears to have been gradual. As a subject either of moral or physical contemplation, we can say nothing better, than that it was the good pleasure of God that this world should be called into existence; but, it seems also to have been his pleasure, that the arrangement, by which it was to become a fit habitation for man, was to be progressive.*

This is in strict analogy with the common course of things in the physical, moral and intellectual world. The human mind, the bodily powers, the inception and growth of the animal and vegetable races, the seasons, seed time and harvest, science and arts, wealth, civilization, national power and character, and a thousand things more, evince, that progression is stamped upon almost every thing, and that most things reach perfection, not by a single leap, but rather by a slow, although sure course.

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* It is a most remarkable fact, that every great feature in the structure of the planet, corresponds with the *order of the events* narrated in sacred history.

The gradual preparation of this planet for its ultimate destination presents therefore no anomaly, and need not excite our surprise.

THE DELUGE AND DILUVIAL ACTION.

XXVIII. *There is decisive evidence that not further back than a few thousand years, an universal deluge* swept the surface of this globe, and produced certain alterations in its physiognomy.*

SUGGESTIONS AS TO A POSSIBLE PHYSICAL CAUSE.

As the immediate cause of the deluge was the will of the deity, it is not necessary to prove that he who created the planet, and covered it with the primitive abyss, could again bring over it a world of waters.

In a moral view then, it is sufficient to say that it was the ordinance of heaven.

But as God, although able to effect the object by the fiat of his command alone, usually works by means, it is very proper to enquire if there are any natural powers which might be employed to deluge the earth.

The rain of heaven is mentioned as having descended for forty days and forty nights, and the fountains of the great deep are stated to have been broken up. It seems necessary therefore to infer, not only that a deluge descended from the atmosphere, but that it burst forth with violence, from the bowels of the earth. In a physical view, such an event would seem to be indispensable, as the atmosphere could discharge only the waters that had ascended into it, by evaporation, unless we imagine that water was created for the purpose in the atmosphere, or brought into it from other regions, either of which would be miraculous.

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* The deluge of Noah as already stated, was however, totally distinct in its effects, from those which we have attributed to the primeval waters of the great abyss, except, that there may have been some similarity near the termination of the primitive deluge, when its waters would most abound with mechanical effects and deposits.

Although the scriptures are not to be regarded as a text book in physics, their allusion to the rupture of the fountains of the great deep seems not to be made without meaning.

When referring to the retiring of the first or primitive ocean, a suggestion was made as to the possibility of the existence of caverns in the bowels of the earth. It is true the fact cannot be proved, but in a sphere of eight thousand miles in diameter, it would appear in no way extraordinary, that many cavities may exist, which collectively, or even singly, may well contain much more than all our oceans, seas, and other superficial waters, none of which are probably more than a few miles in depth. If these cavities communicate in any manner with the ocean, and are (as if they exist at all, they probably are,) filled with water, there exist, we conceive, agents sufficiently powerful to expel the water of these cavities, and thus to deluge, at any time the dry land. These agents are the *aerial fluids, the vapors and the gases*—whose competency to any and every degree of energy, which a given mechanical movement may require, is abundantly exhibited, in the rending force of gun-powder, and of the other still more potent explosive chemical compositions, and in the phenomena of earthquakes and volcanos, whose mechanical effects, depend principally, upon the sudden and abundant evolution and great expansion, by heat, of aerial bodies. These bodies, suddenly evolved, (especially steam at a high temperature,) and subjected to pressure and resistance, are sufficient, not merely to propel cannon balls and bombs, to burst rocks and to explode mines—they can rend mountains—they can shake them from their bases—and cause continents and the globe itself to vibrate and tremble.

If then, there were occasion to elevate a column of water even six miles in height, above the present ocean level, so that it should transcend the highest mountains; aerial fluids, aided by internal heat, would be equal to the effort. Should they be disengaged, abundantly, in the vast subterraneous and subaqueous cavities, they would, of course, occupy the roof or vaults, and would therefore expel the water, which we suppose they may contain, and this water rising, and spreading itself over the dry land:

might submerge the continents, more or less completely. In short, if heat were concerned, it would be merely a case of steam or compressed air, acting to raise a column of water, as in a fire-engine. If it be objected, that the pressure would split the incumbent earth, we answer that it would do so did not its counteracting pressure, arising from a specific gravity at least two or three times greater than of water,* resist, with even superfluous energy, and the overflowing water would add to the pressure.

It will be found that to cover the highest mountains, existing at this time upon the earth, no more water would be required than is sufficient to occupy a cavity whose cubical contents are equal to about $\frac{1}{3}\frac{1}{3}$ part of those of the globe. If the cavity were in the centre and were all in one, its diameter would be nearly one thousand two hundred and seventy-seven miles, extending six hundred and thirty-eight and a half miles each side of the centre, and of course leaving over three thousand three hundred miles for the thickness of the containing shell.†

If the void space were distributed in various parts of the globe, of course the thickness of the walls must depend upon the proximity to the surface; but, a few leagues or perhaps miles of thickness would be sufficient to give the strength, requisite, to resist the pressure.

A force five times as great as that used with safety by Mr. Perkins, in his celebrated experiments with his generator, would raise a column of water, and of course an ocean, higher than the top of the Himmaleh mountains.‡

If volcanic or internal heat in the earth should create steam, sufficiently abundant and elastic, to sustain this enormous pressure, would it not throw the whole ocean into ebullition? It would cause the parts contiguous to the fire to become red hot, and to assume the elastic form, or there would be no power generated, but wa-

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* Possibly even much greater, according to the deductions of Maskelyne and Hutton on the specific gravity of the earth.

† Private communication to the author.

‡ Measuring from the surface of the present ocean.

ter is so bad a conductor of heat that the ocean surrounding the globe, and at a distance from the internal heated cavities, might remain cold. A similar course of reasoning, will apply to the extrication of gas.

How would such an ocean elevated by aerial agency, ever descend? By condensation of the steam and absorption of the gas, on the cessation of the heat.

Would not gas, and much more vapor, under a pressure of perhaps many miles of water be of course condensed by the force,* or be prevented from ever becoming aeriform? It would if cold, but igneous agency has no known limits and would, in a given degree of intensity, counteract and overcome the condensing effects of pressure.

Would not gas or vapor, as the earth revolved, escape, by blowing out of the orifice, connecting the cavity with the surface? It would do so, if the channel had a particular direction in relation to the axis of the earth, but if parallel, and still more if tortuous, (which corresponds with what we know of the inlets to caverns,) the contained aerial matter or most of it would remain imprisoned. It is not pretended that the method here sketched was the one actually employed; it is sufficient for the present purpose to shew that it is physically possible.

Have we any case of analogous facts, which may redeem our supposition from the appearance of hypothesis, invented for the occasion? We have such a case: it is that of volcanic eruption. According to Humboldt, lava sometimes issues, at an elevation of eighteen thousand feet.† As we are wishing to apply a measure to the supposed power, we will take this extreme case, for the very reason, that it shews the extent of the power, (not its extent in possibility, but as far as it has been hitherto ascertained.)

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* As Mr. Faraday has shown that many of the gases are actually condensed by the conjoined effects of pressure and cold.

† The volcanic mountains in Hawaii, (Owhyhee) Mouna Roa and Mouna Kea, each estimated to be over eighteen thousand feet high, evince that this statement is not exaggerated.—*Am. Jour. Vol.* II. *pa.* 2. Cotopaxi is another example.

Molted lava, especially under the pressure of so many thousand feet of its own fluid substance, may be estimated to have the specific gravity of at least 3. water being 1. Consequently, a power which could raise lava eighteen thousand feet, would raise water fifty-four thousand; this would cover the Himalch mountains, and leave twenty-eight thousand feet, (about five miles and a third,) for the depth, from the surface of the earth, of the cavity where the power might be exerted.

But this is not all. It is incredible that such volcanic mountains as Mouna Kea and Mouna Roa in Owhyee, eighteen thousand feet or more high; Teneriffe twelve thousand five hundred; Cotopaxi twenty thousand, three hundred and twenty feet, all raised by volcanic eruptions, could have the laboratory, from which the power and the lava issue, at a smaller depth under the surface, than that by which these mountain rise above it. With any thickness of roof less than this, the whole covering must be blown to atoms, by the tremendous effort which raises the lava.

Take here again the extreme case, Cotopaxi twenty thousand, three hundred and twenty feet high: lava of sp. gr. 3. raised to this height, would imply a power, that would raise water sixty thousand, nine hundred and sixty feet, measuring only from the level of the sea; but, if the cavern, from which the lava issues, is as deep in the earth as the mountain is high above it, the power exerted would raise water one hundred and twenty-one thousand, nine hundred and twenty feet, or between twenty-one and twenty-two miles. It will be observed, that the power which as we *know*, actually raises the lava, is the same, that we suppose, may be employed to raise the water, and this power is actually exerted in caverns deep seated in the earth, for it is incredible that a mountain that has itself been raised by volcanic eruptions, and whose entire substance is congealed lava, should contain the cavities from which floods of lava are still made to flow, age after age, for the mountain would explode with its own throes and convulsions, as that of Sumbawa in the island of Timor, did, not many years since. We have proved therefore, that there are caverns in the earth, where igneous agency is exerted, and suf-

ficient power is generated, to raise all the water that would be requred to deluge the mountains.

Still, we do not affirm that this was actually the *modus operandi*; but merely, that the hypothesis is consistent with physical laws, because the very case which we have supposed, is a frequent occurrence, only the fluid raised is molten rock, instead of water.

We forbear to push our supposition to the extreme, by shewing that it is probable, that volcanic cavities are often much deeper than we have stated—otherwise, the volcanic mountains might be in danger of falling in, as the ancient dome of Kirauea probably has done; and it is very difficult otherwise to conceive, how volcanos communicate with each other under ground, and how the earthquakes which they generate, are transmitted even to other continents.

We forbear from stating other hypotheses which have been or might be suggested; such as that of the approximation of a comet, or of other foreign planetary influence.

XXIX. *The deluge of Noah was an exterminating and punitive infliction; sudden in its occurrence, short in its duration, and violent in its effects.*

The immense, and universally diffused masses of sand, clay, loam, gravel, pebbles, bowlder stones, inhumed wood and forests, bones and skeletons of gigantic, as well as of smaller animals, and the vast cemeteries of animal remains discovered in caverns, owe their preservation, and generally, (except the last, viz. the bones in caverns,) their present position, to the overwhelming destruction of this mighty debacle. Professor Buckland, in his Reliquiæ Diluvianæ, has most ably illustrated this subject; and it is obvious, that the former practice, of attributing the organized remains found in the solid strata, to this catastrophe, is founded entirely in an imperfect acquaintance with the subject, and that no man, at the present period, who had studied geology thoroughly, would fall into such an error.

That the diluvial ocean was equal to all the violent effects now attributed to it, can, we think, be proved, by a little attention to the circumstances of the phenomenon.

In stating these, I shall take it for granted, that the Mosaic account of the event, is true. I would remind the mere geologist, that the evidence of probable history, is always admitted in the statement and discussion of geological facts. In the present instance, the history, without taking into view its divine origin, bears every mark of verisimilitude. It is simple and perspicuous, and it is also probable; because it corresponds with the appearances upon the surface of the earth. We need not the history, in order to prove the occurrence of an universal deluge. This is sufficiently proved, by the vestiges left upon the globe, and geologists are generally agreed in admitting the fact.

The only point, for the establishment of which we need to advert to the history, is the time which the catastrophe occupied, and particularly, the great divisions of this time, by the ascent, the continuance, and the decline of the waters.

Another preliminary to the statements which are to follow, is, that the mountain ranges were the same at the time of the deluge as now, except that they are not so elevated. That an universal deluge has occurred, since the earth was peopled by human beings, is stated in a credible* history, namely, the Mosaic; the traditions, history, mythology and poetry of all nations, contain allusions to the same event: and it being distinctly stated in the Scriptures, and implied in most of the other sources of information just alluded to, that its object was punitive, it of course follows, that it happened since the completion of the series of geological events, which fitted the earth for the reception of man. The mountains, being a part of the "great frame work" of the globe, may reasonably be supposed to have existed before the deluge; since, whatever may have been the proximate physical causes of that event, there is no reason to believe, that on that occasion, continents sunk, or were born from the womb of the deep; but on the contrary, there is positive geological evidence, that the mountain's ranges are the same as before the deluge.

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* We speak of it as *credible*, because it corresponds with *physical appearances*; this being the point, essential to the *geological* argument.

Every thing in the lucid and graphic history of the bible, leads to the conclusion, that the waters rose till the land was submerged, and not that the continents subsided into the bosom of the earth. If they did subside, it must have been all hollow beneath them before; but granting that they sunk into cavities, what power raised the new continents,* or before sustained the old!

RISE OF THE WATERS.

Taking it for granted, that the antediluvian mountains were the same as the present, but somewhat higher, and that agreeably

* Mr. Penn, in his Comparative Estimate of the Mineral and Mosaic Geologies, (second edition,) has stated it as his opinion, that the waters of the primitive abyss retired into superficial cavities scooped out for them, by the breaking up and sinking of the crust of the earth, or of as much of it as was necessary for that purpose; thus forming the bed of the ocean and seas, but, as he supposes the primitive ocean to have been withdrawn in the course of a few days, and maintains that there was no such thing as *formation* or progress in the deposition of the primitive rocks, but that all their crystals and other constituent parts were created at once, as we now see them, no reason appears why the planet was submersed at all, and certainly none why the great waters were so rapidly withdrawn. Mr. Penn, although strenuously opposed to the admission of any more time before the creation of man than what is commonly allowed, is still so much impressed with the utter impossibility of attributing the mineralized organic remains and the fragmentary rocks of the globe to the transient catastrophe of the deluge, that he resorts to a supposition which appears quite original.

Believing the organized remains to have been produced and petrified in the bosom of the oceans and seas, as they existed between the creation of man and the deluge, occupying a space of 1656 years, he supposes that when the deluge came, the then existing continents were also broken up and plunged into the bowels of the globe, and not only so, but that cavities were formed over these sunken continents so deep that the seas and oceans were drained off from their former beds, running by subsidence into these new cavities, and thus disclosing the bottom of the former seas and oceans, which form the continents of our present habitable world.

As this theory supposes, in order to provide for the withdrawing of the two oceans, namely, the primitive and the diluvial, that, first and last, the entire crust of the planet, both the dry land and the submarine must have been broken up and sunk, we are of course led to enquire, whether there was a general cavity beneath the entire crust of the planet, (as a little globe is sometimes, in our artificial apparatus, supported within the encircling rings of an armillary sphere, or like a nut loose in its shell, or as the loose kernel (noyau) often included in the argillaceous iron ore, called aetite.)

to the scripture history, they were all covered; we have the measure of the altitude of the flood; and from the same history, we learn also the time in which it rose.

Supposing that the highest elevation was five and a half miles; as it was forty days in rising, it rose nearly at the following rate, that is, a foot in two minutes, thirty feet in an hour, one hundred and eighty-one feet in the time of a common flood or ebb tide, three hundred and sixty-two feet in the entire time of the flux and reflux of a tide, and seven hundred and twenty-six feet in twenty four hours. This is upon the supposition that the waters rose upon the surface

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If there were such a cavity what filled it before the subsidence? What sustained the encircling hollow sphere in its place? If there were no such cavities how could the continents sink? If the cavities were formed at the time by convulsions, what became of the displaced materials?

But, it is not necessary to pursue these enquiries; for, the discoveries of Prof. Buckland, as to the antediluvian caves, have proved, that the continents that now exist above water, are the same that were inhabited before the flood. The caverns that were then tenanted by hyenas, bears, and other wild animals, as their dens, present innumerable specimens of their remains, and of those of the animals, or parts of animals, which they dragged in for food, or which sought in these places a refuge from the common danger; and these remains are covered by the diluvial sediment, which was floated into them, when the waters were turbid with the suspended mud, and thus these apparently trifling relics have been preserved to the present day, as memorials of that great event.

It is impossible to give, on this occasion, even an abstract of the details by which these indications are established.*

A diligent attention to the facts of the same class that have been discovered since the publication of the Reliquiæ; a very careful re-perusal of that work for the second and third time, after a full consideration of the objections of those two very acute writers, Mr. Penn, an able critic, and of Dr. Fleming, an accomplished naturalist, have left on the mind of the writer a conviction, in no degree impaired, that Professor Buckland's opinions respecting the identity of the *ante* and *post* diluvian continents are sound and correct. We have been delighted with Dr. Fleming's notices of the history of the animal races in Britain and elsewhere, but we still believe that the caverns were antediluvian, and of course, that the continents were not sunk on that occasion, but drowned and ravaged in situ.

Any thing rather than conviction was produced by the effort of Mr Penn to account for limestone caves and their diluvial bones, by the strange imagination, that the supposed calcareous paste of the deluge had been blown up into caverns by the

* For an able analysis of this work by Prof. Hitchcock, see Am. Jour. Vol. VIII pp. 150 and 317.

of a regular sphere, in which case, they would rise in vast ridgy waves, presenting, every where, much the same appearance and effects. But as the hills and mountains, over the entire surface of the land, would oppose barriers to the rise of the water, the rapidity of the tides would be much increased, and in many situations, the water would rise with redoubled force, and every where overflow the land with increased rapidity.

In order to appreciate, justly, the effect of such a tremendous rush of waters, we must compare it not only with common tides, but with those more violent ones with which we are acquainted.

"Between Matacapa and the North Cape, in the place where the great canal of the river Amazon is most confined by the islands, the tide presents a singular phenomenon. During the three

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gases evolved during the "*immense*" putrefaction of the drowned and transported elephants and other animals, involved in that paste, and inflating it by the gases produced during their decomposition, and that thus these extraordinary excavations were formed.

What blew up the stupendous caverns of Kentucky* and other western and south western American states, extending for miles into the earth, and containing no bones except a few inhumed skeletons of the aboriginal Indians? Why is there no *inflation*, around the bodies of fishes and of larger animals whose remains are found in limestone and other rocks?

We decline however to follow this subject, and while we acknowledge with much satisfaction, the instruction derived from the *study* of *both* Mr. Penn's editions of his learned, elegant and very interesting work, we must be permitted to say, that none of the geological theories which he has so ably combated, appear more extravagant than the two to which we have adverted, and no writer on geology who professes to be a believer in the scriptures, has taken that liberty with the history, which Mr. Penn has done, who does not hesitate to pronounce the four verses which mention the rivers issuing from paradise, to be marginal interpolations, because they describe the then existing rivers as being the same that flowed there before the deluge.

To a writer of such high moral tone, and great mental power and acquirements as Mr. Penn, we would not speak in the magisterial manner, which, very prominent in his first edition, but softened in his second, would leave him in such case little cause to complain.

But his work, searching as it is, has served the cause of truth, and we feel obliged to him for its publication, although he has, in our opinion, left the question between the critics and the geologists embarrassed with all its difficulties.

* The mammoth cave of Kentucky has been explored for ten miles, without finding an end; these caves are in the ancient secondary or transition limestone.

days nearest the full and new moons, (the times of the high tides,) the sea, instead of employing nearly six hours to rise, attains its highest elevation in the space of one or two minutes. It may be supposed, that this is not effected very quietly: a terrific noise is heard, at the distance of one or two leagues, which announces the pororoca, (barre or bore;) such is the name which the Indians of the district, give to this terrible tide. In proportion as it advances, the noise increases, and presently, one beholds a promontory of water, from twelve to fifteen feet in height; then a second, then a third and often a fourth; which follow close upon each other, and which occupy the whole breadth of the canal. This surge advances with a prodigious rapidity, breaking down and shaving clean away, every thing that opposes it. I have, in some places seen an extensive tract of soil carried away by the pororoca, trees of very large dimensions uprooted, and devastations of every description. Wherever it passes, the coast is laid as smooth as if it had been intentionally and carefully swept."*

Mr. Penn mentions also, the following fact, which he says, was obtained from an eye-witness.

"At the mouth of a river in Nova Scotia, a schooner of thirty two tons, laden with live stock, was lying with her side to the tide; at the influx of the Bore; which was then about ten feet in perpendicular height. No sooner had this mass of water reached the vessel, than that great body was instantly turned over, like a barrel and presently disappeared. After the tide had ebbed the schooner was so totally absorbed into the sand, that the taffel or upper rail of the deck, was alone visible."

This account corresponds with the the common statements, respecting the tides in the bay of Fundy, which are said to rise sixty feet, to come roaring in like a mighty rushing flood, and that people and animals upon the beach sometimes, with difficulty escape with their lives.

Similar facts are observed in the river Mersey, at Liverpool, and in the Frome, a branch of the Severn, at Bristol, in England,

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* Condamine's Voyage, quoted by Penn, Vol. II. p. 100.

where the tides rise between twenty and thirty feet, rushing in, through the channels, in a tumultuous torrent, which requires peculiar precautions, to guard against its effects.

There are tides in England, of sixty or seventy feet in height. The following notice of such a tide and of some other interesting circumstances, connected with the flow, of water, was communicated to me, by a gentleman from Georgia, who had travelled in England.

"The two principal branches of the river Wye, take their rise in Hereford, and Montgomery Shires, and unite their waters, at Monmouth, from whence to the Severn where it empties, the Wye is navigable. But vessels with masts, never ascend beyond Chepstow, which is situated in Monmouthshire. The country through which this river runs, being of mountainous character, its stream is consequently much broken by rapids, and cataracts, and as it approaches Chepstow, it becomes much more narrow, being confined on either side by precipitous and rocky sides. At Chepstow, the river makes a sudden curve, the town occupying the convex side of the river. The strength of the stream presses against the Gloucester bank, and an eddy is formed on the side of the town, by which vast depositions of mud and sand are made. But these encroachments, are often swept away by the rapid and overwhelming floods that are occasionally poured into the river, through the ravines under the Welsh mountains. I was in Chepstow in 1820. Immediately previous to my arrival at that place, there had been many successive days of rain, and the tide was said to have risen sixty feet on that occasion! and I was informed by the inhabitants that it had been higher. I saw many vessels in the stream secured by cables made fast to capstans on each side of the river. The rapidity of the receding tide was so great, that the water was running two or three feet over the decks of some of the vessels, while others which had not been sufficiently secured against leakage, were sunk; and it frequently happens that after rainy seasons, vessels are unable either to receive, or deliver cargoes until the mountains have "dried their cheeks." The old bridge across

the Wye, which was swept away and rebuilt many times during the last century was finally annihilated, by a freshet which happened sometime in 1813 or 1814. It stood on wooden piers, raised more than forty feet from the bank of the river. The present iron bridge is erected on stone piers, of nearly fifty feet from the bank, and notwithstanding the immense piers of rock and stone, (based in the bed of the river) which support its middle arches, the vibration occasioned by heavy floods is so great, that it is considered dangerous to pass it at such seasons, as the most gentle horses frequently take fright and do much damage, when they find themselves on so unfirm a foundation.—I was told by an intelligent old gentleman of the town, that of late the water has frequently risen much higher than it did when he was a boy, which circumstance was attributed to the great agricultural improvements, which had taken place on the bank of this river, and particularly in draining, as the water, by those means, was more suddenly conveyed into the stream.

"My old acquaintance also showed me a well, situated in a garden about three hundred yards from the river, whose water ebbed and flowed, (as regularly as the river) fourteen feet perpendicular. A little before the tide had attained its height, the water in the well began to recede; at high water the well was dry, and shortly after the river began to ebb, the water of the well returned.—The regularity of this routine was more affected by wet than dry weather."*

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* We had occasion, under the head of land slips and slides, p. 20, to mention those of the White mountains, and they were cited also as instances of diluvial action.

We now add a notice of a slide in the mountains of Vermont, in illustration of the same subject.

It happened in Lincoln, Addison county, on the 27th of June, 1827, in the forenoon. The slide commenced near the top of the mountain, between two large rocks which were stripped of earth, opening a passage of four rods wide, from which it proceeded in a south easterly direction, gradually widening for the distance of two hundred rods, to the south branch of Mill Brook in Fayston. In its course it swept every thing in its way; overturning trees, divesting them of their roots, branches and bark, and often breaking them into short pieces. A number of rocks weighing from fifteen to twenty tons were moved some distance. From where it entered

It is obvious that these facts are cited, in order to give us some standard views by which we may estimate the force of great moving waters, especially when their power is increased by lateral pressure, operating to narrow the channels in which they flow.

Every great rain gives us similar evidence, by the effects of the torrents which it creates, or greatly augments. They produce frightful devastation in their course, and sometimes bear before them every thing but the firmly fixed mountain rocks.

It would not be easy to cite a more striking instance of diluvial ravages, than those produced by the eruptions of Long Lake into Mud Lake, in Vermont, June 6, 1810,* on which occasion,

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* American Journal, Vol. XI. p. 39.

Mill Brook, its course was in a north easterly direction, two hundred and eighty rods, the natural course of the brook being very small; but the channel cut by this torrent is now from two to ten rods in width; and on either side are large quantities of flood wood piled up very high; and from fifteen to twenty rods of the lower part it is blocked up across the channel in every direction; some of the trees are standing on their tops, and generally stripped of roots, branches and bark, and broken into many pieces. A large birch tree, measuring three feet nine inches, was broken off square. A black ash was literally pounded into a broom, whose brush is seven feet long. The force of the water was very great; in some places, it must have been thirty feet deep. Some of the trees on the sides of the channel were barked thirty or forty feet high, and there was mud on them at that height.

The report was heard at the distance of several miles, and by some was thought to be an earthquake—by others, a clap of thunder, but unaccountably prolonged and attended by a perceptible, continued jar. Fortunately, as it was a number of miles distant from any human abode, wild beasts alone, were exposed to its ravages.*

In its whole course before reaching Mill Brook, it swept through a dense forest, mostly of hemlock and spruce, and took off the entire surface, and every thing which it contained. The ground appeared to be as free from roots as if it had been tilled for fifty years. Some trees which were so firmly rooted in the rocks, that they could not be drawn out, were pounded off upon a level with the surface of the ground, as if they had been but slender reeds. At some distance above the stream the mass parted, and left a few rods square of timber standing—but soon united again—and rushing on in all its tremendous power, struck obliquely against the opposite bank of Mill Brook, with a concussion that shook the mountains. When-

* A similar occurrence took place a few years since upon the same peak, but on a much smaller scale.

earth, stones, large rocks, trees and forests, animals, mills, and other structures, were borne away with resistless impetuosity, with the noise of loud thunder, and the concussion of an earthquake—excavating the small outlet of the lakes, called Barton river, into a channel, sometimes one-eighth of a mile wide, and sixty or eighty feet deep—the devastation extending fourteen miles in length, and, to a degree, twenty two miles, quite to Lake Memphremagog.

The effects of the great storm of July 26, 1819, in the Cattskill range;* and those of the tempest in the White mountains,† in New Hampshire, August, 1826, by which the great slides in the

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* American Journal, Vol. IV. p. 125. † Already cited p. 20 of this sketch.

ever a check was given to its progress, the torrent soon accumulated force sufficient to burst every barrier—and again the huge pile proceeded, thundering down the mountain. The forest seems to have been prostrated with as much ease as if it had been but a field of grain. The mass evidently went down in the wildest confusion. The trees sometimes erect, or sweeping around in circles, struck those upon the banks of the stream—as appeared by the bark frequently taken off at a great height—now their tops and roots, alternately projecting forward, and again lying across the current, were shivered in an instant. They are left in considerable numbers throughout the whole course, some lying upon the banks, others in the channel, and wholly or in part, buried in the sand and rocks. But the principal part of the timber swept from twenty-five acres of forest, now converted into a barren waste, lies piled in a confused heap, covering perhaps an acre of ground, one mile and a half from the spot where the slide commenced! Here, having already spent much of its force, and the mountain growing less precipitous, it struck into a cluster of firmly rooted trees and was compelled to stop. At this place it presents a perpendicular wall of logs, &c. across the entire channel, in some places ten or fifteen feet high. The upper end of the pile is buried beneath the sand and stones, and the stream now runs over the top. Perhaps those very logs will be dug out in after times as fossil wood.

Every thing in this mass, bears the marks of the greatest violence. Almost every tree is completely divested of its roots, branches, and bark, as could have been effected by man, with the proper instruments. They are pounded and splintered and broken into all imaginable shapes and lengths. The scene is well worth the attention of all who have never witnessed the effects produced by the agency of rushing torrents of water. No one who has contemplated such scenes, can doubt, that water is adequate to the production of any of those effects, which are ascribed to the deluge.—Cited from Mr. Baldwin's statement, American Journal, Vol. XV. p. 228.

notch were produced, will afford us additional evidence of the tremendous power of great moving waters.

The following fact is cited by Mr. Penn, (Vol. I. p. 50, Introd.)

"On the 14th of October, 1822, a wave, which, during a storm, broke against the pier of Ramsgate, and was dashed upwards to a height of about fourteen feet, fell again upon the stone pavement of the pier head; and, by the force of its reaction, instantaneously raised a thirty-six pound carronade, with its carriage, over a stone ledge, and precipitated it into the sea. The harbor men assured me, that it would have required the utmost efforts of twenty men, to effect the same operation."

In the great tempest of September, 1815, among many similar effects, which happened all along the shores of New England, a vast ridgy wave, raised by the hurricane, came suddenly, in an overwhelming deluge, upon the lower town of Providence, in Rhode Island, and, by its force, entire rows of houses, and stores, and ware-houses, were, in a few minutes, prostrated. Ships of three and four hundred tons, were thrown upon the wharves, knocking down large buildings by their momentum; some were carried into the town, thrusting their jib-booms in at the second and third stories of houses; others were lodged in the streets, and a number, and those some of the largest,* after carrying away a strong bridge, were driven through a bay, usually too shallow, even for small craft, and were thrown up, high and dry, upon a beach, where the salt water has never been since, and may, perhaps, never come again. Nothing would be easier than to swell the list of such events; but these are sufficient for our purpose.

If such effects are produced by torrents, and tides of limited extent, and short duration, the highest of which scarcely equals one third part of that of the diluvial tides, for the same time, and whose duration was not equal, in any instance, to $\frac{1}{1\,0\,0}$ part of that of the waters of the deluge—if such ravages were committed by the Pororoca of the Amazon, by the Bore of Nova Scotia, and by the tides of the English Wye, what must have been those of the forty days tide of the deluge!

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* Among them, the Ganges, formerly a sloop of war.

Granting the measure of time given in the history of the event, and that of the elevation afforded by the highest existing mountains, (both of which appear to be fair grounds of reasoning,) it is not easy to exalt the imagination to an adequate conception of the terrors of that awful catastrophe. The inconceivably violent torrents and cataracts, every where descending from the hills and mountains, and meeting a tide, rising at the rate of more than seven hundred feet in twenty-four hours—resisted and aggravated in force, wherever it encountered the land, and still more, the hills, and the mountain ridges; accompanied, also, we may presume, by other great instruments of almighty power—the tempest, the volcano, and the earthquake: but with, or without them—impelled with resistless violence—it must have swept over the surface, with a force vastly greater than any thing that we now know of the mightiest rushing waters. It evidently rolled every where over the various inequalities of land, in tremendous agitated billows; and where it was narrowed by ridges, and hills, and mountains, and thus forced through valleys and defiles, it must have presented innumerable raging torrents and cataracts, of awful height, force and magnitude, compared with which, even Niagara would be insignificant; and at that time stupendous rapids and cataracts necessarily existed, wherever the water pitched over barriers and precipices.*

PHYSICAL EFFECTS OF THE DELUGE.

Are there any appearances upon the surface of the planet, proving that it has been ravaged by a violent, sudden, and tran-

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* However proper in a moral, it is not necessary in a geological view, to advert to the terrors of the animal creation—and still more, to the dismay and despair of the human race. The traditions of all nations, shew that an indelible impression has been made by the event. Painters and poets have drawn the most vivid and painfully sublime pictures of those overwhelming scenes: and to their graphic touches we leave the subject.

Nor do we think it incumbent on us to shew, that the ark was safe amid that mighty movement of waters. A broad flat vessel, probably without spars and rigging, deeply laden, might well stand the agitation of that ocean; and, if grounded, it would be but for a moment, as the rising flood would immediately lift the floating structure clear again.

sient deluge? The answer is, that they are numerous and convincing.

The effects of the deluge were not forming, but destroying effects: they were mechanical, and not chemical. There is not the least reason to believe, that any solid rock was produced at that period, nor that any of the firmly imbedded and petrified organized remains belong to this epoch. The diluvial ocean was agitated by a mighty moving force, or it would never have attained its greatest elevation within forty days; it was turbid in the extreme, and filled with the wreck of the surface of the planet, with moving rocks, stones, gravel, earth, and coarse and fine sediment—and with extirpated and floating vegetables, and drowned animals.

Its various effects may be included under,

1. Disposition of mineral masses.
2. Of animal and vegetable.

1. Mineral diluvium.

The distinction between diluvium and alluvium has been already pointed out.

Diluvium is found every where. The almost universal deposits of rolled pebbles, and bowlders of rock, not only on the margin of the oceans, seas, lakes, and rivers; but their existence, often in enormous quantities, in situations quite removed from large waters; inland,—imbedded in high banks, or scattered, occasionally, in profusion, on the face of almost every region, and sometimes on the tops and declivities of mountains, as well as in the valleys between them; their entire difference, in many cases, from the rocks in the country where they lie—rounded masses, and pebbles of primitive rocks, being deposited in secondary and tertiary regions, and vice versa; these, and a multitude of similar facts, have ever struck us as being among the most interesting of geological occurrences, and as being very inadequately accounted for by former theories. Pebbles may, in given instances, be formed, (possibly,) by decomposition of the angular portions of a stone—by various chemical agencies, aiding those of a mechanical nature—but an immense number, and, in

our view, much the *greater* number of pebbles, present unquestionable evidence of having been brought to their rounded form by friction.

The attrition of the common waters of the earth, and even that exerted during the comparatively short period, of the prevalence of the deluge of Noah, would do very little towards producing so mighty a result; and we must assign this operation to the more recent periods of the prevalence of the first ocean.

Diluvial formations have a wave-like or undulating appearance.

This we have often observed in the plain of New Haven, and in other regions of Connecticut and New England—exhibiting frequently, a delicacy of flexion, in the layers of gravel and sand, which makes them appear as if they had, but a moment before, received their impulse and position from undulating water, and as if they had copied the very eddies and gyrations of the wave.

Bowlder stones,* consisting of fragments of primitive rocks, probably from north of the great lakes, are found abundantly on the secondary regions of Ohio and Kentucky; the fragments of the primitive Alps, on the Jura chain, (the lake of Geneva intervening;) the ruins of the Scandinavian mountains on the secondary and diluvial plains of Prussia and Northern Germany, (the Baltic being between,) and the fragments of the northern counties of England, cover the southern and middle regions.

In many cases, bowlders and pebbles can be traced to their native beds, and frequently they are strangers to the regions where they are found.

Deserts of sand, covering tracts more or less extensive, such as those in South Africa, and in the Zahara, stretching in a vast belt, from the Atlantic ocean to the desert of Lybia; the sandy plains of Arabia, Germany, and Russia—the great desert at the foot of the Rocky mountains, and all similar deposits, in situa-

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* The rock, in Horeb, that, being smitten by the rod, gave forth water, is, according to SHAW, a bowlder of granite.

tions where no existing causes could leave them, are, with great propriety, referred to the deluge.

The diluvial waters appear to have transported and arranged these masses, by sedimentary deposition, and that they had sufficient power to roll even bowlder stones and disjointed columns* to great distances, is sufficiently evident, from what we know of the energy of torrents in our own time.

Beds of sand, gravel, clay, loam, pebbles and bowlders are found to compose the loose materials of every country, and they invariably exhibit the appearance of deposition from water, sometimes tranquil, sometimes more or less agitated.

The effects of the devastation which every where marked the rise of the deluge, were in a considerable degree veiled, by the gradual depositions of sedimentary matter that took place during the decline of the waters. The history informs us that the waters rose forty days, prevailed one hundred and fifty days, and gradually retired during six months, thus affording a long period, of comparative tranquillity, for the arrangement of the universal sedimentary beds which we now see.

As at the termination of the first ocean, there must have been a multitude of local lakes, determined, by the basin shape, so often traced by contiguous hills and high grounds; in these, separate and independent deposits were doubtless going on, for a length of time, even after the earth began to be repeopled. Those lakes that had no permanent supply of water, would, of course be exhausted by soakage and by evaporation: others would burst their barriers, or gradually wear them down and renew the diluvial ravages, during their escape; while those only would be perennial, which were fed by streams or springs.

Many valleys of denudation, as they are called by Prof. Buckland, were probably produced by the deluge of Noah. Such val-

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* Such as the columns of trap, sometimes of enormous size, which are found scattered, up and down, through the great Connecticut valley, often at a great distance from their parent ridges. The most remarkable case in this range, is ten miles west of Hartford, on the Albany turnpike.—See Tour to Quebec.

leys are conspicuously seen in the South of England: similar strata are found capping contiguous hills, projecting at their sides, and running beneath their foundations; a curve or hollow having been scooped out between, thus indicating the effects of great rushing torrents, attended perhaps by convulsions, that more or less, broke up the superficial stratu.*

It is not intended that all valleys were produced in this manner; many doubtless were thus formed, and many more were deepened and modified, but a multitude of them were probably among the original features of the planet, or produced by early convulsions.

What has been said of diluvium is not intended to exclude the idea of alluvium. This is forming at all times by the action of causes now in full operation, and many instances of great effects of this kind might be cited; as at the mouth of the Nile, of the Mississippi, and in many other embouchures, in bays or sea coasts, lake shores, &c. On this subject it is not necessary to enlarge.†

2. Animal and vegetable bodies covered by diluvium.

A. *Human Remains.*

Are there any remains of the human race covered by the diluvium? Until very recently, it has been confidently answered that none have been found. The human skeletons discovered in tufaceous limestone both in Gaudaloupe, (Phil. Trans. of Lond.,) and more recently in Brazil, (Philn. Trans.) being arranged in uniform order, parallel, sloping, and with their heads all one way, were doubtless deposited in this manner for burial.

Those at Gaudaloupe, being situated where the tide ebbs and flows over them, were evidently in a more elevated situation with respect to water when they were interred than now; and water has probably been the agent, by means of which, the tufaceous rock has been formed around them. The circumstances of those in Brazil indicate that water has stood over them also, but they

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* See this subject ably investigated and illustrated in the Reliquiæ Diluvianæ.

† See Dr. H. H. Hayden's interesting geological essays.

are several miles from the present sea, and the peculiar arrangement and other circumstances of both deposits, indicate that the bodies were interred with the rights of sepulture, and of course that they cannot be diluvial relics. For our present purpose, it is not necessary to discuss these facts any farther.

If there be any human remains, hitherto ascertained, that may be referred to the diluvial catastrophe, they are, perhaps, those discovered in the cavern of Durfort, in France,* and in the quarries of Kosrutz, in Germany. It would appear possible, perhaps probable, that the human remains found in these situations, were deposited there by the deluge. Such discoveries may be, hereafter, multiplied. They should be received with caution; but they cannot fail to be acceptable, both to the friends of geology and of the early scripture history.

When it is considered, that, excepting straggling colonies, scattered here and there, in remoter countries, the human family, at the time of the deluge, had probably, not extended far beyond the neighborhood of the Euphrates, the Tigris and other vicinal Asiatic countries; that even those countries, may not have been, at that time, very populous; that many of the corpses may have been swept into the ocean, many more buried deep in diluvium or in accidental cavities and fissures; that those countries, being without curiosity and without science; and under an arbitrary and jealous government, there is little probability, that discoveries relating to the extirpated human family, would be made, or, if made accidentally, that the remains would be regarded, by the ignorant and incurious inhabitants, in any other light, than those found in burying grounds.

Under a different sway, it is not, perhaps, improbable, that diluvial human bones may hereafter be found in Asia; but under present circumstances, their absence does not operate, in any degree, against the reality of the deluge, attested as it is, by so many geological facts, as well as by the history.

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* Penn, Vol. II. p 394

B. *Remains of Animals and Vegetables.*

These are very numerous and equally unquestionable.

We would by no means insist, that every skeleton and bone, found in diluvium, was buried there by the grand catastrophe. We are willing to allow a reasonable number, and all that can on probable evidence be thus referred, to mere accidents, and to diluvium or alluvium, of a more modern date than that of the deluge.*

Single bones, parts of skeletons, and entire skeletons of the larger animals, often of extinct species, but mostly of known genera, are found abundantly in the diluvium of all countries, where curiosity and intelligence exist.

Whales, sharks and other fishes; crocodiles and other amphibia; the mammoth or the extinct elephant; species of elephants, nearly or quite like those of modern times; the rhinoceros, the hippopotamus; hyenas, tigers, deer, horses; various species of the bovine family, and a multitude more, are found buried in the diluvium, at a greater or less depth; and in most instances, under circumstances indicating that they were buried by the same catastrophe, which destroyed them; namely, a sudden and violent deluge.

The interesting and instructive geological essays of Dr. H. H. Hayden, may be consulted, for a series of facts, relating to the diluvium of the Atlantic portion of the middle and southern states of North America. It appears that under this diluvium, there is buried a great quantity of the bones of whales, sharks, porpoises, mammoths, Asiatic elephants and other large animals, along with numerous trees, sometimes with their fruit. Layers of marine

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* We are not unwilling to concede every fact, that can fairly be claimed, by the ingenious writer, who would have the inhumed remains of elephants and other large animals, referred to the celebration of Roman and Tartarian games, and to their warlike movements; but he must not demand too much. What Roman or Mongul Tartar emperor, ever marched armies or held his court in either of the Americas, on the Ohio, in New Jersey and New York, or at Cheshire, near New Haven, and in innumerable other places, where the bones of the mammoth and of other gigantic animals have been found?

mud, are also found, deep beneath the diluvium, below the present low water mark.

There are also vast quantities of shells, and especially of a gigantic oyster, in many parts of the southern states. They are found, not only in digging for wells, but they form vast beds in various places.

One of the largest beds on the eastern continent, is near Tours, in France; it is twenty seven miles long and twenty feet thick.

But the beds of the southern states far exceed this. A stratum, on the whole continuous, although mixed, more or less, with the general diluvium, and other materials of the country, has been traced from the Eutaw springs, in South Carolina, to the Chickasaw country; six hundred miles in length, by ten, or from that to one hundred, in breadth.*

There can be little doubt that many of the beds of oyster shells which have been attributed to the aboriginal Indians of this country are diluvial deposits.

The bones and skeletons of large animals, especially of the mammoth, are found in wide dispersion, and in very remote countries; in both Americas, in Europe and in Asia. In northern Asia, the tusks of the extinct elephant, are discovered in the diluvial banks of almost every river, and the ivory is found in such abundance, as to be a regular article of commerce. An enormous carcase,† of the northern or Asiatic elephant, a few years since, by the gradual thawing of the frozen bank, in which it was imbedded, high above the water, fell down and exhibited the flesh in full preservation; the long bristly hair and vast massy hide, requiring a large number of men, to carry it, afforded proof irrefragable, of the existence of the animal in those rigorous climates, and of his sudden extinction, inhumation and congelation, with so little interval of time, that putrefaction had not commenced, and has not since taken place, during a long succession of ages.

Indeed, there is but one view which appears to carry with it the least probability, as to the cause of the wide dispersion and

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* Mr. Finch in American Journal of Science, Vol. VII. p. 40.

† Notes to Cuvier's Introductory Discourse

sepulture of the gigantic races; especially of extinct animals in the various quarters of the world. It seems evidently to have been the work of the deluge, which at once drowned, and in many instances, extinguished whole races of animals, and buried their bodies in the wreck of the planet with which those waters were evidently filled. Such a scene of awful devastation, was as well fitted to produce these effects, as it was ill adapted, to the comparatively tranquil life and death of the successive generations of marine and aqueous animals, that peopled the early ocean in its middle and later stages. Organized remains are found at very high levels, not only mineralized but loose or in diluvium, thus proving the prevalence of the ocean, at different periods.

It is said that the skeleton of a whale lies on the top of the mountain Sandhorn, on the coast of the northern sea. The mountain is three thousand feet high, and there is no cause that could have conveyed the whale to that elevation, except a deluge rising to that height.*

So late as June 1824, the remains of a whale were found on the westernmost Stappen, a mountain in Finmarck, at an elevation of eight hundred feet above the ocean. The specimens which were reported to be vertebræ, were lost by shipwreck on their passage to England. Similar remains are said to exist also in North Fugeloe, another mountain in those regions.†

It is common to find trees and their members in the diluvium, and also in the known alluvium of rivers, &c. In general, they are not much altered; sometimes they are partially bituminized or verge towards lignite, or perhaps are really lignite; at other times, they are penetrated by acids and saline substances, and metallic minerals, as pyrites, are occasionally formed upon them.

It has been already said that there is no difference in the nature of the operations by which diluvium and alluvium are produced, and that we must resort to an induction of particulars in order to enable us to distinguish between them, but in most situations, especially those that are remote from rivers and moving waters, there is very little occasion for hesitation, in forming an opinion.

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* Penn, Vol. II. pa. 303. † Ibid.

Extinction of Animal Races by the Deluge.

We cannot reasonably doubt, that many of the skeletons and bones of the animal races, which we find buried in ancient diluvium, in caverns, and in fissures in rocks, were covered by the wreck and sediment of the deluge; others have evidently been covered since, by ordinary or extraordinary events, and our decision, as to the era to which we are to assign them, respectively, must depend on the circumstances of each particular case.

But, is it necessary to suppose, that all the *extinct* races of large animals, found in diluvium, were destroyed at the deluge? If the account of the animals that were preserved in the ark, is to be understood so strictly, as to include *every genus* and *every species*, then we need make no other variation in our conclusions, than that, while all the animals, except a few individuals of each species, perished in the deluge; and therefore, their remains may be naturally found in ancient diluvium; *some* genera and species, of which the representatives were preserved in the ark, with the other animals, have perished since, by unknown causes, so that their races have disappeared entirely from the earth. There can be no objection to this admission—it does not weaken, at all, our view of the peculiar and destroying effects of the deluge.* While we make this remark, we must not however forget, that the fish are not mentioned in the history of the deluge. The obvious answer to this is, that being tenants of the waters, they might well be left to take care of themselves.

Whatever difficulties may arise, from the universal prevalence of a stormy, agitated ocean, (at least stormy and agitated during its rise, although comparatively pacific after it had attained its height,

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* Although it appears to me nearly certain, that most of the mastodons perished at the deluge, I have no objection to admitting, that some of them, whose skeletons are found, may have perished before, or since that event. Those that are buried in ancient diluvium, as that whose remains were recently discovered near New Haven, in the gravel arising from the decomposition of the old red sandstone rock, were clearly antediluvian, and probably destroyed by the deluge; while some that have been discovered, foundered in salt licks and marshes, may have perished by miring, as cattle do at the present day

and dyring its decline,) an ocean filled with the wreck of the surface, turbid with mud, and unfriendly to the preservation even of fishes, especially, as they include the species, both of salt and fresh water, and therefore of widely different habits: we may suppose, that a few might still escape destruction, and thus preserve the races, although the greater number evidently perished, along with the land animals. As might be expected therefore, we find the skeletons of large fishes, (whales, sharks, &c.) buried in ancient diluvium, or grounded on high mountains, especially where cold and ice have aided in preserving the remains from decomposition.*

Preservation of Vegetables.

Without supposing that the ark was a green house, or a repository of antediluvian seeds, it would perhaps not appear incredible, that Noah, so long warned of the approaching catastrophe, which was to tear away the soil, and root up the forests by the force of rushing waters, should have preserved some of the more important esculent plants and seeds; a degree of care not exceeding that which is exercised by every leader of a colony, when passing over seas to a new abode. But, however this may have been, there is no serious difficulty in believing, that in an ocean, which, from its magnitude and depth, was probably never warmed to that degree that favors germination, or vegetable decomposition: seeds of almost every kind, may have floated, uninjured, during the short period of a year, (for we know that seeds and seed vessels, are actually floated from continent to continent, without losing their germinating powers,) and when the waters subsided, they would of course, at least those that were in favorable circumstances, again shoot and grow.

We know also that seeds lie uninjured in the earth for many years, for every movement of the soil in cultivation is sure, after a little repose, to bring up a new crop of plants, and successive

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* We do not refer to remains of fishes in the solid rocks, which obviously belong to the first ocean.

crops spring up spontaneously, on the same ground, even when left untilled from year to year.

It is obvious also, that the roots of plants and trees, would again strike into the ground and vegetate anew, as soon as the waters were sufficiently withdrawn, and the kindly influence of the sun was felt.

There seems therefore no serious difficulty in the restoration of vegetation to the earth, after the deluge.*

The loose materials by which the surface was covered, were a mixture of all preceding soils, and therefore fitted for the immediate renewal of vegetation. Horticulture and agriculture, especially the cultivation of the vine, (which needs little besides sand, and sun, and moisture, to make it grow,) might therefore have been resumed immediately. As vegetation increased, the soil would of course improve in fertility, by a natural process of manuring.

SUBSIDENCE OF THE DILUVIAL OCEAN.

The retiring waters of the Noachic deluge occupied half a year in their descent; and thus time was allowed, for that gradual and comparatively tranquil deposit and arrangement of the ruins of the surface, of which we every where find the most decisive evidence.†

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* Nor does the diluvial action, violent as we have supposed it to be, *necessarily imply* the extirpation of *every* plant; an olive may have been plucked from the tree *in place*, protected by some peculiar circumstances of situation.

† Taking the Himmaleh mountains as the measure of the height of the deluge, it fell at the rate of about one hundred and forty feet in twenty-four hours, or a little less than six feet in an hour—which, although a rapid descent for a common tide, was slow, compared with the ascent of the diluvial waters; a *partial* deluge, pervading the earth for a year, could not have happened; it must have flowed all round the globe. Statical principles forbid us to suppose that it was accumulated over a part of the world, and not over the whole. I know not on what authority, physical or historical, any person is permitted to say, that its elevation was less, than to cover "all the high hills and mountains under the whole heaven."

Nothing in geology has struck me with more interest, than the beautiful arrangement, in strata, of the beds of sand, gravel, clay, loam and pebbles, which may be observed in every country. A section of a bank of any of these deposits—or better still, an avulsion or fall, which leaves the stratification exposed, without being obscured, by the rubbish, produced by digging, or by the sliding of loose sand—never fails to exhibit the effects of sedimentary deposit; sometimes horizontal—sometimes inclined at various angles, great or small—sometimes undulatory, and recording, in a language that cannot be misunderstood, the effects of subsiding water. The beds are not always in the order of the magnitude of the parts. Sometimes coarser gravel, or even pebbles, will form a layer, above fine sand, and then perhaps the order will be reversed, indicating that there were currents, and these, relenting and increasing, alternately, as they were impelled, probably by tides or storms, so that coarser or finer materials were transported and deposited, as the waters were more or less agitated; for currents must have existed to the last. Could these sedimentary deposits be now all removed, we should see the naked, scarred, and devastated skeleton of the planet, exhibiting the most decisive proof that it had been swept by violence, of which we find evident marks in the scratches and furrows, found in the fixed rocks, that are covered by diluvium.

If a section of the deepest diluvium could be made quite down to the solid rock, there can be little doubt, that, on the whole, the magnitude of the parts would correspond with the depth, and the larger fragments of these loose materials would often be found at the bottom. This does not render it improbable, that bowlder stones should be occasionally deposited on the surface, especially when they are found on the firmer materials, or on rocky ledges.

SUBSIDENCE OF THE PRIMITIVE OCEAN.

If it was necessary that the diluvial ocean should retire with moderation, it was indispensable that the primitive ocean should

decline with extreme slowness, in order to give time for the various arrangements of firm materials, which were going on, and for the consolidation of the fragmentary and petrifaction rocks, with their extraneous contents of organized bodies, both vegetable and animal. We have no reason to suppose, that there was any miraculous interference to get rid of the water, and indeed the innumerable marine races, found in the rocks, prove its presence, during the gradual progress of their lives, death, and sepulture. A rapid retreat of the waters would have been entirely inconsistent with this state of things; it could have produced no other than the most destructive effects, and, instead of fitting the earth to become the abode of living beings, and of man, their lord, would have exhibited only a scene of the most frightful devastation, and a long time must have passed after the event, before it could have become habitable.

As the waters of the primeval ocean, after the mountains and hills began to be uncovered, would be pent up and forced into sluices and narrow passes, the rapidity and devastating effects of the currents would have been greatly augmented, and for a time progressively so, as the waters descended.*

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* It is obvious, that the retreat of the waters could not, upon physical laws, have been so rapid, as to have been compassed, with safety, to the surface, within three natural days, the period that must be allotted to it by those who understand the account of the time in the common sense; for two days had passed, before the tops of the mountains appeared, and every thing was finished on the evening of the fifth day, at least, to such an extent, that the ground was dry enough, to be fitted for the reception of man, and of the terrestrial animals, which were created the next day.

Now the Himmaleh mountains are nearly twenty-six thousand feet high; probably, they were then considerably higher, perhaps twenty-seven thousand; as every thing on the surface, indicates that the mountains have been much degraded by the wear of time. The drainage of the earth, to have been accomplished in three days, upon the supposition of twenty-seven thousand feet elevation, would have required a descent of three hundred and seventy-five feet in an hour, or nine thousand in twenty-four hours; or, if these mountains were only twenty-six thousand feet high, the drainage must have been at the rate of more than three hundred and sixty feet in an hour, or over eight thousand six hundred and sixty-six in twenty-four hours, or two thousand one hundred and sixty-six feet in the time of the descent of a common tide.

The difficulty would not be diminished by the supposition that the mountains were elevated from the bottom of the ancient ocean, for, if they rose within the time of a few days, the effects on the waters would have been still more violent; if they were rising gradually during an indefinitely long period, this supposition concedes the very point in discussion. Every geological theory supposes the mountains to have been in existence, before the earth was habitable, and the Mosaic history necessarily implies the same fact.

XXX.—VOLCANOS.*

Among the physical phenomena of our planet, none arrest the attention of its inhabitants more forcibly, than those connected with earthquakes and volcanos. These tremendous displays of power cannot fail to interest even barbarous nations, who consider volcanic craters as the residence of demons, and their eruptions as the demonstrations of their anger, and as the means employed by them to spread destruction. The missionaries in Owyhee, (Hawaii,)† have given us a very interesting account of the goddess Pele, and of the highly poetical mythology, which the natives have built upon her supposed dominion.

It is not surprising, that such terrific appearances should be imputed by barbarians, to the agency of a local deity, and that the visitations of earthquakes and volcanos, should be regarded as malignant and vindictive inflictions.

Much of the poetical machinery of the Greeks and Romans, was fabricated out of physical phenomena. The struggles of the Titans, buried beneath the mountains, by the anger of the gods, were assigned by poetry, as the causes of the earthquakes of Italy, and Vulcan and the Cyclops, according to the annals of fa-

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* This introductory notice of volcanos, is taken, principally, from the Am. Journal of Science, Vols. XIII. and XIV. having been prepared by the editor of that, and the author of the present work.

† See Ellis' Tour, and the analysis of it, Vol. XI. p. 1. of the American Journal.

ble, forged their thunder bolts in the bowels of Etna and of the neighboring Lipari islands.

But in modern times, since the exact sciences have received so much attention, volcanos have been studied with a philosophical spirit. Sir William Hamilton, Spallanzani, Ordinaire, Brieslak, Brocchi, Humboldt, Von Buch, Beudant, Mackenzie, Monticelli, De la Torre, Bory St. Vincent, Webster, Scrope, Daubeny, and others, have given us accurate statements of facts, and have reasoned upon them, with direct reference to the present state of physical science.

To Mr. Scrope, and Professor Daubeny, we are particularly indebted, for recent and very valuable observations and discussions. Mr. Scrope published, in 1825, his "Considerations on Volcanos," and, more recently, his "Memoir on the Geology of Central France." Professor Daubeny has also very recently published his "Description of active and extinct Volcanos."

All these works are of great value, and as they have not been republished in this country, it may not be improper to refer the reader, who may not possess the original works, to very full analyses of them, in the thirteenth and fourteenth volumes of the American Journal of Science.

While we entertain and express the highest respect for the authors of the works alluded to above, we wish to be understood, to attach the principal value to their precise, methodized, and copious statements of facts; with most of their conclusions we do, indeed, fully agree, but there are theoretical points in these discussions, which will probably never be settled, and about which there will continue to be a diversity of opinion.

Definition of a Volcano.

Professor Daubeny states the following distinction between active and extinct volcanos—the former includes all those which have been eruptive at any time since the existence of authentic records—the latter, those that have, within the same limits of

time, exhibited no signs of activity, although incontestably of the same origin.

Thus, although a mountain should not exhibit a crater, and the usual figure and stratification of a volcano,—if its materials have "a vitreous aspect and fracture, together with a cellular structure—cells generally empty, and elongated in the same direction, and, if they have a glazed, internal appearance," there need be no hesitation in pronouncing that the materials are of volcanic origin.

1. *Extinct Volcanos of France and Germany.*

Much philosophical scepticism formerly existed with respect to extinct volcanos. They were vaguely referred to, but without decisive proof of their real volcanic origin; and many persons, very imperfectly qualified to judge of such questions, were sufficiently inclined to infer the existence of volcanos of former ages, wherever they saw a conical hill, or almost any hill, with a hollow on its summit, and porous stones, of whatever kind, were referred to a similar origin. It was a very imposing and sublime idea, that volcanic fire, still active in our planet, and still bursting forth, in many places, with destructive energy, had, in ages long past, exerted agencies still more extensive—covering provinces with ruins, and operating, even in the bed of the primeval oceans. The speculation seemed, however, to claim quite as much affinity with poetical, as with philosophical conceptions, and, it was not till the middle of the last century, that the subject of extinct volcanos began to be investigated with accuracy and skill.

The much disputed country of Auvergne, Velay, and Vivarais, in France, has been often visited, and examined by able geologists, and we believe, that within a few years past, no one of them has left that region, without being convinced that it is of volcanic origin. The celebrated geologist, D'Aubuisson, visited the country in question, with the strongest belief, that he should find this district of Neptunian origin, but he returned a convert to the opposite opinion; a change, the more creditable to his candor, and

to the vigor of his mind, because he had before published an able and interesting treatise, to prove that basalt, and especially the basalt of Saxony, was of aqueous formation.

The volcanic district of France, lies upon the river Rhone, nearly in the angle formed by it with the Mediterranean, and covers an area nearly square, of from forty to fifty leagues in diameter.

We have never visited that country, but the evidence of its volcanic origin, exhibited by Mr. Scrope and Professor Daubeny, confirming, extending, and giving precision to the observations of many previous writers, leaves not the shadow of a doubt, that the tremendous subterraneous agency of fire has covered this fine country with floods of molten rock; no more doubt, indeed, than that similar events have happened at Vesuvius, Cotopaxi, and Ætna.

With the aid of a fine series of specimens, from this very region;* with the full descriptions of the authors whom we have just named, and with the noble atlas—geological—geographical, and picturesque, of Mr. Scrope, illustrating the striking features of this interesting region—we feel the fullest conviction, that their conclusions are substantially correct; and we can easily imagine, that we see the floods of lava, pouring from the now quiet and cold craters, and that the skies of that part of France were once dimmed by the clouds of volcanic ashes, as those of Italy are at the present day.

Craters, regularly formed, often entire, sometimes with the thin and scorified edge of the lip in fine preservation, and occasionally of vast dimensions; here, black, rugged and scathed with fire; there, overgrown with trees, and there, filled with water, forming lakes; currents of lava, lying where they flowed from the crater, or where they burst from the side or foot of the ruptured mountain, extending many miles, and many leagues, traceable directly to their parent mountain, winding along the gorges and the sinu-

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*Furnished to the cabinet of the American Geological Society, by our celebrated geologist, Mr. William Maclure.

ositics of the vallies, now and then diverted from their course by rocks, hills, and other obstacles; sometimes damming up rivers, whose courses they have crossed or obstructed, and thus forming lakes of considerable dimensions; exhibiting all the varieties of lithoid lava, from that which is compact and rock-like, to that which is porous and vesicular in an incipient, or in a prevailing degree; crowned or mixed with slag, scoriæ, pumice, olivine and other exuviæ of known and active volcanos; displaying frequently a structure, now spherical, ovoidal and concentric; now prismatic and columnar, and fronting streams, and bounding valleys, with ranges of columns, equalling or rivalling the regularity of the famous colonnades of Fingal's cave, and the Giant's Causeway; these are a few of the most striking features of these countries, which are so affluent in proofs of their igneous origin, that there is nothing needed, but to select carefully and judiciously, those facts which will be the most decisive, especially with respect to minds not familiar with such contemplations.

The volcanos of the Auvergne, &c. are regarded as of different ages; some appear to have been active before the formation of the present valleys, and some since; where the currents of lava have been cut through, by those causes which formed the present valleys, they are obviously older than the valleys, and where these currents have flowed into valleys, beds of rivers, &c. they are as obviously of a more recent date.

Although the local geographical names may be supposed to allude to the former character of the country, as Auvergne, (Avernus,) Valleé d'Enfer, &c. still, it is thought that these names convey no allusion to historical events, but rather to the actual appearance of the surface.

Although the formation of these volcanic regions was anterior to the records of history, it was evidently in the most recent portions, posterior to the existence of organized beings, which are found imbedded in the volcanic tufa.

Principal Volcanic Phenomena.

"They are commonly preceded by earthquakes of different degrees of intensity and duration, and with loud sounds or detonations, resembling the noise of ordnance and musketry, apparently produced by the disengagement of aëriform fluids, and the increase of bulk in the fluid rocks; and their sounds are conveyed through the solid earth, not by means of the air. The atmosphere, at this time, is remarked to be in a peculiar state of stillness, attended by a sense of oppression.

"During this period, also, springs are apt to disappear, so that wells become dry; and it is known that the extent of this affection is sometimes very considerable.

"When the eruption first appears, it is generally with sudden and great violence. Explosions, apparently from confined air, take place with loud noises, and succeeding each other with rapidity, and often with increasing force; the vent being, commonly, the central point or crater of the mountain. And in its attempt to escape, this air throws up fragments of rock, which sometimes fall back into the crater, and are again repeatedly projected, together with clouds of aqueous vapor. And as the fragments also are often broken into small pieces, and even into dust, this, uniting to the vapor, or mixing with it, produces dense black clouds, or smoke, often assuming the form of a column of entangled or successively formed clouds.

"Having arrived at a certain height, this column generally spreads laterally or horizontally, forming, if the air is calm, a shape, resembling that of a pine-tree, or if there be wind, a horizontal stream. Out of this cloud proceed lightnings of great vividness, while the falling of the dust, added to the density of the cloud, produces darkness over the surrounding country. The melted rock or lava now boils up in the crater, and is often so thrown up into jets by the extricated air, as to resemble flames; and at length it either boils over the edge of the crater, so as to run down the mountain, or else finds an issue laterally, by some

crevice, equally flowing down in a stream, which holds its course as circumstances permit, down to the lower grounds.

"In the night this current is luminous; but in the day, it is generally obscured by vapors, or loses its light by the cooling and blackening of the surface. There are cases, however, in which no torrent of lava occurs, and where no other rocks than scoriæ are erupted. The greatest period of violence is generally over when the lava has flowed for a little while, or this is the crisis of the volcano. But commonly, the explosions of fragments and dust continue for some time, gradually diminishing, till the whole falls into a state of quiescence, and is finally extinguished. Lastly, it must be noticed, that from the action of the volcano on the atmosphere, clouds are generally formed in it, which produce falls of rain, often causing torrents, or even inundations.

"The intervals of repose are various, reaching in some cases as far as to many centuries; so that cultivation and population are renewed, to be dispersed again at some future day. In these intervals of repose, however, it is common for vapors to continue to be produced, either from the craters, or in the course of the currents of lava; and when these are sulphureous, they deposit sulphur; and in other cases, from their acid nature, they corrode and decompose the rocks through which they find a vent. What are called solfataras and souffrières are the result."*

The display of electrical phenomena during volcanic eruptions is often very brilliant; Mr. Scrope remarks that this was the fact with the eruption of Vesuvius, in October, 1822. "From every part of the immense cloud of ashes which hung suspended over the mountain, flashes of forked lightning darted continually. They proceeded in greatest numbers from the edges of the cloud. They did not consist, as in the case of a thunderstorm, of a single zigzag streak of light; but a great many coruscations of this kind appeared suddenly to dart in many directions from a central point."

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* Jour. Roy. Inst. No. 40, p. 356.

Stromboli appears to have been in ceaseless activity for at least twenty centuries, throwing out, not flames nor lava, but scoriæ. It is most violent before and during stormy weather, especially in winter, when lava is said to burst occasionally from its side into the sea, heating it to such a degree as to destroy the fish, which are cast on shore ready boiled.

This volcano is viewed by the fishermen as a weather glass, by which they augur the approach of tempests.

The volcano in the island of Nicaragua, called, by the sailors, the Devil's Mouth, is said to be constantly active, and this appears to be nearly the case also, with that of Kirauea, in the island of Owyhee, (Hawaii,) but these instances are very rare.

Many volcanos are in a state of moderate activity, with occasional paroxysms. Vesuvius was in this condition from the beginning of the present century to October, 1822, when there was a violent eruption. A similar state of things existed from 1767 to 1779, when a violent eruption gave vent to the force.

Ætna was eruptive with intermediate agitations in 1805–9–11–12 and 19, but both these volcanos have had periods of long repose, even for centuries.

Popocatepetl, in Mexico, has been active ever since the conquest of Mexico, and that of Sangay in Quito, has been in incessant activity for about one hundred years.

Mr. Scrope mentions as instances of remarkable volcanic paroxysms, those of Vesuvius, A. D. 79, 203, 472, 512, 685, 993. 1036, 1139, 1306, 1631, 1760, 1794 and 1822.

Ætna, in 1169, 1329, 1535; this latter eruption lasted two years "with terrific violence," and occurred after a quiescence of nearly one hundred years.

Teneriffe, in 1704, 1797–8.

San Georgio, one of the Azores, in 1808.

Palma, one of the Canaries, in 1558, 1646 and 1777.

Lanzerote, one of the same group, in 1730.

Kattlagia Jokul, in Iceland, in 1755, which lasted a year.

Skaptar Jokuhl, in 1783.

Violent eruptions are generally succeeded by periods of long repose, sometimes extending even to centuries. Decomposed lava forms a soil even in the crater, and vegetation springs up.

"All appearances of igneous action are effaced; forests grow up and decay, and cultivation is carried on upon a surface, destined, perhaps, to be blown to atoms, and scattered to the winds, when the crisis arrives for the renewal of the volcanic phenomena. Thus during the quiescent interval, between the eruptions of 1139 and 1306, the whole surface of Vesuvius was in cultivation, and pools of water and chesnut groves occupied the sides and bottom of the crater; as is at present the case with so many of the craters of Ætna, Auvergne, the Vivarais, &c.

"Terrific eruptions occasionally break out from mountains not previously suspected to be of a volcanic nature, or in which the accounts, of former catastrophes of this sort, existed but as vague traditionary fables."

One of the most remarkable examples of the explosion of an entire volcanic mountain, happened in 1668, in the island of Timor, one of the Moluccas.

The whole mountain which was before this continually active, and so high that its light was visible, it is said, three hundred miles off, was blown up and replaced by a concavity now containing a lake.

Theories, suggested anterior to the discovery of Galvanism and the Metals of the fixed Alkalies and Earths.

It is necessary, to occupy very little time, either in reciting or discussing these obsolete theories. We wish, however, not to treat them, or their authors, with contempt; for they were, perhaps, the best that the then existing state of science presented.

"According to the first and most ancient of these, volcanos were attributed to the combustion of certain inflammables, similar to those which exist near the surface of the earth, such, for instance, as sulphur, beds of coal, and the like; and, in order to account for the spontaneous inflammation of these substances, an

appeal was often made to an experiment of Lemery, which went to prove, that mixtures of sulphur and iron, sunk in the ground, and exposed to the influence of humidity, would give out sufficient heat to pass gradually into a state of combustion, and to set fire to any bodies that were near."

Brieslak supposed, that volcanos are produced by petroleum, collected in subterranean caverns, and kindled in some unknown way. Brieslak has shewn, that petroleum is very abundant in the globe; a conclusion which has been still further extended by the researches of Hon. George Knox.* It appears, that petroleum is found, abundantly, in the vicinity of volcanos, and that it is exhaled during their eruptions. The uniform presence of sulphur also, in volcanos, and its copious exhalation, during their state of activity, seem to countenance the general idea, that they may arise from the burning of combustibles.

There are many reasons why this theory, however plausible, appears untenable.

1. The quantity of any of the ordinary combustibles, which could be supposed to be present in any one place, would be totally inadequate to the effect. Reasoning, analogically, from our knowledge of other parts of the world—what supply of coal, bitumen, or sulphur could be adequate to sustain the fires of Vesuvius, or of Etna, of Hecla, of Cotopaxi, of Teneriffe, of Sumbawa, or of Kirauea! The most powerful beds of coal, are but a few yards in thickness, and a few miles in extent. A few capital operations of any principal volcano, would soon destroy the greatest existing bed of combustibles, and instead of continuing from age to age, as many of them do, all would soon be exhausted by the intenseness of their own energy, and the consumption of their inadequate magazines of fuel.

2. There are many volcanic countries, (indeed most are of this description,) where the geological structure and associations are such, as to forbid the existence of coal, the only combustible, sufficiently abundant to countenance such a theory. We should

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* See Vol. XII. p. 147. of the American Journal

look in vain for many active volcanos, in countries of the coal formation, or of the anthracite series. ' Although volcanic fires, occasionally force a passage through any and every species of formation, there is reason to believe that they are deep seated—probably even in the primitive rocks, and in granite itself, where, of course, there is no coal and little sulphur.

3. When also (in the language of our author,) "we examine more narrowly into the analogies between the *effects* of volcanic fires, and of those which we know to result from the combustion of either of these materials, we are soon brought to confess the inadequacy of such an hypothesis to account for the facts before us. What resemblance, for example, do the porcelain-jaspers and other pseudo-volcanic rocks, as they are improperly termed, which we observe in coal mines, that have been for centuries in a state of inflammation, bear to the lavas and the ejected masses of a genuine volcano; or where do we observe from them the same evolution of aeriform fluids, and of streams of melted materials which are so characteristic of the latter?"

4. The fermentation of pyrites and the combustion of sulphur and bitumen and coal, do, without doubt produce certain effects, and sometimes those that are considerable; still these causes are totally inadequate to account for the prodigious extent, inconceivable energy, indefinite continuance, and successive reproduction, of volcanic phenomena.

It is plainly impossible, that such results should take their origin from a few comparatively trifling beds of common combustibles, and we must obviously seek for other causes more extensive and more powerful; and which are not limited in their range, their energy, or their capability of reproduction.

5. Gay Lussac urged, with much force, against the theory of burning combustibles being the cause of volcanic action, that the atmosphere cannot possibly penetrate to those seats of volcanic power, when there is brought into action a pressure capable of raising a column of melted lava, three times as heavy as water, to the elevation of one mile or several miles. The objection seems unanswerable, as far as the atmosphere is concerned:

although we may suppose, that the combustion is sustained by water, provided there are combustibles capable of decomposing that fluid, which would not be the fact, with either of the combustibles named, except coal, and that only at the temperature of intense ignition, which must not only be produced, but must also be sustained in some other way, as the affusion of water upon ignited coal, unless there is also a copious supply of air, soon puts an end to the combustion.

Earthquakes, &c.

"Some are unwilling to admit earthquakes, as any probable indication of subterranean fire, whilst others not only include them, but go so far as to class hot springs, gaseous exhalations, and the eruptions of mud and petroleum amongst volcanic phenomena."

Do earthquakes and volcanos depend upon the same cause? On this point, we conceive, that there can scarcely be any ground for hesitation.

Volcanic eruptions are invariably preceded, and accompanied by earthquakes, and when the volcano discharges its contents, the earthquakes immediately relent, and ultimately cease. It is plain, therefore, that those causes which produce volcanos do also produce earthquakes. But, it will be asked may not earthquakes be produced by other causes? To this inquiry we must answer, that we know not of any other causes that are sufficient to produce earthquakes, except those which modern science has assigned as the causes of volcanos, and, as these are, agreeably to the Newtonian rule, "*both true and sufficient*," we are bound to admit them, at least till other and more probable causes can be suggested.

"When we observe two volcanic districts, both subject to earthquakes, which are ascertained to have a connexion with the volcanic action going on, and find that an intermediate country, in which there are no traces of the operation of fire, is agitated by subterraneous convulsions, similar in kind, but stronger in degree than those which occur in the more immediate vicinity of the

volcanos; have we not reason to conclude, that the same action extends throughout the whole of the above space, and that it is *this* which produces in the intermediate country the effects alluded to, which are only the more alarming from the absence of any natural outlet, from which elastic vapours might escape?

"Now in proof of the former of these positions, it may be scarcely necessary to do more than appeal to the case of Etna or Vesuvius, which rarely return to a state of activity, after a long interval of comparative quiescence, without some antecedent earthquake, which ceases so soon as the mountain has established for itself a vent.* Such was the case before the celebrated eruption of 79 in Campania, and in that of Etna in 1537, where, says Fazzello, noises were heard, and shocks experienced, over the most distant parts of Sicily. In such cases no one would doubt the connexion between the volcano and the earthquake."

Teneriffe, furnished with the volcanic vent of Teyde, enjoys comparative immunity, while the neighboring islands are dreadfully agitated. If it be objected, that earthquakes are too exten-

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* Humboldt gives us the following series of phenomena, which presented themselves on the American Hemisphere between the years 1796 and 97, as well as between 1811 and 1812.

1796.—September 27. Eruption in the West India Islands; volcano of Guadaloupe in activity.
———November——The volcano of Pasto begins to emit smoke.
———December 14. Destruction of Cumana by earthquake.
1797.—February 4. Destruction of Riobamba by earthquake.
1811.—January 30. Appearance of Sabrina Island in the Azores. It increases particularly on the 15th of June.
———May———Begining of the earthquakes in the Island of St. Vincent, which lasted till May, 1812.
———December 16. Beginning of the commotions in the valley of the Mississippi and Ohio, which lasted till 1813.
———December—Earthquake at Caraccas.
1812.—March 26. Destruction of Caraccas; earthquakes which continued till 1813
———April 30. Eruption of the volcano in St. Vincent's; and the same day subterranean noises at Caraccas, and on the banks of the Apure.

See also Gemellaro on the Meteorological Phenomena of Mount Etna, extracted in the London Journal of Science, Vol. XIV, 1813.

sive to have their effects attributed to the same cause with volcanos, we may reply, that volcanic movements generally accompany or succeed them, although it may be in remote countries, and the earthquakes of one country are often connected with those of another.

To account for the extent to which the vibration of the solid substance of the earth will communicate both shocks and sounds, Mons. Gay Lussac ("Annales de Chimie," &c. Tome xxii, page 429,) remarks, that a vibration of the earth is similar to that of the air; that it is a powerful undulation, produced in the mass of the earth, by some commotion, and that it is propagated, with the same celerity as sound. If we are surprised at the immense extent, to which the shock, the sound, and the ravages of an earthquake are perceived, we may be instructed by considering, that the shock produced by the head of a pin, at one end of a long beam, is distinctly perceived at the other, in consequence of a vibration of all its parts. The movement of a carriage upon the pavements shakes vast buildings, and is communicated through great masses of matter, as in the deep quarries under Paris. M. Gay Lussac inquires, therefore, whether it is astonishing, that a violent commotion, in the bowels of the earth, should cause it to tremble through a radius of many hundred leagues. This philosopher concludes, that earthquakes are the result of the communication of a commotion through the mass of the earth, so independent of subterranean caverns, (which some have supposed favorable to the propagation of the sound and motion) that these effects will be propagated the more extensively, the more homogeneous the materials of the earth are.

Our knowledge of elastic agents justifies us in concluding, that steam and gases, in a word, aeriform agents, as the immediate moving power, are the causes of volcanic eruptions, and of earthquakes. When evolved rapidly and suddenly,—that is, in very great quantities, in a given short time, and endowed by heat with great elastic power, they have, without doubt, sufficient energy to rend mountains, to raise floods of fiery lava—to project stones to great heights in the atmosphere—to rock alpine ridges, on their foundations, to heave the ocean into unwonted undulations

—to shake continents, and the solid globe itself, to its very centre. The effects of gunpowder, of fulminating preparations, and of imprisoned steam, when suddenly liberated, (now so familiar to mankind,) fully justify us in attributing to elastic agents, all that we have done in this statement.

This subject has been fully illustrated by Mr. Scrope, in his Considerations on Volcanos.*

Most hot springs have their origin from volcanic action.—Many that are not connected with active volcanic regions arise from basaltic rocks, and their composition is observed to be similar to that of the waters of volcanic districts, especially in their containing soda or the mineral alkali. It is possible that some hot springs—as, for instance, those of Bath and Bristol, may be derived from the fermentation of pyrites, or from other chemical agencies, generating heat, and that the permanency of the temperature may arise from the great depth, at which the chemical action, giving origin to the heat is sustained.

There can be no doubt that Water is a great agent in producing Volcanos.

Mons. Arago enumerates one hundred and sixty-three active volcanos, nearly all of which are situated near to the sea, "in islands and maritime tracts."

The apparent exceptions are few, and generally when examined, they will not prove to be real.

If there are, as is stated, but not fully confirmed, one or two volcanos in the centre of Tartary, they may communicate with the lakes of that country, some of which are saline.

Jorullo, in Mexico, is one hundred and twenty miles from the ocean—but Colima, on the Pacific, and Tuxtla on the Atlantic, may be regarded as the wings of a vast subterranean gallery, by which the waters of either ocean, may, ultimately, communicate with Jorullo, and we may presume, that a similar state of things exists with respect to the various mountain groups of Guatimala, Colombia and Chili.

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* See Am. Jour. Vol. XIII, page 108.

It does not appear to us important to insist, that the communication supposed, should, in every case, be with salt water. It is true, that muriate of soda is frequently sublimed in volcanos, and we may generally attribute this to the proximity of, or at least to a communication with the sea. But those great effects, for which water is necessary in volcanos, depend, not upon the foreign ingredients it may chance to contain, but upon its action in its own proper character, either fluid or aeriform, and upon the agency of its elements. It would, therefore in our view, not operate, seriously, against the reasoning founded upon the supposed presence of water, if volcanos should break out, or be discovered in the midst of our greatest continents. We are always at liberty to suppose a communication with water, when we have so much evidence of its existence in the bowels of the earth, in caverns, and internal lakes and springs, and rivers, besides the vast stores which we see on the surface.

As to the extinct volcanos of France and other countries, as neither history nor tradition reaches to the period of their activity, although the evidence of their ancient existence is unquestionable, we may, with good reason, refer their origin, at least, to the period, when the countries in which they are situated, were *sub-marine*, or, when water existed abundantly, on the surface, in natural hollows, forming lakes and inland seas, more or less extensive.* But, it must be allowed, that water at the bottom of the ocean, existing under an enormous pressure of we know not how many miles of fluid, would be much more prone to reach the seat of igneous agency through the natural chinks and fissures, by which the earth is, more or less, intersected, and therefore, this is an additional reason to prove, that the oceanic waters are principally active in producing volcanos.

It does not however follow, that the volcano, which is fed by the waters of the ocean, must, of course, be submarine; it may break out either through the communication, by which the water

* This does not exclude the supposition, that some of these volcanos may have continued to be active after the land was uncovered, and after they had thus ceased to be sub-marine.

was admitted, or elsewhere, under the sea or the land, according to circumstances, depending upon the strength, nature, and connexions of the superincumbent strata.

Professor Daubeny founds his explanation of the causes of volcanos, upon the very interesting discovery of Sir Humphrey Davy, "that the solid constituents of our globe all contain some inflammable principle, and owe their present condition to the union of this principle with oxygen," and he thinks it by no means improbable, "that at a certain depth, beneath the surface, at which atmospheric air is either wholly or partially excluded, those substances may still exist in their pure unoxidized state."

As they do not and cannot exist, at the surface of the ground, no analogous phenomena can happen under our observation, and we are, therefore, at liberty to reason strictly with reference to the known action of the subtances in question.

Water having access to them, would be decomposed, great heat would be generated, sufficient to melt the rocks and the stony matter, formed by the oxidizement of the metalloids; immense quantities of gas and of steam would be thus evolved, and all the mechanical effects so familiar in volcanic eruptions and earthquakes, would occur.

The composition of the lava of Catania, near Etna, as ascertained by Dr. Kennedy, is,		That of Santa Vennera, Piedmont, west of Etna, is,
Silex,	51.	50.75
Alumina,	19.	18.5
Lime,	9.5	10.
Ox. Iron,	14.5	14.25
Soda,	4.	4.
Muriatic Acid,	1.	1.

Prof. Daubeny has reviewed the structure and mineralogical and chemical composition of the volcanic masses, in order to shew the correspondence of facts, with the theoretical views which he has adopted, and it must be allowed, that he has so far made out his case, that there appears to be nothing connected with volcanos, which is materially at variance with the supposition of their origin from metalloids, acted on by water.

There is good evidence that "volcanos have universally broken out amongst the older formations, or those most near to the nucleus, whatever it may be, of the globe." The lavas themselves appear to be the materials of primitive rocks altered by fire, and the accidentally imbedded fragments are portions of primitive rocks. It seems to be irresistibly inferred, that the seat of volcanic action is deep, because the immense masses ejected from such mountains as Vesuvius and Etna do not exhaust them—because the materials are raised to a vast height, as at Teneriffe and Cotopaxi, and because the mountains are not often shattered by the tremendous explosions, which would blow up any superficial strata into the air.

Conclusion.—Theory of Volcanos.

In concluding this account of volcanic phenomena, and of their possible and probable causes, we may be permitted to observe—

That the act of creative energy, admitted alike by religion and philosophy, necessarily implies the production of all the elements of which our physical universe is composed. How far these elements were originally united in binary, ternary, or still more complex combinations, we cannot possibly know. The revelation of this fact, not being necessary to our moral direction, has been withheld by the Creator, and we know only—that "In the beginning God created the heavens and the earth." As to the actual condition of the elements, at that primeval period, science may fairly enquire, and is justified in reasoning within the limits prescribed by our moral condition and intellectual powers.

In the present state of chemical science, our elementary bodies are divided, very nearly, between the two classes, combustibles and metals, which really form but one class—and those agents, which from their acting with peculiar energy upon the combustibles and metals, and altering their properties, are called by some, supporters of combustion;—they are oxygen and chlorine. and some add iodine.*

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* There seems to be no reason for mentioning the imaginary body called fluorine.

If we extend the idea of combustion, as several authors are disposed to do, to other cases of intense chemical action, especially if attended with the extrication of light and heat, we shall include the agency of the combustibles and metals upon each other, as well as upon the proper supporters of combustion. For our present purpose, it is quite immaterial which view is embraced.

If we suppose that the first condition of the created elements of our planet, was in a state of freedom; the globe being a mass of uncombined combustibles and metals, and that the waters, the atmosphere and chlorine, and iodine and perhaps hydrogen were suddenly added; it will be obvious, from what we know of the properties of these elements, that the reaction, awakening energies before dormant, would produce a general and intense ignition, and a combustion of the whole surface of the planet. Potassium, sodium and phosphorous would first blaze, and would immediately communicate the heat necessary to bring on the action betweer. the other metals and combustibles, in relation to the oxygen and chlorine, and in relation to each other. Thus a general conflagration would be the very first step in chemical action.

In this manner might be formed the fixed alkalies, the earths and stones and rocks,—the metallic oxides properly so called—the sulphurets and phosphurets of the metals—the carburet of iron—the acids, including the muriatic, and ultimately the salts, and chlorides, alkaline, earthy and metallic, and many other compounds resulting either from a primary or secondary action.

In such circumstances, there would also be great commotion —steam, vapors and gases would be suddenly evolved in vast quantities, and with explosive violence; the imponderable agents, heat, light, electricity, and magnetism, and attraction, in various forms, would be active in an inconceivable degree, and the recently oxidated crust of the earth would be torn with violence. producing fissures and caverns, dislocations and contortions, and obliquity of strata; and it would every where bear marks of an energy then general, but now only local, and occasional. It is

however obvious, that this intense action would set bounds to itself; and that the chemical combinations would cease, when the crust of incombustible matter thus formed, had become sufficiently thick and firm, to protect the metals and combustibles, beneath, from the water and the air, and other active agents.

As we are not now giving a theory of the earth, but merely stating the conditions of a problem, we forbear to descant upon many obvious collateral topics, or to pursue the primitive rock formations, through the vicissitudes which might have attended them. We do not even say, that we believe that such events as we have endeavored to describe, did actually happen; we say only that their existence is consistent with the known properties of the chemical elements, and with the physical laws of our planet. Supposing that such was the actual progress of things, it is obvious that the oxidated crust of the globe, would still cover a nucleus consisting of metallic and inflammable matter. Of course, whenever air and water, or saline and acid fluids, might chance to penetrate to this internal magazine, the same violent action which we have already supposed to have happened upon the surface, would recur. and the confinement and pressure of the incumbent strata, increasing the effects a thousand fold, would necessarily produce the phenomena of earthquakes and volcanos.

Still, it is equally obvious, that every recurrence of such events, must oxidize the earth deeper and deeper, and if the point should ever be attained, when water or air ceased to reach the inflammable nucleus, or the nucleus were all oxidized, the phenomena must cease, and every approximation towards this point would render them less frequent.

Does this correspond with the actual history of these events? Are they now less frequent, than in the early ages of our planet! The extensive regions, occupied by rocks of acknowledged igneous origin, but where fire is not now active, would seem to favor this idea, but the answer to this question must depend so much upon the theoretical views entertained of the formation of granite, and of the other primitive rocks, that it may be impossible, at present, to bring it to a decision.

Whatever we may think of the hypothesis now detailed, may we not suppose, with sufficient probability, that those Voltaic powers which we *know* to exist—whose action we can command, and whose effects, having been first observed within the memory of the present generation, now fill us with astonishment, are constantly active in producing the phenomena of earthquakes and volcanos.

Arrangements of metals and fluids are the common means by which we evolve this wonderful power, in our laboratories; and it would seem that nothing more than juxta position, in a certain order, is necessary to the effect. Even substances apparently dry and inert, with respect to each other, will produce a permanent, and in proportion to the means employed, a powerful effect; as in the columns of De Luc and Zamboni. It would seem indeed, that metals and fluids are not *necessary* to the effect. Arrangements of almost any substances that are of different natures, will cause the evolution of this power. Whoever has witnessed the overwhelming brilliancy and intense energy of the great galvanic combinations, especially of the deflagrator of Dr. Hare, and considers how very trifling, in extent, are our largest combinations of apparatus, compared with those natural arrangements of earths, salts, metals and fluids, which we know to exist in the earth, in circumstances similar to those, which, in our laboratories, are effectual in causing this power to appear, will not be slow to believe, that it may be in the earth, perpetually evolved and perpetually renewed; and now mitigated, suppressed or revived, according to circumstances influencing the particular state of things at particular places.

In our laboratories, we see emanating from this source, intense light, irresistible heat, magnetism in great energy, and above all, a decomposing power, which commands equally all the elements and the proximate principles in all their combinations.

Sir Humphrey Davy, after discovering that the supporters of combustion and the acids, were all evolved at the positive pole, and the combustibles and metals, and their oxidated products, at the negative—proved, that even the firmest rocks and stones could not resist this power, their immediate principles and ele-

ments being separated by its energy. The decomposition of the alkalies, earths, and other metallic oxides being a direct and now familiar effect of Voltaic energy—their metals being set at liberty, and being combustible both in air and water—elastic agents produced by this power, and rarefied by heat, being also attendant on these decompositions, it would seem that the first principles are fully established by experiment, and that nothing is hypothetical, but the application to the phenomena of earthquakes and volcanos.

It appears an important recommendation of the present view, that causes are here provided which admit of indefinite continuance, and of unlimited renovation. There appears no reason why, on the whole, the phenomena should cease, as long as the earth exists. It has therefore the great Newtonian requisites of a good theory; *its principles are true*, and *it is sufficient*.

It has this additional advantage—it embraces all that is possible in former theories. Coal, lignite, sulphur and petroleum, and fermenting pyrites, will all conspire with the great operations, at which we have so briefly hinted. Burnt substances will return again to their combustible condition, and combustibles will burn anew, in unlimited succession. Heat, light, electricity, magnetism, decompositions and recompositions without limit and without number,—the evolution of elastic fluids in boundless quantities, and all the violent mechanical effects, which their action is known to produce; these are among the known and familiar effects of this power, and all the materials, necessary to render it active, are existing in the earth, on a scale of immense extent. These suggestions might be fortified by many particulars. At present they are thrown out, as leading, although not entirely original thoughts.*

* The present hypothesis does not exclude the subsequent action of water, in dissolving chemically, or disintegrating mechanically, the crust of the globe. If that which is described in the text, were the first state of the planet as it came from the hand of the Creator, the next step, as we certainly know, was to surround it with water; and then, water, fire, and all the great chemical agents cooperating; all that has been detailed in the preceding sketch would seem to follow, as a natural consequence.

SUMMARY.

1. *In the beginning, God created the heavens and the earth,* and established the physical laws,* by which the material world was to be governed.

2. The earliest condition of the surface of our planet, of which we have any *certain knowledge,*† was that of a dark abyss of waters, of unknown depth and continuance.

3. The structure of the crust of the planet affords decisive evidence of a series of events, in relation both to the formation of rocks, and to the creation and succession of organized bodies of which many of them contain such astonishing quantities.

4. Time, and order of time; event; succession and revolution are plainly recorded in the earth; and no history or tradition contradicts the supposition, that the events involved both time and order of time.

5. Geology cannot decide on the amount of time, but concludes that there was enough to cover all the events connected with the formation of the mineral masses, and with a great many generations of living beings, whose remains are found preserved in the strata.

6. The deepest rocks—the foundations upon which the others repose—being mainly crystaline, bearing marks of a chemical origin, and being destitute of fragments, and of organized remains, are regarded as the oldest, and are called primitive.

7. The rocks, called transition, are partly chemical and crystaline, and partly mechanical, and include remains of plants‡ and

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* Beautifully styled in sacred writ, "the ordinances of heaven."

† We do not *exclude* the *hypothesis* of an original action of fire; it is not material to decide whether the *very* first agency, was igneous or aqueous; it seems certain, that they were, very early, coexistent.

‡ Wood and terrestrial plants are found in most rocks, from the old red sandstone upwards, and in fact, in the order of rocks immediately beneath, *i. e,* the transition; proving that dry land must have existed, more or less, previous to, or at the time of the formation of most of these rocks. We may suppose, therefore, that ponds, lakes and rivers, existed also.—*De La Beche's View.*

marine animals,* and fragments of the primitive rocks upon which they lie.

8. The rocks, called secondary, include also chemical deposits, but less numerous and distinct, and their character is progressively more and more mechanical.

9. They contain numerous remains of plants and animals, in an entombed, and generally in a mineralized condition.

10. The organized deposits of the transition and secondary formations, belong to the primitive ocean, and prove that rocks were forming, by mineral laws, at the same time, that plants and animals were called into being, lived and died, and many of them were enclosed in the concreting rocks.

11. The existence of a universal primitive ocean is certain, and it was without a shore, till its diminution uncovered the tops of the highest mountains, and successively the lower elevations, and finally, such of the plains and valleys as were then formed.

12. Its retreat was gradual, and proceeded in such a manner as to be consistent with the due arrangement of the earth's crust and surface, and with the progressive creation, life, death and sepulture, of animals and plants.

13. Near the period of the earliest transition rocks, we find the beginning of the anthracite coal—perhaps a mineral creation—but, being associated with distinct impressions and remains of vegetables, and containing even fibrous charcoal,† we cannot deny an intimate connexion between the anthracite and the commencement of vegetable life.

14. The earlier animals are referred to a period not remote from this, and the transition and earlier secondary rocks contain abundance of encrinites, madrepores, molluscous shell fish, trilobites, orthoceræ, and other races, chiefly (as far as we know) extinct.‡

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*The terebratulæ have continued nearly without interruption, from the transition limestone, to the present time.—*De La Beche.*

† Which abounds in the anthracite of Pennsylvania.

‡ It cannot be expected, that every minor division of a formation should contain its peculiar fossil, which shall, at the same time, be characteristic of it, at great distan-

15. The earlier fragmentary rocks, make their appearance soon after the primitive, indicating, that mechanical causes—sometimes violent—were producing their effects.

16. It would appear, from the relics of the periods immediately succeeding, that vegetation had increased prodigiously upon the earth, and that there were even trees and forests upon those parts of the surface, that had become sufficiently dry.

17. Bituminous coal, belonging to the era of the earlier secondary, seems now to have been formed, as there is great reason to believe, from submerged and inhumed wood, and other vegetables, whose vestiges are so numerous in the coal mines.

18. Coal, being peculiarly limited in its local relations, and often contained in basins, it seems probable, that it generally arose from local circumstances, with all its alternating and attendant strata of shales, sandstones, limestones, clays, iron ores, pudding-stones, &c.; and, as these depositions are often repeated several times, in the same coal basin, and the mines are occasionally worked to a great depth, (even to twelve hundred feet, in some places in England) it is plain that no sudden and transient event, like the deluge, could have produced such deposits, although it might bury wood and trees, which, in the course of time, might approximate to the condition of lignite or bituminized, or partially mineralized wood, which is often found under circumstances, indicating a diluvial origin.

19. We find, in the strata of this period, not only great abundance of shells, (bivalves, univalves, &c.;) but in the later, and sometimes in the middle secondary strata, oviparous animals, including several gigantic species of crocodiles* and other saurian amphibia.

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ces;—the general resemblance of the organic remains, contained in the more recent rocks, is a better guide than any fossils, supposed to be characteristic; though the latter become more valuable, as we descend in the series; the older rocks being much more uniform in their fossil contents, in parts of the world, far distant from each other, than the more modern.—*De La Beche's View.*

*The crocodile has been continued, perhaps, from the new red sandstone—certainly from the lias to the present time—and, as its remains often occur in the interval, the crocodile appears to have been a tolerably constant inhabitant of our globe.

20. In the secondary strata, above the bituminous coal,* we find perfect fish. Nothing can be finer in this way, than the ichthyolites, found in the lias limestone of England, and in the calcareous marl of Mount Bolca, near Verona, in which place, there are stated to be one hundred and five species.† They are numerous, at Beyroot, in Palestine,‡ at Sunderland, (Mass.) on Connecticut river, and in many other places.

21. Birds are very rare in the fossil state. Their habits would expose them, very little, to those accidents, by which the other organized beings were so abundantly inhumed, for even aquatic birds, have their nests on shore.

It is, however, remarkable, that in the recent secondary, and the tertiary, we first find remains of birds; they come in, in the strata, at the time when, we may presume, that the state of the planet admitted of their existence.

22. The loose materials, that cover the rocks, more or less, in every country, are attributable chiefly to the wearing effects of agents, operating, *in all time*, to produce disintegration and decomposition.

23. The primitive ocean appears to have had a greater agency than any other cause, in producing and rounding the bowlder stones and pebbles, and fragmentary materials, whether consolidated or loose; but the diluvial ocean, and the present ocean

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since its first appearance on the surface. The fossil crocodile appears to have been an inhabitant of fresh water, and of rivers, as at present. In the West Indies, the crocodiles frequent muddy, and sometimes brackish ponds, and in shallow water, they often remain for hours, with the tips of their noses out of water. The organization and habits of crocodiles, do not enable them to contend with the agitations of the sea, which they shun. It would seem, however, that the organization of the ichthyosaurus would enable him to swim in the waves.—*De La Beche's View.*

* Fragments of fish are stated to be found even in earlier strata.—*De La Beche's View.*

† Thirty-nine species are said to come from the Asiatic seas, three from the African, eighteen from South America, and eleven from North America—but in this distribution, imagination may have had a share, the resemblance being, perhaps, generic, rather than specific.

‡ Am. Jour. Vol. X. pa. 28.

and seas, and waters, of every kind, including lakes, rivers, and rain and snow floods, and currents, operate in the same manner, and in the direct and combined proportion of time and energy of movement.

24. The actual disposition and arrangement of the loose materials, as we now see them, is to be attributed, chiefly, to the diluvial ocean—no other cause being capable of reaching the regions remote from, and elevated above the present great waters of the globe.

25. The arrangement of the loose materials, on shores, and in outlets, and in regions occasionally flooded, is, at least to some depth, and to some extent, to be referred to agencies now in operation.

26. Some materials are undergoing consolidation, in the progress of the present times; but, the masses thus produced, are limited and accidental, and are easily known by their loose and porous character, and *generally* by their want of firmness. They belong, for the greater part, to the tufas—the fragments and accidentals aggregates, being often cemented by infiltration of carbonate of lime, oxide of iron, or other substances; there is no difficulty in distinguishing them from the early formations.

27. Volcanic deposits obey no law; they are found wherever subterranean fire has accumulated sufficient power, to force a passage through the incumbent masses, and the lava, in fusion and ignition, flows over every thing, and in every direction, *qua data porta*.

28. The trap rocks and many of the porphyries, and the extensive deposits of ancient trachytic rocks, have the same accidental position, and occasionally cover any thing, and every thing, from granite to coal, and clay, and gravel, but appear to have abounded most in the earlier periods.

29. The analogies which favor the opinion of their igneous, but principally sub-marine* and often subterraneous origin, are numerous and strong, and the admission of this fact, militates in no degree, against the prevalence and peculiar effects of the primitive ocean.

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* Chiefly under the ancient ocean.

30. In the like manner, any rock, for whose ignigenous origin, derived from an examination of its character, contents and position, there appears sufficient evidence, may be referred to that cause, in perfect consistency with the early and indispensable dominion of water.

31. Thus the two great theories, that have so long divided geologists, may be made to harmonize, and nothing more remains than the perhaps superfluous task of settling the balance of power between them, and their auxiliaries, namely, pressure and the other modes of mechanical action, and the agency of the imponderable elements, which are closely connected with heat.

32. It is not necessary even to exclude the supposition that ignition and fusion may have preceded the period when the primitive ocean brooded over the planet, and as there is incontrovertible evidence of the ancient, as well as continued and present prevalence of internal fire, it is clearly *possible*, that it might have been in operation, as early as there were any materials upon which it could act.* It seems therefore a matter of little importance, whether the fire was kindled before or after water was poured round the globe. It is certain that they have maintained their separate dominion ever since, although with occasional coalition, and with great vibrations in the balance of power.

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It would appear from a notice in the public journals, that Professor Leslie considers it as certain, that the density of bodies increases as we descend below the surface of the earth, that air at the depth of thirty-three miles and three fourths, would have the density of water, and the density of quicksilver at one hundred and ninety-seven miles, that marble would have its density doubled at two hundred and eigthy seven miles, &c.

It is inferred that if the globe were solid, that its density would far exceed that of 5. and therefore, it is supposed that the earth must be hollow or cavernous.

The application of these opinions to some of the views which have been presented in the preceding sketch is obvious; they pro-

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* See the theory of volcanos in this sketch, page 98.

vide for the high specific gravity of the earth, not only in consistency with the existence of caverns; but caverns (a vast cavern,) are necessary to the theory. The learned author, as is stated, imagines that these caverns are filled with "*concentrated light*, which when embodied, constitutes elemental heat or fire," and the elasticity of this light is supposed to prevent the collapse of the walls of the cavity. On the latter very extraordinary suggestion, not having seen the author's own statement, we offer no opinion.

Conclusion.

It will be seen, that the only point in which the view, presented in the preceding sketch, differs from the common understanding of the Mosaic account of the creation is, not in the order of the events, but in the amount of time, which they are supposed to have occupied before the creation of man; every thing since that event, being understood according to the received chronology. In the prefatory remarks I have expressed the opinion, that there is no real inconsistency between the Mosaic history, and the actual structure of the earth. As I understand the account there is not, but, on the present occasion, I shall not enter upon the discussion of that part of the subject; believing that the period is not distant, when Geology will be admitted into the train of her elder sister Astronomy, and that both, however regarded while they were imperfectly understood, will be eventually hailed, as friends and allies of revealed religion.

REMARK.

In giving the limits of the Tertiary, it should have been stated, that it is always newer than the chalk and in England and France, lies upon it.

☞ The "author" referred to without name, in the preceding pages, is Mr. Bakewell, to the 3d Edition of whose Geology this "outline" was added as an appendix.

NOTE.—CORRECTION, p. 56.

The Megalosaurus is found in limestones and sandstones lying higher than the lias, and the ichthyosaurus and plesiosaurus are found also in many of the strata above, and in some of those below the lias.—*Comparison with De La Beche's View.*

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