OUTLINES

OF

GEOLOGY:

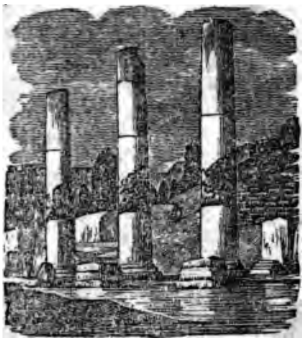
INTENDED AS A POPULAR TREATISE ON THE

MOST INTERESTING PARTS OF THE SCIENCE.

TOGETHER WITH AN EXAMINATION OF THE QUESTION,

WHETHER THE DAYS OF CREATION WERE INDEFINITE PERIODS.

DESIGNED FOR THE USE OF SCHOOLS AND GENERAL READERS.



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PREFACE.

GEOLOGY is peculiarly adapted to impress the mind of the student with ideas of the wisdom and power of the Creator, and to lead him to the acknowledgment of a Great First Cause. In addition to this, it is applicable to various, and highly important practical purposes. Millions have been expended in boring for salt, in mining for coal, and in searching for metallic veins, when even a slight knowledge of the nature and geological positions of rocks, as indicated by external appearances, would have shown that such explorations would be fruitless.

In the sinking of wells, in excavations for canals, roads, and buildings, and for a great variety of other purposes connected with both civil and military engineering, a knowledge of geology is often of the highest importance to the contractor, and not less so to the contracting party.

Is it not time, then, that we should begin the study of the earth on which we live, and from which, in common with all terrene animals, we derive our subsistence? And can it be doubted, that the knowledge to be derived from this source, is fully as important to the youth of this great and unexplored country, as that pertaining to the names and sources of rivers, the extent and situation of seas, and the boundaries of nations, states, and towns, which our scholars spend so much time in committing to memory?

To supply the deficiency of books on this subject, adapted to general readers and to our higher schools, is the object of this work.

Possibly the clergy of our country, who have no time to read extensive geological works, and thus to collect the scattered facts which show the coincidence and connexion between the Scriptures and geology, may find this little volume an acceptable assistance. At the present day, when infidelity looks almost exclusively among the higher departments of science for aid, ought not theologians, at least, to understand the ground of such hopes, in order to make good their own defence? An experienced soldier always looks well to the strength of his outposts.

With respect to the matter of the following treatise, it is perhaps sufficient to say, that almost every recent systematic geological writer in the English language, as well as many periodical publications, have been consulted. The plan has been to treat of the most interesting and important parts of the science, as a whole, and hence particular notices on American geology have been omitted, only in conformity to this design.

To those acquainted with the present state of geology, it hardly need be said, that to have prepared a volume which should embrace and unite the opinions of even the most recent and respectable authors on many subjects contained within its outlines, would have been impossible: and to those who are not acquainted with this science, it may be proper to state, that from the very nature of many of its subjects, there must always exist a variety of theories to account for the same facts, until more is known concerning them. This arises from the circumstance, that the causes of many phenomena which the earth exhibits, have long since ceased, and therefore these causes must remain matters of conjecture. Thus coal is found in the earth in great abundance, but none is formed at the present day, and therefore the causes which have produced this substance, or at least the circumstances under which it was formed, remain a subject of theory.

In other instances, the causes still exist, but their effects only are apparent, as in the case of volcanoes and earthquakes.

In these instances, the leading facts are admitted by all, but men have chosen to account for them in different ways, and thus different theories have been proposed, to solve the same phenomena.

Again, in many things connected with the natural history of the earth, the chief circumstance in question may rest on a variety of collateral facts, of the bearing of which geologists differ in opinion. Thus fossil plants, belonging to orders which at present only grow in tropical climates, and the remains of animals whose species are now found only in the hottest regions of the earth, occur in many parts of Europe, and even in frozen Siberia. Hence some have supposed that the climate of Europe has changed since the deposition of these remains, and that the plants grew, and the animals lived, where their relics are now found: while others, reasoning from what they consider conflicting facts, maintain that no change of climate has taken place, and that the main circumstance may be accounted for, by supposing that these remains were transported from hot climates.

At the present day, geological writers profess to maintain their theories only by facts, and fair deductions from them, and thus investigations are constantly going on, and new facts are perpetually accumulating, so that ultimately it may be expected that this science will consist of deductions from truths which are generally admitted. But in its progress towards such a state, hypothetical reasonings, under the restrictions which the present advanced state of the sciences impose, are not to be deprecated, since this is often almost the only means by which men are stimulated to that thorough investigation of facts and phenomena, which characterizes the practical geologists of the present day.

It must not, however, be understood, that geology consists chiefly of the conflicting opinions of different authorities. On the contrary, though of so recent an origin, it already embraces numerous series of highly interesting, curious, and instructive facts, many of which seem destined to be of great importance to mankind; while others are calculated to excite profound considerations.

An examination of the earth shows that its crust has undergone great, and sometimes repeated mutations. The strata which once corresponded, are now completely dislocated, one portion being thrown up, broken, and distorted, while the other is depressed, and equally mutilated; the whole indicating the effects of an enormous force acting from beneath, and at an unknown depth.

Every part of the earth, except the most recent deposites, present similar phenomena, more or less striking, and in this manner the original disposition and direction of all ancient stratified rocks have become changed. In some instances, the changes have been so great, as to repeat the original number of strata many times. In one locality, this effect has been such as to produce from 30 to 40,000 strata, where the original number was only four.

We shall find that these dislocations are marks of wisdom and beneficence, as well as of power; and that this earth would have been but poorly fitted for the residence and comfort of man, had these strata remained in a horizontal position.

The organic remains of plants and animals, the relics of a former world, are not only objects of great curiosity, but afford to the mind subjects of the deepest contemplation. Here we have before us the remains of vegetables and animals which covered and inhabited the earth thousands of years ago; and some of them are so unlike any existing species, that no living analogues are anywhere to be found.

Other remains prove that monstrous reptiles, sixty or seventy feet in length, once crawled among canes and rushes, which emulated in height the forests of the present day; while huge quadrupeds, of unknown tribes, inhabited the higher grounds, where they reigned lords of the creation.

Probably these are the remains of animals which were known to Noah and his family; and possibly some of them belonged to the identical beasts to which Adam gave names.

Thus has the earth preserved, for our examination and instruction, natural bodies of the earliest growth, and with which no works of art can compare in antiquity. Even the remains of Babylon and Egypt are infants in age, when compared with these things.

With respect to what has been advanced on the subject of the days of creation, we are aware that the opinions of several American, and some foreign geologists of high standing, are against us. But having examined several learned expositions of the original text, both for and against the admissibility of a different translation from the common one, we are fully satisfied that the word rendered *day*, connected as it is in the history of the creation, admits of no other meaning. This, if so, ought for ever to settle the question; for the *necessity*, which geology, or the Hindoo tables, or the Egyptian Zodiacs, or the strata at Etna, seem to present, ought never for a moment to be admitted in the mind of a believer, as an excuse for misinterpreting the plainly intended meaning of the Scriptures. Both the Indian tables and the Egyptian Zodiacs presented much stronger apparent proofs against the veracity of Moses, than any which geology now opposes to his literal meaning.

We have only to add on this subject, that when it can be shown, that the *roots* in philology admit of a different translation, and the *substrata* in geology require it, we will cheerfully relinquish the opinion here attempted to be maintained.

PREFACE

TO THE

SECOND EDITION.

In the preface to the former edition of this work, it was stated that the plan being to treat of the most important and interesting parts of the science, articles of American geology had been admitted only so far as might be necessary in conformity to this design. The author has, however, become convinced by the communications of Professors of Colleges, and the Principals of other institutions where the work has been introduced, that further illustrations from the geology of our own country would make the work more acceptable as a class-book; and in conformity to such hints, the present edition will be found much improved in this respect. For these notices the author is indebted to a variety of American publications, but more particularly to Professor Hitchcock's "Report on the Geology of Massachusetts," and Dr. Hildreth's Communication on the Valley of the Ohio, contained in the 59th No. of Silliman's Journal.

The article on the length of the creative days has also been particularly examined, most of it re-written, and several new objections answered. On this part of his work, the author takes pleasure in acknowledging the assistance of the Rev. S. F. Jarvis, D. D., Professor of Oriental languages and literature in Washington College. Dr. Jarvis has not only had the kindness to collate many passages of the Hebrew text with reference to the meaning of the word *yom*, but also to translate for his use the theory of Paradisi, an abstract of which he has given in this work.

Besides these additions, the author has made many others, as the subjects seemed to require, the whole amounting to nearly forty pages, with twelve new illustrations by wood cuts.

It is hoped, therefore, that this edition will be found much more worthy of public patronage than the former one.

Hartford, Ct., January, 1834.

CONTENTS.

OUTLINES OF GEOLOGY.

THE term GEOLOGY comes from the Greek *ge*, the "earth," and *logos*, "reason," or "discourse," and signifies the doctrine, or science of the Earth.

The object of Geology is to investigate the phenomena of the external and internal parts of the earth—to inquire into the modifications and changes which have taken place in the crust of the globe since its creation, and to account for these phenomena in a rational and scientific manner.

This science, though of very recent date, has already been the means of offering to the consideration of the world, most important information, both of a physical and moral nature. Many important geological facts, it is true, have been long known; but in attempting to account for them, theorists have indulged themselves, until recently, in the wildest imaginations, and the most unfounded and singular fancies.

No subject of importance has come down to the philosophers of the present age, so incumbered with false theories, false reasonings, and whimsical vagaries, as Geology.

It is true, that a few writers of early date have reasoned correctly from the facts then known, but the great mass of authors on this subject, seem to have had no other object in view, but to establish theories founded on plausibilities, without the aid of facts, or observations.

From the earliest antiquity men have been inquisitive in relation to the origin and duration of the earth, and the mutations which it has undergone already, or is likely to undergo in future times. In the absence of knowledge concerning the earth's structure, or of observations on the phenomena which its surface exhibits, it was easier to found theories, and reason for the ignorance then existing, than to undertake long excursions in order to observe facts, from which to reason correctly, and draw just conclusions.

It appears, from the remotest records of profane history, that philosophy had assigned to this earth a perpetual series of mutations, either by fire or water, or by both.

Some supposed that this fair world was occasionally, or periodically destroyed, and again renovated under a new aspect; and that a new creation of men and animals took place after every such renovation. The ancient Egyptians believed that this world was subject to occasional deluges and conflagrations, and that the gods by such awful judgments arrested the career of human wickedness, and purified the habitation of man from his own guilt. It was supposed that all the wicked were destroyed by such disasters, and that the few who escaped, were the wise, virtuous, and happy, but that their descendants gradually became wicked, and were in like manner swept away by the wrath of the gods.

Baron Humboldt states, that after the destruction of a large portion of the inhabitants of Cumana, in South America, by an earthquake, in 1766, an extraordinary fertility ensued, in consequence of the rain which had accompanied the convulsion. On this occasion, says he, the Indians celebrated, in conformity to an ancient superstition, by festivals and dancing, the destruction of the world, and the approaching epoch of its renovation.

The Egyptian priests assigned certain periods of time for the destruction and renovation of the world. According to Pritchard, in his Egyptian Mythology, the cycles, or periods of these catastrophes, were variously estimated. Orpheus supposed their duration to be 120,000 years; Cassander, 300,000 years, &c. The Greek philosophers and stoics also, believed that the Earth was liable to be afflicted by periodical catastrophes, both by flood and fire. The first, they supposed, destroyed the whole human race, and annihilated all animal and vegetable productions, and that the second dissolved the Earth itself, but that this was afterwards renovated or re-produced.

The connection between the doctrine of successive catastrophes, and repeated deteriorations in the moral character of the human race, is more intimate and natural to the minds of men than might at first be imagined. For in a rude state of society, all great calamities are regarded by the people as the immediate judgments of God on the wickedness of man. Thus, says Mr. Lyell, in our own times, the priests persuaded a large part of the population of Chili, and perhaps believed themselves, that the great earthquake of 1822, which convulsed that country was a sign of the wrath of heaven on them, for the great political revolution just then commencing in South America.

We may observe from the accounts of travellers, and voyagers among barbarous tribes in the South Sea Islands, and in India, that earthquakes are almost universally considered among these people as judgments sent by a supreme, or superior being, on the wickedness of men. In countries not subject to earthquakes, as among the Egyptians, there are still traditions, or forebodings of conflagrations, as we have already seen; and so far as is known, all nations and tribes, whether civilized or barbarous, are not without their notions, however vague, of a flood of water which destroyed at least most of the inhabitants of their own country. Were it not most probable that this idea has been handed down by tradition from the time of Noah, it would often appear as though it were an innate moral sentiment, designed by divine authority to impress all mankind with the fear of punitive justice.

This subject will come under consideration when we come to treat of the Deluge, and we will only remark further at present, that it is believed, neither the ancient philosophers, nor modern barbarians, ever entertained any idea of the final destruction of the Earth, this belief being derived exclusively from the sacred scriptures. We have seen that several ancient nations held to the doctrine of perpetual changes, consisting of the alternate destruction and renovation of the Earth. A similar doctrine is said to have been taught by the Gerbanites, a sect of astronomers who flourished before the Christian era. They believed that after every period of 36,000 years, there were produced twenty-five pair of every species of animals, male and female; and that these multiply and spread over the face of this lower world. But that when a circulation of the heavenly orbs was completed, which is finished in the above named space of time, then other species of animals are created, together with new plants and other things, *and so it goes on for ever and ever.—Oriental History.*

It is the light of revelation alone, to which we are indebted at the present day, for that knowledge and understanding which places us above a belief in the false doctrines of heathen philosophy. Civilization and experience never yet corrected the speculative philosophy, or the religious opinions of heathenism.

With respect to the knowledge which the ancients possessed of geology, nothing of importance can be said. The Greek naturalists, and the Arabian physicians and philosophers have recorded some few geological facts, and several Latin writers have noticed phenomena connected with earthquakes and volcanoes, especially the rising of islands out of the sea. But the geologist will search in vain, for any facts or speculations concerning the history of the Earth, worthy his notice, until the beginning of the 16th century; when some shells dug out of the Earth at Verona in Italy, became the subject of a controversy which may be considered as having laid the foundation of geolo gical knowledge.

These fossil, or petrified shells, were found in 1517, in consequence of some excavations which were made for the purpose of repairing some part of the city of Verona. Such remains, it is true, had long before been discovered in various places; but no persons of learning or judgment seem previously to have troubled themselves about such matters. The idea seems to have prevailed, that these were the products of what was then termed "plastic nature;" that is, that shells, and other organic remains, found in the solid earth, above the sea, were not the exuviæ of animals, but were formed in the rocks where they were discovered, and that they were nothing more than imitations of real shells and bones. This idea was probably suggested for the purpose of accounting for the appearance of shells in places where it was supposed impossible the sea should ever have been; the idea that the sea had changed its bed, or that the strata had been elevated by subterranean forces, being then entirely unknown. At present, such phenomena are readily accounted for on the hypothesis that many parts of the earth have been thrown up from the bottom of the sea by volcanic action.

The shells at Verona furnished matter for much speculation, and many writers gave their opinions concerning them, as well as of other fossils found in similar situations. Among these, one writer named Fracastoro, gave it as his settled conviction that these and other fossil shells, wherever they were found, had once belonged to living animals, and at the same time ridiculed the notion that the "plastic force" of nature ever formed them, or any other such like productions. He also maintained that these belonged to animals which grew and multiplied in the places where they were found, and that the time of their growth was before Noah's flood. All this no doubt was true; but such new and strange doctrines raised against Fracastoro many bitter opponents. His clear and philosophical views were disregarded, his ideas concerning plastic nature combatted, and the passions, as well as the arguments and learning of the times, were arrayed against him.

The questions discussed, were, *first*, whether fossil remains had ever belonged to living animals; and, *second*, if this be admitted, whether all the phenomena concerning them can be explained in consequence of the changes which took place by the waters of Noah's flood.

At this period, the idea prevailed in the christian world, that the earth had undergone no considerable changes, except those produced by the general deluge, and that, therefore, to attempt to shew that fossil remains had been elevated by any other catastrophe, would be opposing physical appearances against christian faith. The clergy, on this ground, entered warmly into this dispute, but at the same time, it appears that they allowed the subject to be canvassed with considerable freedom, though the arguments on both sides were often such as would have little effect on the mind of a geologist at the present day.

"The system of scholastic disputation" says Mr. Lyell, (speaking on this subject,) "encouraged in the universities of the middle ages, had unfortunately trained men to habits of indefinite argumentation, and they often preferred absurd and extravagant propositions, because greater skill and acuteness was required to maintain them; the end and object of such intellectual combats, being victory, and not truth."

No theory, at that period, was so whimsical as not to find advocates, and as theories of the earth were chiefly founded in opinions and conceits, rather than on facts and observations, the greatest latitude was indulged in the display of ingenuity and imagination in their support. Some of the inventions brought forward in the shape of arguments against the doctrine that shells once belonged to living animals, were indeed quite too ridiculous to have come from any source claiming to possess the power of reasoning. Thus one of the opposers of Fracastoro, by name Mattioli, professed to account satisfactorily for the facts in the case of the shells at Verona, and other such like appearances, by supposing that a certain *materia pin-*

guis, or fatty matter, set into fermentation by the heat of the earth, gave form and substance to these objects. Another author, Fallopio, of Padua, Professor, &c., conceived that petrified shells, had been generated by fermentation, in the places where they were found, and that in some cases at least, they had acquired their forms by the "*tumultuous movements of terrestrial exhalations*." Fallopio was the renowned professor of anatomy at the celebrated school of Padua, and whose name, on account of his discoveries, is seen in every book of anatomy, to this day. Yet this learned man taught his pupils, from the chair of that famous university, that certain elephant's tusks which were dug up in some part of Italy, were nothing more than *earthy concretions*. And agreeably to the same doctrines, he intimated, that in his opinion, some ancient vases which were disinterred at Rome, were natural impressions, formed by the *plastic force of nature*, and that they were not the artificial works of man. To the same school of reasoners belonged Mercati, who published a book in 1574, containing some good figures of fossil shells, preserved in the Pope's museum at Rome. In explaining these subjects, the author has no doubt that the fossils there represented, are not real shells, but mere stones, which had assumed the appearances of shells, "*through the influence of the heavenly bodies*." Olivi, a contemporary author, after much reasoning on these subjects, satisfied himself that fossil shells, bones, and such like things, were nothing more than the "*sports of nature*."

In the midst of those who entertained such fanciful notions, which indeed were characteristic of the age, there was not wanting a few, who, like Fracastoro, saw their folly and ridiculous tendency, and who dared to assert the truth on the subject of fossils. Among these was Palissy, a Frenchman, who in 1580 undertook to show that shells and bones, found in rocks, were really animal remains, and that they had been deposited there by the universal deluge, &c.

Although similar doctrines, as we have seen, had before been advanced in Italy, it appears that in France they were entirely new, for Fontenelle, who pronounced an eulogy on Palissy before the French Academy, fifty years afterwards, says, that he was the first who "dared to assert in Paris, that the remains of testacea and fish, had once belonged to marine animals."—*See Lyell*, vol. 1, p. 26.

At about this period a host of writers of various merit, arranged themselves on both sides of the question, "whether fossils were real organic substances; and if so, how they came in the places where they are found?" and other such like subjects. The consequence was, that these writers began to investigate facts in proof of their theories, and from this period may be dated the commencement and dissemination of just opinions on the subject of geology. At this time, Steno, a Dane of considerable reputation, demonstrated that some fossil teeth found in Tuscany, were those of a species of shark still living in the Mediterranean. Steno's work "On Gems, Crystals, and organic Petrifactions inclosed in solid Rocks," was published in 1669. He also maintained that fossil vegetables had been living plants,* and hinted that these remains might indicate the distinction between marine and river deposites.

Steno, as well as some other writers on these subjects, although anxious to make their doctrines and statements agree with the Mosaic history, alarmed the clergy by their deductions, and hence many theologians again entered the field of controversy. The points which these reverend men were chiefly desirous of protecting from the intrusion of philosophy and physics, were, as before, the Mosaic history, especially that of the Deluge; and knowing little of geology, they accounted those as nearly confirmed heretics, who could not ascribe all marine organic remains found in rocks, to the effects of the flood. We shall see that the Mosaic history is, however, not contradicted by supposing the shells in solid strata were deposited long before that catastrophe occurred.

In the mean time, among popular writers, the old doctrine that petrified shells had never belonged to real animals, still maintained its ground. Even so late as 1677, the famous Dr. Plott, in his "Natural History of Oxfordshire," attributes the origin of fossil shells and fishes to "a plastic virtue latent in the earth."

Our limits will not allow us to enlarge on this curious subject, and to detail the different opinions which were of-

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* Fossil strictly signifies any thing dug out of the earth, but in geology this term is restricted to organic bodies which have been petrified, or mineralized by long residence in the ground. Most fossils are supposed to be of antediluvian origin.

fered to the world by more of the early geological writers; nor is this perhaps necessary, since the specimens already given are examples of the prevailing opinions of the times. The light of truth, however, gradually followed the accumulation of facts, and the doctrine of "plastic nature" became obsolete, and ridiculous, in proportion as men reasoned on what they saw.

About this time, the celebrated Robert Hooke, a name well known in the annals of Mathematics and Natural Philosophy, published his "Discourse on Earthquakes." Hooke was at least a century before his contemporaries, on this subject, and it appears that his discourse did more to induce others to think and reason correctly on geological subjects, than all who had written before him. He ridiculed most effectually, the old notion that fossil shells were mere stones, so shaped by nature as to imitate such remains, or to use his own words, "formed for no other purpose than to play the mimic in the mineral kingdom." He maintained, also, that many species of shells might be extinct, or not now living; for it was known at that time, that several fossils had been found, of kinds not known in the living state.

At the present day, many hundred species of shells are found, which are considered extinct, no living specimens of the same having any where been discovered. But in the days of Hooke this idea was considered as improper, and even heretical, since, as was claimed, it derogated from the wisdom and power of the Creator, in as much as it was declaring a want of perpetuity in his works. But Hooke, in his defence, declared that such an opinion was not repugnant to holy writ, for the scriptures taught that there should be a final dissolution of all things, "and as when that happens, all the species will be lost, why not some become extinct at one time, and some at another."

It will be observed that the early writers of Geology admitted only the two epochs, the creation, and the deluge, as producing all the appearances which the globe exhibits. They did not estimate the effects of earthquakes, running streams, and mountain slides, which in the course of ages have undoubtedly produced very considerable changes on the earth's surface. Hence early theorists attempted to make their doctrines agree with the changes which they attributed to the flood, but which in many instances were undoubtedly to be assigned to causes now in operation. There was a prevailing timidity with respect to the conclusions to be drawn from geological facts, lest they should be brought to contradict the Mosaic history. But this apparent want of confidence in the triumph of the scriptures, was rather a desire to keep from the hands of designing men any excuse to deny the veracity of Moses; and which arose partly from want of geological knowledge, and partly from the religious character of the times.

Under such circumstances, geological theorists directed their efforts to account for the present actual appearances of the earth, by allowing it a certain form at the creation, and then ascribing the changes since made, to the Noachian deluge.

We will now present the student with a short account of several of the most celebrated early systems, or theories of the Earth; at the same time premising that although some of them are from the pens of those who ranked among the most talented men of the age, still as theories of the earth, they are devoid of any probable foundation in truth.

Burnet's Theory. This was published in 1680,* and its title is strikingly characteristic of that age. It runs thus. "The Sacred Theory of the Earth, containing an account of the original of the Earth, and of all the general changes which it has undergone, or is to undergo, till the consumation of all things."

Burnet supposed that the primeval earth, down to the time of the flood, enjoyed a perpetual spring, and accounts for this assumed fact by assuming that the plane of the ecliptic was then coincident with the earth's axis, and that the commotions during the flood turned the earth into its present position, and thus produced the vicissitudes of the seasons. He endeavours to show, that the original form of the Earth as it rose out of chaos, was so contrived, as to contain within itself the water necessary to produce the deluge. A smooth crust of earth is made to conceal the waters of the abyss from the time of the creation, but the rain on the outside, together with the expansion of the

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* Professor Brande quotes Burnet's book as being published in 1726, but this was probably a second edition.

waters beneath by heat, rent this crust, which falling down into the abyss, caused the universal flood, and at the same time, by the inequality of the fragments, formed the mountains of the earth as we now see them.

"Not satisfied with these themes, he derived from the sacred scriptures, and from heathen authorities, prophetic views of the future revolutions of the globe; gave a terrific description of the final conflagration, and proved that a new heaven, and a new earth will rise out of a second chaos, after which will follow the blessed millenium."

This was called, and is known to the present day as the "Sacred Theory," and as absurd, and utterly void of all foundation as it appears at the present time, it was received in that day with great applause. King Charles II. commanded it to be translated out of the Latin, in which it was written, into English. Addison eulogised it in Latin verses; Steele praised it in the Spectator, and Warton ranked its author among the "first for understanding, judgment, imagination and memory." These encomiums show that Burnet, though ignorant of geology, was no ordinary writer, and that it was his fine taste, and his inventive genius that caught the admiration of men, who, though judges of these qualities, knew nothing of the science about which he wrote.

Woodward's Theory. In 1695, another celebrated theory of the earth was laid before the public. It was entitled "An Essay towards a Natural History of the Earth and Terrestrial Bodies, especially Minerals; as also of the Sea, Rivers and Springs, with an account of the Universal Deluge, and of the effects it had on the Earth. By Dr. Woodward, Professor of Medicine at the University of Cambridge.

Professor Brande thinks that Woodward must be considered the first geological theorist who professed to have minutely examined the crust of the earth, and to have founded his system on the facts thus developed. He made geological tours into different parts of England, and examined strata, and collected specimens with a view to illustrate his intended work. He also appears to have been the first who drew up a series of geological enquiries, which he sent to his friends abroad for the purpose of obtaining more extensive information on these subjects.

From these circumstances it might have been expected that Woodward's views would have been more sound and enlarged than any of his predecessors or contemporaries; but it was the fashion of that day to form theories rather than to state facts, and he fell into this common error.

His theory supposes that the whole terrestrial globe fell in pieces and was dissolved by the waters of the flood, and that the strata of the earth settled down from this promiscuous mass. In corroboration of this view, he insisted that marine bodies, as shells, are lodged in the strata according to the order of gravity, the heavier shells in stone, and the lighter ones in chalk, and so of the rest. But this doctrine was immediately contradicted by the fact, that fossil bodies are often, however, mixed, the heavy with the light, in the same stratum.

Although Woodward's Theory is not founded on any grounds, even of plausibility, still his book contains many important facts, and in this respect was greatly in the advance of any of his contemporaries.

Whiston's Theory. The next famous work of this school, and equally characteristic of that period, was that of Whiston. Its title was, "A New Theory of the Earth, wherein the Creation of the World in six days, the Universal Deluge, and the General Conflagration, as laid down in the Holy Scriptures, are shewn to be perfectly agreeable to reason and philosophy." Published in 1696.

Whiston was originally a disciple of Burnet, and adopted his views, until Sir Isaac Newton showed there was no probability that the earth's axis had changed its direction, and consequently that the cause of perpetual spring before the flood, as assumed by Burnet, was without foundation, on which this part of his master's system was relinquished.

It seems to have been a principal point in all the geological theories of that day, to account for the general deluge by the action of some extraordinary natural cause. In conformity to this fashion, Whiston in the first place shows how this earth was originally a comet, which being modified, or re-modelled, was brought into its present shape. The great heat which the earth retained, owing to its igneous origin, inflamed the passions of the whole antediluvian race, so that "every imagination of the thoughts of man's heart was evil continually." The awful catastrophe which swept this wicked race, with the exception of Noah and his family, from the face of the earth, was occasioned by the train of a comet, which passing near the earth, was condensed upon it in the form of a deluge of waters.

It is hardly necessary to say that such a supposition is without a single circumstance in favor of its probability, and therefore, being entirely hypothetical, is unworthy of arguments either for or against it.

Whiston was the first who proposed that the first book of Genesis should be interpreted differently from its ordinary acceptation, so that it should not be heretical to believe that the earth had existed for an indefinite period before the creation of animals, and man. He had the art to throw an air of truth or probability over the most whimsical and improbable assumptions, and by absorbing the mind of the reader with mathematical calculations, to make him assent to propositions, which in themselves were utterly false.

Theory of Leibnitz. Leibnitz was one of the most profound mathematicians of his time. His theory was published in 1680, and is another curious specimen of imaginary cosmogony. He supposed that this globe was originally a luminous burning mass, and that from the time of the creation it had been gradually cooling. When the water which surrounded it in the form of steam, became condensed by the cooling of the earth, then the sea was formed, which at first entirely surrounded it in every part, and was of such depth as to cover the highest mountains Further consolidation of the earth by cooling, produced rents, which opening into caverns beneath the crust, admitted a part of the universal ocean, thus leaving a portion of the earth dry land, preparatory to the creation of man, and for his habitation. He imagined, also, that the temperature of the earth was continually diminishing, and that the level of the sea was constantly sinking. The first idea was considered as entirely groundless by succeeding geologists, but recently the doctrine of subterranean heat has been embraced by several respectable naturalists, and is now the prevailing foundation of the theories of earthquakes and volcanoes. The gradual sinking of the sea, is a doctrine which has had many strong advocates, and is still supposed to have been proved by various tests. But it will be seen in the progress of this volume, that facts have decided against this hypothesis.

We might occupy our whole volume with the different theories which have been proposed, to account for the present appearances of this earth, but we must close this part of our subject, by an epitome of those of Buffon, and Kepler, and with a short account of the Neptunian and Plutonian doctrines.

Buffon's Theory. This is principally an extension of that of Leibnitz. He adds another comet, which by a violent blow upon the sun, struck off the mass of which our earth is composed in a liquid state, and with the earth, all the other planets which compose our system.

From such suppositions, Buffon was enabled to assume data by which he arrived at several important conclusions. Thus by estimating the heat of the sun (the earth being originally of the same temperature) and comparing it with the present heat of the earth, it could be told (by assuming a rate of cooling) how long it had taken to cool down thus far. Then as the other planets had come from the sun at the same time with the earth, it could be calculated by the same rules how many ages is still required to cool the larger ones, so as to admit of their being inhabited, and how far the smaller ones were now frozen, so as to have destroyed all animal life.

He accounts for the spherical form of the earth and other planets from their being set in motion while in a semi-fluid state. With Leibnitz, Buffon supposed that the ocean once enveloped the whole earth, covering the highest mountains, and hence the appearance of shells far above the level of the sea. The water afterwards ran into caverns which opened into the earth, and thus the ocean subsided to its present level. Soon, after Buffon's theory was published, he received an official letter from the Faculty of Theology at Paris, dated January, 1751, stating that some of his propositions were reprehensible, and contrary to the creed of the Church. One of these propositions were as follows. "The waters of the sea have produced the mountains and valleys of the land—the waters of the Heavens reducing all to a level, will at last deliver all, over to the sea, which successively prevailing over the land, will leave dry, new Continents like those which we inhabit." The objectionable doctrine seems to have been that in the opinion of Buffon the present mountains and valleys of the earth are due to secondary causes, and that the same causes will destroy all the continents, hills, and valleys, and re-produce new ones, and so on perpetually, while the scripture doctrine warns us that there shall be an end of all created things, &c.

Buffon was invited to a conference with the Faculty in order to make an explanation, or rather a recantation of his errors. To this he submitted, and having satisfied that body of his Orthodoxy in a written instrument, called his "Declaration," he was required to publish the same in the next edition of his work. This declaration begins thus. "I declare, that I had no intention of contradicting the text of the Scriptures;—that I believe most firmly all therein related about the creation, both as to the order of time and matter of fact; and I abandon every thing in my book respecting the formation of the earth, and generally all which may be contrary to the narrative of Moses," &c.

Kepler's Theory. Kepler, one of the profoundest mathematicians and astronomers the world has ever seen, offered a theory of the earth more singular and whimsical than any of his contemporaries, or predecessors. His notions, indeed are so odd, and void of common sense, that it might be supposed he intended to ridicule his brother theorists by going beyond them in improbabilities, rather than to offer the world his sober opinions.

Kepler supposed, or pretended to suppose, that the earth contained a circulating vital fluid, and was possessed of living powers—and that a process of assimilation goes on in it as well as in other animals. Every particle of matter, according to him, is alive, and possesses volition and instinct; hence these particles attract and repel each other according to their several sympathies, or antipathies. Thus the particles of water will repel those of oil because they have an antipathy to each other, but each fluid will readily unite with another portion of the same kind because the particles possess mutual sympathies. Each kind of mineral substance is capable of converting masses of other matter into its own peculiar kind, as animals convert their aliment into blood. The burning mountains are the respiratory organs of the globe; and the slates are the organs of secretion, as the glands are those of the animal. The slates decompose the waters of the ocean, in order to prepare its elements to produce earthquakes and volcanic eruptions. The metallic veins in the strata of the earth, are caries or abscesses of the mineral kingdom, and the metals themselves are the products of decay and disease, and hence the offensive odour of some of these products.

These several theories, and a great variety of others, have been invented in order to account for the same phenomena, and to solve the same problem, viz. in what manner, or by what changes, or events, are we to account for the present appearances, or condition of the earth's surface? The reader will observe in general, that these theorists, instead of taking the trouble to observe facts and to draw just conclusions from them, have in the first place formed their systems, and supported them in the best manner they could, calling to their aid, ingenuity, plausibility, and false argument.

The science of Geology never progressed until men saw the folly of forming theories which had no concern with facts. To record facts is the first business of the geologist, and if he cannot account for them in a rational and scientific manner, to let them stand recorded until further investigations.

Plutonian and Neptunian Doctrines. We shall close this part of our volume by an abstract of the theories of Werner and Hutton, commonly entitled the Neptunian and Plutonian doctrines.

The theories of these two distinguished geologists for the last half century have divided the opinions of geological writers, each side insisting in the most positive and uncompromising terms, on the truth of their adopted cause.

The *Plutonians* or *Huttonians*, attribute most of the present appearances of the globe, and the changes it has undergone, to the agency of *fire*, not, however, entirely rejecting that of water.

The *Neptunians* or *Wernerians*, on the contrary, affect to prove in as positive terms that these same changes, and appearances may, with the exception of volcanic products, be traced entirely to the agency of *water*—"to aqueous solution, disintegration, and deposition."

There is one difficulty in attempting to expound the doctrines of Werner, which is, that we are obliged to take them second handed, from the writings of others, he having never himself published them in a connected view. In speaking therefore of Werner's theory, we can only avail ourselves of such transient glimpses as he has himself thought fit to give us, and must fill up the various chasms with materials derived from the more extended sketches and illustrations of his pupils.*

Werner's theory may be thus stated. The matter of our globe was once in a soft, or fluid state, or at least its nucleus was once enveloped by a chaotic aqueous solution of such a nature as to retain the various earthy bodies found in the lowest strata in chemical combination; but this state of things was of short duration, and during which, there was deposited from the water a variety of crystalline aggregates, such as the different species of *granite*, and what are called *primitive* slate, and primitive limestones. These constitute the primary rocks, or formations of the Wernerian school, and are supposed to have had their origin before the creation of animated beings, and hence no organic remains, such as shells, are found in these rocks. The second class of rocks are supposed to have been formed during the *transition* of the earth from its chaotic, to its habitable state, and hence are called *transition* rocks. These are partly crystalline aggregates, and partly mechanical deposites from water: they contain the fragments of pre-existing rocks cemented together, and sometimes contain imperfect remains of the lower orders of animals and plants, as shells and impressions of ferns. Certain kinds of limestone and sandstones belong to this class. These rocks are derived from the fragmentary remains and the disintegration of the primitive rocks.

The third class of rocks are supposed to have been formed by the action of the natural elements on these, and by which they have been broken down, and mechanically diffused in water. The action of frost, water, and attribution, are supposed to have chiefly produced this effect, after which the materials were deposited in horizontal strata. These are the *Floetz*, or flat rocks of Werner, and the *Tertiary*, or secondary rocks, of later authors. They abound in vegetable and animal remains, as ferns, shells, fish, and bones. The newer limestone, red sandstone, and coal strata, belong to this class.

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* Brand's outlines of geology. P. 21.

Above these rocks we find depositions of sand, and gravel, and clay; accumulations of peat, and other substances now in the progress of deposition, and which are included under the general terms *alluvial* formations. These constitute the fourth class. The fifth class contains the products of volcanoes, whether the result of fusion or not, such as rocks thrown out without melting, volcanic mud, &c.

It is supposed that all the *formations* as they are termed, or all the different kinds of rocks and strata now found on the earth, will fall under one or another of these classes. But it will be seen hereafter, that this theory is, in many respects, unsatisfactory, and that there are several rocks, such as basalt and greenstone, which certainly are not of aqueous origin, and which do not come within Werner's volcanic class.

Werner was appointed professor of mineralogy, at the school of Mines, in Saxony, 1775, and was undoubtedly a man of the highest order of talents. His mind was at once sound, imaginative, and richly stored with miscellaneous knowledge. He had a great aversion to the mechanical labor of writing, and could never be persuaded to pen more than a few brief sketches, and which never contained a connected development of his geological views. Although the natural modesty of his disposition was excessive, approaching even timidity, yet he indulged in the most bold and sweeping generalization, and he inspired all his pupils, some of which became writers of great eminence, with the most implicit faith in his doctrines.

"Their admiration," says Mr. Lyell, "of his genius, and the feelings of gratitude and friendship which they all felt for him, were not undeserved; but the supreme authority which he usurped over his contemporaries, was probably in the event prejudicial to the progress of science."

The *Plutonic*, or *Huttonian* Theory owes its origin to Dr. Hutton of Edinburgh. It was published in 1788, but has been more recently illustrated and defended in a republication by Professor Playfair, also of Edinburgh.

We have already stated that the Plutonians attributed the same phenomena to fire, which the Neptunians did to water. The Plutonians, however, supposed that most stratified rocks were deposited from water.

Hutton's Theory may be stated shortly, as follows.—The materials which compose the present surface of the globe, have been derived from the ruin of ancient rocks, which have been disintegrated and pulverized by the continued action of torrents and currents of water; and by the same means these materials have been transported to the bottom of the ocean. Here they have been consolidated, partly by time, and partly by the pressure of the water, but chiefly by the effects of subterranean heat. By the same cause, more powerfully exerted, that is, by the expansive power of volcanic heat, the strata thus formed have been elevated from the bottom of the ocean, to occupy the situations under which they now appear. Thus the strata are thrown into different degrees of inclination to the horizon; or are broken and dislocated; or appear in nearly a vertical position, depending on the degree of force, or the point of its application. Sometimes, also, where the heat has been most intense, an entire fusion of the materials has been effected. The rocks which are not stratified, or not composed of layers, as granite, are supposed to have undergone complete fusion, while those which consist of layers, as mica slate, are supposed only to have been softened by the heat. The same disintegration, and corrosion, and the same transportation to the sea, is constantly going on with respect to the present rocks, so that finally these materials will again be restored to the sea, to be again raised above its surface by volcanic fire, as before; and as the present continents were formed by the destruction of ancient rocks, so future continents will be formed in their turn, by rocks now preparing for that purpose.—*Brande's Outlines of Geology.*

It is generally acknowledged at the present day, that Hutton's theory will account for a much greater number of geological phenomena than Werner's. It is impossible, for instance, to account for the present situation of stratified rocks containing sea shells, unless we suppose, either that the sea occupied the earth for ages, or that these strata were formed under the ocean, and elevated by some mighty force; and as we know that islands are thrown up from the sea, by volcanic force, at the present day, it is reasonable to attribute the same effect to the same cause, anciently.

GENERAL FORM AND CONSTITUTION OF THE GLOBE.

Although in a popular sense the form of the earth is that of a globe, yet science has long since determined, that its figure is not that of a perfect sphere, but of an *oblate spheriod*, the diameter at the equator being greater than at the poles. This difference has been variously estimated, but if we consider the polar, to the equitorial diameter in the proportion of 304 to 305, we shall perhaps come as near the truth as the present state of observations will allow. This allows the poles a compression equal to $\frac{1}{305}$, and the two diameters as follows.

Equitorial diameter, about	- -	7,924 miles.
The Polar diameter	- - -	7,898 miles.
	Difference.	26 miles.

This estimate is from the authority of Daubuisson. Dr. Macculloch makes the difference somewhat greater, but we need not here go into comparisons on a point where no two authors agree, the difference of a few miles being a matter of no consequence to our present purpose.

This form of the earth is precisely such a one as it would have taken had it been a homogenous semi-fluid with a rapid motion round its axis. This form may be illustrated by fixing a ball of soft clay on a spindle and setting it in motion. The ball will be flattened at the poles or axis of motion, and elongated, or thrown out, at the circumference, or equator. This is obviously the consequence of the greater centrifugal force at the circumference than at the centre of motion.

Density of the Earth. It has been attempted to estimate the density of the whole earth from that of a particular mountain. For this purpose Dr. Maskelyne made an experiment on mount Schihallien, a high precipitous cliff, in order to ascertain the force of its attraction, on a suspended plummet; with the view of deducing the density of the whole earth by comparing its attraction with that of the mountain. From such data it was found that the mean density of the earth was to that of the mountain as 9 to 5; and from hence it was concluded that the interior of the globe must be composed of substances whose density was about double that of the mass of the mountain. But it was subsequently found that the specific gravity of the mountain, an item in these calculations, had been estimated too high, and by the corrections made by Mr. Playfair, the density of the earth obtained in this way was found to be only 5. That is, the whole earth, bulk for bulk, is five times the weight of water. This estimate, which is most generally received at the present day, makes it necessary to suppose that the interior of the earth is much more dense than its surface; for the heaviest rock with which we are acquainted has a density of only 3, and the lightest about 2½, while the specific gravity of the ocean is a little more than 1. The specific gravity of the earth's surface including the water, therefore, cannot be much above 2½. But the mean density of the whole earth being 5, is more than double that of its surface, and hence the interior of the earth must have a greater density than 5, to counterbalance this want of weight at the surface.

From these considerations, it has been supposed that the interior of the earth, instead of being composed of rocks, like the surface, must consist of metallic substances. It has also been shown from mathematical calculations that there is a gradual increase of density towards the centre of the earth, and hence it has been thought still more probable that its nucleus is of a metallic nature.

La Place, with this view of the earth's structure, has estimated its density at the centre. If 5, 4 be taken as its mean density and its superficial densities be assumed as 3, 13; 3, 2; 2, 79; and 2, 60, then on the theory of the compressibility, the density at the centre will be 13, 25; 14, 54; 15, 78; and 20, 10, respectively. The least of these is about double the density of iron, and the greatest exceeds that of gold, being about equal to that of hammered platina, the most ponderous of all known substances. But both philosophy and conjecture are alike useless on this subject, for in spite of both, we must remain ignorant concerning the composition of the earth's centre.

Distribution of Sea and Land. Nearly three fourths of the whole surface of the globe is covered by water. The surface of the Pacific Ocean alone is estimated to be somewhat greater than all the dry land with which we are acquainted.—(*Daubuisson.*)

The greatest elevation of land is about 25,000 feet above the level of the sea; but its greatest depression, being concealed by the water, cannot be ascertained, and hence the quantity of water which the oceans contain cannot be estimated with any degree of accuracy. La Place, however, has made a computation of the mean depth of the sea, founded on the theory of the tides, by which he concludes that it is about twelve miles. Concerning the bottom of the sea, we know little more than that it consists of mountains and valleys, like the surface of the land. This is ascertained by the rocks, and islands which rise above the surface of the water, and the reefs and deep water, which are known to exist alternately, below it. The sounding line of the mariner not only detects this unevenness of the submarine surface, but also the steep acclivities of its mountains and the gradual risings of its sand banks.

Composition and specific gravity of the Sea. The whole ocean is composed of salt water, though it varies considerably with respect to the quantity of solid matter it contains. At the mouths of rivers, and in bays which receive streams from the land, it is obvious that the water cannot be so fully saturated with salt, as it is where it is not thus diluted. There is also a difference wlth respect to the quantity of salt which different oceans contain, independently of any such circumstance. This is ascertained, not only by the analysis of their waters, but also by their different specific gravities.

It will be remembered that the standard, or unity, by which specific gravities are estimated, is distilled water, which is 1; and therefore the greater the quantity of solid matter any water contains, the greater will be its specific gravity.

Dr. Marcet instituted a series of experiments on sea water from different parts of the world, from which he ob tained the following results and conclusions.

1. "That the Southern Ocean contains more salt than the Northern, in the ratio of 1.02919 to 1.02757."

2. "That the mean specific gravity of sea-water, near

the equator, is 1.02777, intermediate between that of the northern and southern hemispheres."

3. "That there is no notable difference in sea-water, under different meridians."

4. "That there is no satisfactory evidence that the sea at great depths, is more salt than at the surface."

5. "That the sea, in general, contains more salt where it is deepest and most remote from land; and that its saltness is always diminished in the vicinity of large masses of ice."

6. "That small inland seas, though communicating with the ocean, are much less salt than the ocean itself.

7. "That the Mediterranean contains a larger proportion of salt than the ocean."

Temperature of the Earth. The superficial temperature of the earth, if not entirely due to the heat of the sun, is greatly influenced by it. Still local circumstances cause considerable variations in different places situated under the same latitudes. These circumstances will be noticed in their proper place.

Geological investigations have proved that the temperature of the earth has not always remained the same; but that the climates of different countries, and probably the superficial heat of the entire globe, have greatly deteriorated, since the time when the elephant inhabited Siberia, and the mastodon, the forests of North America. This subject will be examined under the articles "Change of Climate," and "Organic Remains."

With respect to the internal temperature of the Earth, the prevailing opinion among geologists of the present day, appears to be that the heat increases in some proportion to the distance of the descent from the surface. That this is the case, seems to be proved by the experiments made in mines, situated in different parts of the world, an account of which will be given hereafter.

Temperature of the Sea and of Lakes. The maximum density of fresh water is at the temperature of 40 degrees of Fahrenheit, and it has been considered that sea-water follows a similar law of condensation. Now water being free in its motion, arranges itself according to its density, that which is at, or near the temperature of 40°, occupy ing the lowest place, while that which is warmed by the sun, is superincumbent on this.

In 1819 and 1820, Mr. De la Beche made numerous experiments, with great care, on the temperature of the Swiss lakes, and from which he found that between the surface and the depth of 40 fathoms, there was a material variation of temperature. From one to five fathoms, in the month of September, the heat was from 64° to 67°; but below this, the temperature decreased down to 40 fathoms. From 40 to 90 fathoms, the thermometer stood almost uniformly at 44°; and from 90 to 164 fathoms, it invariably stood at 43° 5′

In the winter, these experiments were repeated, and it was found that the temperature of the water followed the same law.

The temperature of the sea at different depths, accords sufficiently with the observations already made; the temperature diminishing to the depth where the fluid attains its greatest density, below which it remains the same, or at a similar temperature. It appears, however, that there is considerable difference in the temperature of different seas, at similar depths. Thus Capt. Kotzebue, in latitude about 36° N. and longitude 148° W. when the surface of the water was nearly 73°, found the temperature 57°, at 25 fathoms; 52° 8′ at 100 fathoms; and 44° at 300 fathoms. While the same observer in lat. 30° 39′ S. found a temperature of 49° 5′ at 35 fathoms; and in a similar latitude S. 38° 8′ in 196 fathoms. It will be observed, however, that the same law is maintained, both in salt and fresh water, viz. a decrease of temperature downwards. But this fact is not at variance with the probability of an internal, or central heat, since the waters arrange themselves in the order of their densities, and this would take place, whether the bottoms of deep seas were cold or warm.

Temperature of the Atmosphere. The atmosphere is composed of two gaseous substances, called *oxygen* and *nitrogen*, and in the proportion of 20 parts of the first, to 80 of the last. From its refractive powers, it has been calculated that the atmosphere reaches to the height of about 45 miles above every part of the earth.

The heat which is constantly radiating from the earth, is absorbed by the atmosphere, so that its temperature in hot climates often exceeds that of the human system. That the temperature of the air is dependent on the heat of the earth's surface, is proved by the well known fact, that it constantly diminishes as we ascend upwards, or recede from the earth. Hence, in the hottest climates, there is a region a few thousand feet above the earth, to which its heat never ascends in such quantity as to prevent perpetual congelation.

The line of perpetual snow, we should suppose would differ in elevation, (under equal circumstances,) according to the distance from the equator. It is, however, liable to considerable variations, probably from local causes.

The following table, from Encyc. Britannica, article *Climate*, presents the different elevations at which there is constant frost, under different latitudes.

Lat.	Height in feet.	Lat.	Height in feet.
0°	15,207	45°	7,671
5	15,095	50	6,334
10	14,761	55	5,034
15	14,220	60	3,818
20	13,478	65	2,722
25	12,557	70	1,778
30	11,484	75	1,016
35	10,287	80	457
40	9,001	85	117

From this table, we learn that there is no regular correspondence between the latitude and the height of perpetual frost, and that the difference in this respect is much greater than might have been expected from the influence of local causes. Thus the difference between the freezing height at the equator, and in latitude five degrees, is only one hundred and twelve feet; though at the other extreme, from eighty to eighty-five degrees, this difference is upwards of three hundred feet. Much the greatest difference is in the temperate latitudes, as between thirty-five degrees, and forty degrees, where the elevation is from 10,287, down to 9,001, making a difference of 1,286 feet in five degrees. Whether these differences are entirely dependent on local causes, we have no means of deciding.

In the elevation of mountains to the region of perpetual frost, and in such a disposition of things, as that their summits should constantly be covered with snow, there is a striking display of wisdom and design. Such mountains, in ardent climates, not only temper the atmosphere below, but serve as perpetual reservoirs of water, during the summer, from the melting of the ice, and thus become the parents of innumerable streams, without which, many regions would be uninhabitable.

EFFECTS OF CAUSES NOW IN OPERATION ON EARTH'S SURFACE.

The earth almost every where presents appearances which cannot be traced to causes now existing, or which have existed since the historical era. No high mountains have been elevated, or deep valleys formed, within the age of history, nor can these great effects be attributed to the slow causes now in operation. It is true that occasional excavations by uncommon floods of water are made, and now and then there happens a subterranean convulsion, which elevates a small portion of earth, but such effects, though supposed to have operated constantly, from the remotest period which the imagination can suggest, will never account satisfactorily, for the changes which the surface of the earth has undergone since the creation. We may hence conclude, either, that the causes which produced such mighty effects, have entirely ceased, and are unknown to us, or that they operated with infinitely greater force formerly than at present.

If we attribute the elevation of mountains, to subterranean fire, and the excavation of the great valleys, to floods of water, it is obvious that these causes must have been infinitely more powerful at some remote period than at present.

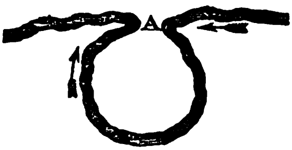
It being one of the great objects of Geology to point out the changes which the crust of the earth has undergone, and if possible to account for them; it becomes necessary that the causes now operating, and the effects of which are apparent, should be distinguished from those, the effects only of which, are certainly known at the present day.

We begin with the "Effects of causes now in operation," that we may be enabled to judge how far they have been the instruments of producing the changes which it is evident the earth has undergone, and how far, with more time, or greater force, they might account for the phenomena which the earth presents.

General effects of running water. It is well known that mountains, or lands elevated far above the level of the sea, attract the moisture of the atmosphere, in some proportion to their elevation. By this provision, the higher regions of the earth become perpetual reservoirs of water, which descend and irrigate the plains and valleys below. Thus a great proportion of the water which falls upon the earth, is carried first to the higher regions; and then made to descend, often by steep declivities, towards the sea, so that it requires a rapid velocity, and removes a greater quantity of soil than it would do, if the rain was equally distributed on the mountains and plains. Thus without reference to the disintegration or decay of rocks, the water constantly transports more or less soil and gravel from the hills to the plains.

Among the most powerful agents in effecting the decay of rocks, is the mechanical action of water, especially in cold climates. It is well known that water expands in the act of freezing. The effect of this expansion is so powerful as to burst bomb-shells, and large cannon, when closely confined in them. When, therefore, water falls into the fissures of rocks, and there freezes, the rocks are rent apart with the force of a powerful lever; and the more porous ones are divided into small pieces. These are often further divided by the frequent fall, and consequent crushing and grinding motion of one rock on another on the declivities of the mountains. Water also has the power of dissolving considerable quantities of some kinds of rocks, especially those of the limestone and gypsum kinds. The Oxygen of the atmosphere is another cause of the decay of rocks. "This element is gradually absorbed by all animal and vegetable substances, and by almost all mineral masses exposed to the open air. It gradually destroys the equilibrium of the elements of rocks, even the hardest aggregates belonging to our globe."—*Sir H. Davy.*

When earthy matter has been once mixed with running water, a new mechanical power is obtained by the attrition of sand and pebbles, borne along by the violence of the stream. Rapid streams charged with foreign matter, and thrown against their rocky sides, will, in the course of time, produce excavations, in consequence of which, rocks are often undermined and precipitated into their beds. The water being thus obstructed, accumulates, and cuts for itself a new channel, taking with it an additional quantity of earth. In this manner, also, the stream is often made to take a new direction, perhaps obliquely across the valley through which it runs. The unequal hardness of the soil is another cause of change in the direction of streams, and so also are logs of wood, leaves, and other matters with which streams are often charged. When from these, or other causes, a current is made to deviate from its course, it gradually wears a curve into the opposite bank, where the water for a moment accumulates, and then receiving a different direction from the lower side of the curve, shoots across to the opposite side, where a similar curve is soon formed, and the water made to re-cross the channel as before. Thus we often see brooks and rivers crossing and re-crossing the valleys through which they run, many times; and sometimes, after taking a wide sweep, returning again nearly to the point where the same water had passed, an hour, or many hours before. When this happens, and every one has seen such instances, it is often the case that during some overflow of the stream, the water cuts across the isthmus at A, as seen in the diagram, and thus forms an island. In consequence of this, the water not only takes a new direction at that particular point, but often the foundation is thus laid for considerable changes below the island.



These serpentine windings, not only take place in trout brooks, but in the largest rivers, and thus become the means of levelling and fertilizing tracts of country of greater or less extent. The Mississippi, through a considerable part of its course, cuts across its immense valley in the manner here described, and sometimes after running ten or twenty miles, returns back again nearly to the same point. The fertile valley of the Connecticut has been formed in a great measure by the same means. The rich meadows, now every year irrigated by its waters, have been formed in the course of time, by the changes of its bed. This is shown by the logs of wood uncovered in its banks by every new change its current makes at the present time. Charcoal and other organic substances

stances have been found 20 feet below the present surface of its banks.

In estimating the transporting power of water, we are apt to forget its buoyancy, and on which indeed its power of moving heavy substances, such as rocks, in a great measure depends. The specific gravity of many rocks is little more than twice that of water, that of granite and limestone being about 2.50, that is, two and a half times, bulk for bulk, the weight of water. Hence a stone weighing twenty-five pounds in the air or under ordinary circumstances, will weigh only fifteen pounds when immersed in water. Those who have never tried the experiment of lifting a stone under water, will be surprised to find, with what ease he can raise a block of granite to the surface, above which, however, with all his efforts, he cannot lift it. If a man can lift a stone weighing one hundred pounds whose specific gravity is two, in the air, he can lift one weighing two hundred pounds in the water, because the fluid lifts just one half of its weight. It is from our not taking this circumstance into account, that we are often surprised at the power of torrents to move stones of great size.

According to experiments recorded in the Encyclopedia Britannica, a velocity of water equal to three inches per second is sufficient to tear up fine clay,—six inches per second fine sand—twelve inches per second fine gravel; and three feet per second small stones. It is obvious, however, that the depth of the water will influence these results, and that the power of moving bodies will be in proportion to its depth and velocity.

Since the time of historical records, the power of running water has produced many, and great changes in various parts of the world. In some instances, lakes have been filled up, in others, deep ravines have been formed, in others whole districts have been ruined in consequence of rivers having changed their beds, and in others, considerable tracts of land have been accumulated, or sometimes swept away, by the force of mountain torrents.

Effects of the River Po. The Po affords a grand example of the manner in which a great and rapid stream, bears down to the sea, the alluvial matter poured into it by a multitude of tributaries, descending from lofty chains of mountains. The changes gradually produced by this river in the great plains of Northern Italy since the time of the Roman Republic have been exceedingly disastrous to some parts of that country. Extensive lakes, and marshes, have been slowly filled up, as those of Placentia, Parma and Cremona, while others have been drained by the same cause. Since 1390 the Po deserted its bed through a part of the territory of Cremona and invaded that of Parma, its old channel being still obvious, and retaining the name of *Po morto*, or dead Po. The town of Bressello, which formerly stood on the left bank of the river, now stands on the right, the river, not the town, having changed its locality. In the ancient parish records it is stated that several churches were taken down and afterwards rebuilt at a greater distance from the new bed of this devastating stream, and in 1471 the friars of a monastery pulled down their edifice and erected it at a greater distance from the Po.

To keep this wild stream within bounds, a general system of embankment, through the plains of Northern Italy, was commenced in the thirteenth century, which has continually been increased until the present time. The increased velocity of the river, in consequence of its being thus confined, causes it to transport to the sea a much greater quantity of alluvial matter than it would otherwise do, because there are no sluggish intervals where its waters can deposit their sediment. Hence the delta of the Po, even since the memory of man, has greatly increased. The ancient city of Adria was originally a sea port of the Adriatic, but it is now twenty miles from the shore. In the twelfth century, Adria was about six miles from the shore, the Po having added fourteen miles of alluvial soil since that period.

But notwithstanding more alluvial matter is carried into the sea in consequence of this embankment, more is also deposited in its bed; for that which would be spread upon the plains during an overflow is now confined within the narrow limits of its banks. In consequence of this constant deposition, it is found necessary every year to remove the mud and sand from the bed of the river, and place it on the embankment, otherwise the water would be in danger of breaking through, and destroying the whole plain below.

This system has been so long continued, that at the present day, the Po crosses its plains to a considerable distance, on the top of a high and continued mound like the waters of an aqueduct, and to the great hazard and terror of the people in the valleys every spring.

M. de Prony, who has recently been employed by government, to examine the present condition of this river, and if possible to suggest some method of security against a catastrophe which every year threatens the lives and property of so many inhabitants, ascertained that the bed of the Po is now higher than the roofs of the houses in the city of Ferrara, near which it runs. The magnitude of these barriers, already so immense, it is found necessary to increase every year, to prevent an inundation.—*Lyell and Cuvier.*

When we consider that the smallest stream breaking through or running over this embankment, would, if not discovered within a few seconds, destroy, in spite of all human power, many cities, towns, and villages, with all their inhabitants, we may in some degree conceive of the constant anxiety which those must feel who reside within the danger.

Falls of Niagara. This is the most magnificent waterfall in the world. It is situated between lake Erie above, and lake Ontario below, the cataract being formed by the passage of the water from one lake to the other. The distance between the nearest shores of these lakes is about thirty-seven miles, and the height of Erie above Ontario is, according to Mr. Featherstonhaugh, 322 feet. On flowing out of the upper lake, the river is almost on a level with its banks, so that if it should rise perpendicularly eight or ten feet, it would lay under water the adjacent flat country of Upper Canada on the west, and part of the State of New-York on the east. The river where it issues, is about twenty-five feet deep, and three quarters of a mile wide. Its descent is fifty feet in half a mile. Goat Island, at the very verge of the cataract, divides the water into two parts. The stream on the American side is 1,072 feet wide; and the curvature of the great Horse-shoe fall is 2,376 feet wide, making the width of the whole at the falls, 3,448 feet.

Although the aggregate descent from Erie to Ontario is 322 feet, the perpendicular fall at the cataract is less than one half this distance.

The following particulars are from Mr. Featherstonhaugh's journal.

	feet.		miles.
Fall from Erie to the rapids above the Cataract of Niagara,	15	in	23
Fall of the rapids to the edge of the Cataract,	51		½
Fall of the Horse-shoe Cataract,	150		
From Horse-shoe fall to Lewiston,	104		13
From Lewiston to Ontario,	2		
	322		36½

There is no doubt but the Falls of Niagara at some remote period, were at Queenstown, which is about seven miles below their present situation. The breadth of the gorge or excavation made by the waters, is, on approaching the falls, about 1200 feet, but is much narrower towards Queenstown.

The kind of rock through which it passes consists of limestone and shale, the latter a dark coloured shelly formation, 80 feet thick, lying under the limestone. The limestone is 70 feet thick, above which is the ordinary soil of the country.

The limestone is hard, and lies in horizontal strata at the edge of the falls; but the shale is soft, and is acted upon with much greater facility than the limestone, so that the latter rock often overhangs the former perhaps forty feet at the edge of the precipice.

The blasts of wind charged with spray, which rise out of the pool into which this enormous cascade is projected, strike against the shale beds, so that their disintregration is constant; and the superincumbent projecting limestone being left without a foundation falls from time to time in immense rocky masses. When these enormous fragments fall, a shock is felt, often at considerable distances, accompanied by a noise resembling a distant clap of thunder.

The waters which expand at the falls, where they are divided by the island, are contracted again after their union into a stream averaging not more than 500 feet broad. In the narrow channel, immediately below this immense rush of waters, a boat may pass across the stream with safety. The pool into which the cataract is precipitated being 170 feet deep, the descending water sinks down and forms an under current, while a superficial eddy carries the upper stratum back *towards* the main fall.—*See Mr. Bakewell, Jr., on the falls of Niagara, London Magazine*, 1830.

There is no doubt but the falls of Niagara were once at Queenstown, as above stated and have gradually cut their way through the rock to their present situation.

Mr. Lyell, who refers all the changes which have taken place on the earth's surface to "causes now in operation," states that the recession of the falls have been at the rate of *fifty yards in forty years*, and therefore a little more than three feet on an average in each year.

If the ratio of recession says he, "had never exceeded fifty yards in forty years, it must have required nearly *ten thousand* years for the excavation of the whole ravine; but no probable conjecture can be offered as to the quantity of time consumed in such an operation, because the retrograde movement may have been much more rapid when the whole current was confined within a space not exceeding a fourth, or a fifth part of that which the falls now occupy. Should the erosive action not be accelerated in future, it will take upwards of thirty thousand years for the falls to reach lake Erie (twenty-five miles distant) to which they seem destined to arrive in the course of time, unless some earthquake changes the relative levels of the districts. The table land extending from lake Erie, consists uniformly of the same geological formations as are now exposed at the falls. The upper stratum is an ancient alluvial sand, varying in thickness from 10 to 140 feet; below which is a bed of hard limestone about 90 feet in thickness, stretching nearly in a horizontal direction over the whole country, and forming the bed of the river *above* the falls, as do the inferior shales *below*. The lower shale is nearly of the same thickness of the limestone."

"Should lake Erie remain in its present state until the period when the ravine recedes to its shores, the sudden escape of that great body of water would cause a tremendous deluge, for the ravine would be more than sufficient [in depth we suppose,] to drain the whole lake, of which the average depth was found, during the late surveys, to be ten or twelve fathoms."—*Lyell's Geology, vol.* 1, *page* 179—182.

Such is the tenor of Mr. Lyell's reasoning when attempting to "*explain the former changes of the earth'* *surface by reference to causes now in operation;*" and thus to deny the Mosaic history of the creation, and of the deluge.

Although he owns that no probable conjecture can be afforded with respect to the time which has elapsed since the falls of Niagara were at Queenstown, still, it is obvious that the impression intended to be left on the mind of the reader is, that it was about 10,000 years ago; that is, about 4,000 years before the creation of the world, according to Moses, these falls were at Queenstown. And at some future period, say 30,000 years hence, there will be a great flood in America, just as there have happened great floods at different periods according to what he calls the "uniformity of the order of nature."

Now let us see, in the first place, whether the data stated by the author, can possibly warrant the supposition that the falls of Niagara have been 10,000 years, or even half that time, in passing from Queenstown to their present location.

Mr. Lyell, who quotes Capt. Basil Hall for his authority, makes the falls 800 yards wide at the verge of the precipice; viz. the American fall 200 yards, and the Horse-shoe fall 600 yards wide. The channel below the falls towards Queenstown, according to the same authority, is 160 yards wide. Mr. Featherstonhaugh, (Monthly American Journal, No. 1,) we have already seen, makes all these widths more considerable. But we will take Mr. Lyell's own account.

The old channel being 160 yards wide, is exactly one fifth the width of the present falls. Now supposing the retrograde movement of the cataract had been in proportion to its width, then according to Mr. Lyell's estimate it could have been only 2000 years in travelling from Queenstown to its present place; for 160 being a fifth of 800, and allowing the present movement to be at the rate of 7 miles in 10,000 years, then, being only a fifth as wide, anciently as now, there is reason to believe that it moved at least five times as fast. But reasoning from the data before us the time must have been even less than 2,000 years, for it is plain that a given quantity of water, say a yard in breadth, would perform the work of excavation more than five times as rapidly as it would if spread over five yards in breadth. It is however but fair to state that the falls at Queenstown were not so high as they are at present, and therefore, estimating the quantity of water the same as at present, the movement must have been slower than now. For, we know that the denudating, or excavating power of water, bears not only a proportion to its depth and rapidity, but also to the heighth from which it falls, so that cataracts of little elevation produce no perceptible effects for centuries, while, if the same quantity of water were precipitated from a height of several hundred feet, the whole precipice would gradually retrograde up the stream. Allowing, therefore, that the falls moved only at half the rate above estimated, this would fix the time at 4000 years since they were at Queenstown.

Now, without giving any opinion as to the real epoch, when this cataract was at Queenstown, for there are no grounds on which such an opinion ought to be formed; still we must be permitted to say, that according to the data Mr. Lyell has given us, it is quite plain that the cataract of Niagara could not have been more than 3 or 4000 years in moving from Queenstown to its present place, instead of 10,000 years, which impression, if any, he conveys.

American Deluge. With respect to the deluge which Mr. Lyell predicts will happen about 30,000 years hence in North America, we will state the grounds on which his profoundly scientific vision presages a catastrophe so awful to this devoted country.

"It was," says he "contrary to analogy to suppose that nature had been at any former epoch, parsimonious of time, and prodigal of violence, to imagine that one district was not at rest while another was convulsed—that the disturbing forces were not kept under subjection, so as never to carry simultaneous desolation over the whole earth, or even over one great region." ****. "In speculating on catastrophes by water, we may certainly expect great floods in future, and we therefore presume that they have happened again and again in past times. The existence of enormous seas of fresh water, such as the North American lakes, the largest of which is elevated more than 600 feet above the level of the ocean, and is in part 1200 feet deep, is alone sufficient to assure us, that the time will come, however distant, when a deluge will lay waste a considerable part of the American continent. No hypothetical agency is required to cause the sudden escape of the confined waters. Such changes of level and opening of fissures, as have accompanied earthquakes since the commencement of the present century, or such excavations of ravines as the receding cataract of Niagara is now effecting, might break the barriers. Notwithstanding, therefore, that we have not witnessed within the last 3000 years the devastation by deluge of a large continent, yet as we may predict the future occurrence of such catastrophes, we are authorized to regard them as part of the present order of nature, and they may be introduced into geological speculations respecting the past, provided we do not imagine them to have been more frequent, or general than we expect them to be in time to come."—***Principles of Geology**, vol.* 1, *p.* 88.

It is on such grounds that one of the most voluminous and learned among the recent English geologists disputes the Mosaic history of the deluge; and we have introduced the above extract to show, that even men of argument on other subjects, often reason in the most ridiculous manner, and on grounds totally false, when they undertake to deny the truth of the Holy Scriptures.

Mr. Lyell's argument runs thus. "Because there are great lakes in North America situated 600 feet above the sea, and because the cataract of Niagara is receding towards these lakes at the rate of fifty yards in forty years; therefore we may anticipate great floods in future, and we therefore presume that they have happened again and again in past times." Consequently we must presume that all the changes the earth has undergone by water, have been produced by such catastrophes, and therefore Noah's flood never happened, and so the Mosaic history is not to be believed.

It is plain that Mr. Lyell's zeal to show that there has been no universal deluge, made him forget, that in another part of his volume he states that the quantity of sediment which is every year deposited in lake Erie is such, that it will finally be filled up and become dry land, and as he does not expect the cataract of Niagara will drain this lake until the end of 30,000 years, we may hope that it will become solid within that period.

But independently of this oversight, no person of the least reflection, whether geologist or not, would for a moment believe that a lake, formed like a dish, and surrounded on all sides by solid limestone rocks 90 feet thick, as

Erie is, could be drained to its bottom in a few hours by the action of its own waters. Suppose the cataract of Niagara now at the outlet of lake Erie and moving into it at the rate of 50 yards in 40 years, or a little more than a yard per year, we would inquire of Mr. Lyell how long a period would be consumed in draining it to the bottom, and whether the escape of its waters thus *sudden* "would cause a tremendous deluge," as he asserts.

The title of Mr. Lyell's book being, "*An attempt to explain the former changes of the Earth's surface, by reference to causes now in operation,*" is itself an attack on the sacred Scriptures, but we are happy to believe that Christianity is in little danger from his arguments.

Mountain Slides. Instances have happened in various parts of the world, where considerable changes have been produced in the surface of the globe, by the sliding of large portions of earth, together with fragments of rocks, from the declivities of mountains. These changes are readily distinguished from those occasioned by the general deluge, not only by their local and more recent appearance, but also by the direction in which these precipitated rocks remain with respect to the range of the mountain from which they have fallen. For the great currents of the deluge left their effect in lines corresponding with the ranges of most of the high mountains and considerable valleys, where they are still to be seen; whereas occasional slides leave their effects at the feet of the mountains, in piles, or downward ranges.

Slide of the White Mountains. The White Mountains are situated in New Hampshire, and are the highest land in New-England. The slide to be described took place in August, 1826, and was in consequence of the fall of an immense quantity of rain on the mountain.

On both sides of the river Saco, innumerable rocks and stone, many of them of sufficient size to fill a common apartment, were detached, and in their descent swept down before them in one promiscuous and frightful ruin, forest shrubs, and the earth in which they grew. No tradition existed of any similar catastrophe at former times, and the growth of the forests on the flanks of the mountain clearly proved, that at least for a long interval, nothing similar had occurred. One of these moving masses was afterwards found to have slid three miles, consisting of rocks, earth, trees, &c., with an average breadth of a quarter of a mile. The excavations commenced generally in a trench a few yards in depth, and a few rods in width, and descended the mountain, widening and deepening until they became vast chasms. Forests of spruce and hemlock were apparently prostrated with as much ease as if they had been fields of grain. The valleys of the rivers Amunoosuck and Saco presented for many miles, an uninterrupted scene of desolation; all the bridges being carried away and the ground strewed with the wrecks of trees and rocks, and in many instances large quantities of soil. In some places the road was excavated to the depth of 15 or 20 feet; and in others it was covered with rocks, trees and soil to as great a height. In various places, as shown by the remaining marks, the water rose to the height of 25 feet above its ordinary level.

But these thing are of little consequence when compared with the human suffering which this catastrophe occasioned, for a family of nine persons were destroyed on the night of the 28th, and not one lived to relate the circumstances.

This family, named Willey, occupied a house at the foot of the mountain, a most lonely place, six miles from any other human habitation. It was a resting place for travellers. On the morning of the 28th the house was found standing but not a human being was there. In the course of a few days seven out of the nine bodies were found at a short distance below the house, buried under the ruins of the mountain, and most of them shockingly mangled. It appeared that one of the heaviest slides from the top of the mountain had rushed in the most impetuous manner towards the house, but when within six feet of it had divided, and passed on each side, leaving the house untouched, but sweeping away the stables and horses. At this time it is supposed that the family left the house, and met their destruction; had they remained, all would have been safe.—*Silliman's Journal for January*, 1829.

Flood in the Valley of Bagnes, in 1818. The Valley of Bagnes forms a part of the main valley of the Rhone, above the lake of Geneva, in Switzerland. Through this valley passes the river Dranse, which falls into the Rhone above the lake. In 1818, in consequence of the fall of avalanches, the Dranse was completely dammed up, so that a barrier of ice remained across its channel, until the melting of the snow in the spring, formed a lake in its bed, a mile and a half in length, about seven hundred feet wide, and in some places two hundred feet deep. To prevent the consequences apprehended from the sudden bursting of this barrier, the people cut a tunnel through it, several hundred feet in length, before the water had risen to any considerable height. When the water had accumulated so as to reach this tunnel, or gallery, it ran through, and melting the ice it drained off about one half of the lake. But at length, on the approach of the hot season, the central portion of the remaining mass of ice gave way with a tremendous crash, and the residue of the lake was emptied in half an hour. In the course of its descent, the water encountered several narrow gorges, and at each of these it rose to a great height, and then bursting its barriers, rushed forward with increased violence, sweeping along rocks, houses, trees, bridges, and cultivated lands. For the greater part of its course, the flood resembled a moving mass of rocks and mud, rather than of water. Some fragments of primary rock of enormous magnitude, and which from their dimensions, might be compared, without exaggeration, to houses, were torn out of a more ancient alluvion, and borne down for a quarter of a mile. The velocity of the water in the first part of its course, was thirty-three feet per second, which diminished to six feet, before it reached the lake of Geneva, where it arrived in six hours, the distance being 45 miles.

This flood left behind it on the plains of Martigny, thousands of trees torn up by the roots, together with the fragments of many buildings. Some of the houses in the town of Martigny were filled with mud up to the second story. After expanding in the plain, where the town stands, it passed into the Rhone, and did no further damage. Many lives were destroyed by this flood, and the bodies of several persons were found on the surface of the Geneva lake, thirty miles from the place where they were swept away.

Inundations precisely similar, and from the same cause, are recorded to have happened in former periods. In 1595, the town of Martigny was destroyed by such a flood, and from sixty to eighty persons perished; and in a similar catastrophe which took place, fifty years before, one hundred and forty persons lost their lives.

For several months after the debacle just described, the river Dranse, having no settled channel, shifted its position continually from one side to the other of the valley, carrying away newly erected bridges, undermining houses, and continuing to be charged with as large a quantity of earthy matter as the fluid could hold in suspension."—*See Ed. Phil. Jour.* vol. 1. p. 178: *and Lyell's Geology,* vol. 1. p. 194.

Now although we have no disposition to deny that great changes have been wrought on the face of the earth by the power of running streams, the bursting of lakes, &c. yet all these effects combined, utterly fail to account for the appearances enumerated under the article "Deluge." The phenomena presented by the great valleys of the Alps, the Pyrenees, and the Jura, cannot be attributed to any cause, but a sudden and mighty torrent of water, such as no one has thought fit to ascribe to the bursting of a lake, and of which history contains no account, except that of the Noachian deluge.

CHANGES EFFECTED BY SPRINGS.

The Theory of springs will be reserved for another place. At present, our object will be to show the effects which springs have had in changing the surface of the globe.

It is obvious that springs of pure water, unless uncommonly powerful, will produce but little effect on the surface along which they run, and with a few exceptions, their excavating effects are scarcely to be taken into account. But springs which contain carbonic acid gas, often hold considerable quantities of calcareous matter in solution, and which is deposited along their courses, producing what geologists term *calcareous tufa,* or *travertine.*

These deposites are generally porous, and mixed with leaves, bits of wood, mud, &c. but when more pure, they are so solid as to be employed for building stones. Many of these springs are *thermal,* or warm, and abound chiefly in volcanic countries.

In those parts of France and Italy which skirt the Apeminces, innumerable mineral springs, chiefly containing carbonate of lime, issue from the ground. As the water evaporates, the lime is left on the surface, and thus the ground in some parts of Tuscany is covered to a considerable extent with the kind of deposite called Travertine, already noticed. In some places these deposites are solid and smooth on the surface, much resembling currents of lava.

Baths of San Vignone. This spring is also in Tuscany, and affords a striking example of the rapid precipitation of carbonate of lime from thermal waters. The spring issues from near the summit of a hill about one hundred feet high. The water is hot, but Mr. Lyell, from whom this account is taken, does not give its temperature.

So rapid is the deposition from this water, that a pipe leading from the spring to the baths, and inclined at an angle of thirty degrees, is found to contain a coat of solid limestone half a foot thick every year. A mass of solid rock below the hill, formed by this water, is two hundred feet thick. This is employed as a building stone, and in quarrying it, Roman remains of art, such as tiles, have been found five or six feet below the surface, being covered by the deposite.

Baths of San Filippo. These baths are situated only a few miles from those already described. The waters which supply them are impregnated with carbonate of lime, and sulphate of lime, (gypsum.) They flow from the spring immediately into a pond where in *twenty* years a solid rock is deposited *thirty* feet thick. A curious manufactory which produces medallions in *basso-relievo* is carried on at this place.

The water is first allowed to stand in a cistern where the sulphate of lime is deposited. It is then conveyed to a chamber through a tube, from the end of which it falls ten or twelve feet, the current being broken by numerous small sticks crossing each other, and by which means the spray is dispersed around the room. Here are placed the moulds of the medallions to be formed, which are first rubbed over with a little soap. The water striking on these moulds leaves particles of carbonate of lime, which gradually increasing, leaves exact and beautifully white casts of their figures.

The solid matter left by this spring, is a mass of limestone and gypsum rock, a mile and a quarter long, the third of a mile in breadth, and in some places at least two hundred and fifty feet in thickness. The length of this deposite terminates abruptly, being crossed by a small stream, which carries away the undeposited matter with the waters of the spring, otherwise it would have been much more extensive.

The quantity of matter deposited from these springs, show the newness of the earth, or at least of the present order of things on its surface; for had they existed at the period when Mr. Lyell supposes the cataract of Niagara was at Queenstown, and discharged their waters, and formed depositions as they do at the present day, and which it is certain they did at the time of the Romans, these strata ought to have been at least ten thousand feet thick. It is true, however, that these thermal springs being caused by volcanic heat, might have been formed within the last two thousand years.

It is apparent from what has been stated concerning calcareous springs, that in the lapse of ages considerable changes must have been made in the earth's surface from this source. But it must not be forgotten that this cause is local in its nature, being confined chiefly to volcanic districts; and that even such districts seldom contain springs which work such changes as are above described.

Silicious Springs. Although we possess no chemical process by which water can be made to dissolve pure silex, or flint, yet in the great laboratory of nature, this effect is produced. There is, however, a process in chemistry, in which by a previous combination, silex becomes soluble in water, and which, perhaps, affords an analogy to the process employed by nature. If silex be finely pulverized, and then melted with a quantity of common alkali, the whole becomes soluble in hot water. Now springs containing any considerable quantity of silex, are always of high temperatures; and it is to the great degree of heat which exists at their sources, together with small portions of alkali which volcanic rocks contain, and which the water dissolves, that we are to attribute the property these waters possess, of holding silex in solution. Springs containing any considerable quantity of silex, are, however, exceedingly rare, and are mentioned here, rather on this account, than for the changes they have produced on the earth's surface.

Springs of St. Michael. The hot springs of St. Michael, one of the Azores, have been long celebrated. These waters rise from among volcanic rocks, and hold large quantities of silex in solution. As the waters descend from the fountain, they deposite their silex in the form of what is termed *silicious sinter*, which may be considered as answering to the travertine, or tufa, of calcareous springs.

The herbage and leaves along the course of the stream are more or less encrusted with silex, and exhibit all the successive steps of petrifaction, from a soft state to a complete conversion into stone. Branches of ferns, such as now grow in the vicinity, are thus changed, still preserving their appearance of vegetation, except that they have acquired an ash grey colour.—*Dr. Webster, Ed. Phil. Jour.*

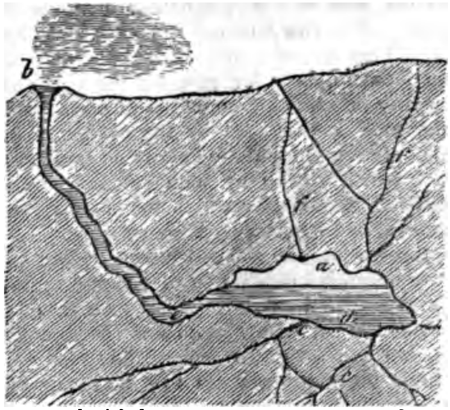
Geysers of Iceland. But the Geysers of Iceland afford the most remarkable examples of the deposition of silex. These springs are situated in a volcanic district, the surface of the ground out of which they rise being covered with streams of ancient lava, through the fissures of which, steam, and hot water, are emitted in various places.

The great Geyser, which has excited so much interest, on account of the singular phenomena which it exhibits, rises out of a basin at the summit of a circular mound, composed of silicious incrustations deposited from the spray of its waters. The diameter of this basin or crater is 56 feet in one direction, and 46 in the other.

In the centre of this basin is a natural pipe seventy-eight feet in perpendicular depth, and from eight to ten feet in diameter, gradually widening as it opens into the basin. The basin, as the spring intermits, is sometimes empty, but is more commonly filled with beautifully transparent boiling hot water, which is often in a state of violent ebullition. During the rise of the water up the pipe, especially when the ebullition is most violent, subterranean noises are heard, like the distant firing of cannon, and a slight tremor of the earth is felt near the place. The sound then increases, and the motion of the earth becomes more violent, until at length a column of water is thrown up from the pipe, in a perpendicular direction to the height of from one to two hundred feet, attended with loud explosions. This is continued, with interruptions like an artificial fountain, for a few minutes, the water at the same time giving off immense quantities of steam and vapor, when the pipe is evacuated by the discharge of its whole contents of water, and there follows an immense column of steam, which rushes up with amazing force and a loud thundering noise, after which the eruption, or paroxysm terminates, and the Geyser becomes quiet.

If stones are thrown into the pipe, or crater, during an eruption, they are instantly ejected, and such is the explosive force of the steam, that masses of hard rock thrown in, are returned into the air, shivered into small fragments. Mr. Henderson, late a resident in Iceland, and well acquainted with these phenomena, states that by throwing stones into the pipe of the Geyser, he could bring on an eruption in a few minutes, and that in such cases the fragments of stone as well as the water were thrown much higher than usual. When an eruption had been brought on in this manner, and the water had been ejected, the steam continued to rush up, with amazing force, and attended by a deafening roar, for nearly an hour, but the Geyser, as if exhausted by this effort, did not give symptoms of a fresh eruption when its usual interval had elapsed.

In the different explanations which have been offered to account for phenomena so singular and astonishing, and which have been no where else observed, most writers agree in supposing a subterranean cavity, where water and steam collect, and where the free escape of the steam is interrupted at intervals, or until it acquires sufficient force to overcome the resistance occasioned by the pressure of the water. This will be readily understood by the annexed diagram, reduced from Mr. Lyell, and we may remark that the theory is the same with that of intermitting spring, only that the Geyser acts by steam, while the other is explained on the principles of the syphon.—*See the Author's Nat. Philosophy*, p. 107.



In explaining this cut, suppose water percolating from the surface of the earth, or from springs below, finds its way into the subterranean cavity *d*, by the fissures *f f*, while at the same time steam of an extremely high temperature, emanates from volcanic rocks into the same cavity through the fissures *c c*. A portion of the steam in the first place would be condensed into water, but its temperature continuing to increase by the latent heat of the steam, the lower part of the cavity would soon be filled with the boiling fluid, while the upper part would be filled by steam under considerable pressure. The steam continuing to form, the water being now too hot to condense it, would soon by its expansive force, drive the water up the pipe or fissure *e*, *b*, whatever might be its height, and thus the basin at the surface would be filled, and an eruption take place. When the pressure is thus diminished, the steam in the upper part of the cavity *a*, would expand, or probably a portion of the boiling water under diminished pressure would be instantly converted into steam, and the passage being free, would rush up the pipe in the same manner as is seen and heard on opening the safety valve of a steam boiler. If the pipe be choked up artificially with stones, even for a few minutes, a great increase of heat would be occasioned, since the steam would thus be prevented from escaping, so that the water would be made to boil in a few minutes and thus an eruption would be brought on, as stated by Mr. Henderson.

This explanation accounts for all the phenomena observed in the Geysers, and although we cannot be certain of its truth, still there is every reason to believe that such a cavity exists, and it is certain that steam is the moving power.

Mr. Lyell forms a theory of earthquakes on this explanation.—*See Seat and Theory of Earthquakes.*

DELTAS IN LAKES.

Considerable changes have taken place by causes now going on, in consequence of the deposition of earthy matter at the mouths of rivers where they enter lakes, or seas. We have already given an account of the accumulation of land along the shores of the Adriatic in consequence chiefly of depositions from the river Po. The quantity of matter thus carried down by different rivers, of similar magnitudes, differs exceedingly; this difference depending much on the rapidity of the stream, and its liability to overflow its banks at certain seasons.

Delta of the Lake of Geneva. The Lake of Geneva is thirty seven miles long, and from two to nine miles broad. The Rhone enters at one end of this lake and the city of Geneva stands at the other. The water where it discharges itself near the city is exceedingly clear and transparent, but at the upper end it is commonly turbid, in consequence of the matter brought down by the Rhone.

Mr. De La Beche, after numerous soundings, found that the depth of the water in the middle of the lake was from one hundred and twenty, to one hundred and sixty fathoms; but on approaching the mouth of the Rhone, the water began to grow shallower at the distance of a mile and three quarters from that end of the lake. It may be stated therefore that the strata annually produced by the river are about two miles in length. From soundings it has been ascertained that in some places the deposites from the Rhone are probably from six to nine hundred feet in thickness; and from the remains of some Roman buildings on the border of the lake, Mr. Lyell judges that this accumulation has taken place within the last eight hundred years. "If," says he "we could obtain the depth of this accumulation formed in the last eight centuries, we should see a great series of strata, probably from six to nine hundred feet thick, and nearly two miles in length, inclined at a very slight angle."

Mr. Lyell proposes a plan for estimating the time when the Lake of Geneva, or the Leman Lake will become dry land by the accumulations from the Rhone.

The capacity of the lake being obtained, "it would," says he, "be an interesting subject of inquiry, to determine in what number of years the Leman lake would be converted to dry land. It would not be difficult to obtain the elements for such a calculation, so as to approximate at least to the quantity of time required for the accomplishment of this result. The number of cubic feet of water annually discharged by the river into the lake being known, experiments might be made in winter and summer to determine the proportion of matter held in suspension or in chemical solution, by the Rhone."

Such calculations, however, after all the data that could be obtained, would be exceedingly uncertain, and since the elements proposed by the author have not been obtained, we do not extract his speculations on this subject.

But were it ascertained exactly how much alluvial matter is carried down by the Rhone at the present day. still this would decide nothing definitely with respect to the time during which this accumulation has been forming According to Mr. Lyell's supposition above cited, a part of the delta has formed at the rate of about a foot in a year, namely, from six to nine hundred feet in eight hundred years. Now allowing that the Rhone has, on an average, deposited a foot of matter a year in the lake, and has continued to do so ever since the deluge, then the accumulation ought to be at least four thousand feet thick, which would long ago have filled up the Leman lake, and made it solid ground. The phenomena of this lake, therefore clearly shows that either it has not received the Rhone for so many years, or if so, that its waters contained less solid matter anciently than at present. In either case, it is quite certain that no argument can be derived from the present condition of this delta, in favour of the high antiquity of the present form of the earth. But on the contrary, if any conclusions can be drawn from this source, they are in direct coincidence with the idea that the present order of things are of recent origin, and therefore in confirmation of the truth of the sacred history of the deluge.

DELTAS IN THE SEA.

Accumulations in the Baltic. The question whether the waters of the Baltic sea have been sinking, or whether they have remained stationary, has been a subject of controversy since the middle of the last century. Celcius, a Swedish astronomer, attempted to prove that the waters of this sea had suffered a depression at the rate of about forty-five inches in a century, from the earliest times. He contended that the proof of this change rested not only on modern observations, but also on the authority of the ancient geographers, who stated that Scandinavia, now a peninsula, was formerly an island. But most of the arguments of Celcius and his followers show that they did not sufficiently distinguish between the shallowing of the water by the deposition of sediment, and the actual lowering of the sea. It appears that the sinking of the waters, on which estimates were chiefly made, were at the mouths of rivers, and in bays, where in the one case inland sediment might be expected, and in the other where loss of depth might be occasioned by the shifting of sand bars by the current of the sea. But the facts stated concerning the gradual conversion of the Gulf of Bothnia into dry land merit more attention. Thus it was shown that at Pitea, half a mile of land had been gained in forty-five years, and that at Lulea a mile of ground had been added in twenty-eight years. Ancient ports on the same coast had become inland cities. Considerable portions of the gulf were also shown to have become three feet shallower in the course of fifty years—many old fishing grounds had been changed into dry land, and small islands had been joined to the continent. Besides these changes, it was asserted that along the coast of West Prussia, and Pomerania, anchors, and the hulls of old ships, had been discovered far inland.

But since it was possible that all these facts might be accounted for by the accumulation of land, instead of the depression of the waters, Celcius derived a stronger argument still for his theory from the exposure of certain insular rocks in the gulf of Bothnia, which were once entirely covered by water. These rocks, it was shown, had risen in the course of a hundred and fifty years, from below the water to the height of eight feet above its surface, and there they stood, the most certain and permanent of all witnesses, that the sea was so much lower than formerly. To this it was opposed, that this island consisted of sand and drift stones, and that during great tempests, not only more sand, but additional stones, also, were thrown upon it. Besides this, icebergs, heavily laden with stones and rocks, sometimes floated in this sea, when the ice was breaking up in the spring, and the fact that this low island had gradually increased in height, was readily accounted for by supposing that the stranded ice fields had forced these stones above the level of the water, where of course they would remain after the ice was melted away.

This question, about which volumes were written in the course of half a century, was finally settled by a curious, but conclusive proof, brought forward by the opposers of Celcius. On the Finland side of the Baltic, there grew, close to the water's edge, some large pine trees. Some of these were cut down, and by counting the concentric rings of annual growth, it was found that they had stood there four hundred years. Now according to Celcius, the sea had sunk fifteen feet during that period, so that were this the case, these trees must have commenced their growth in at least two fathoms of water, a thing absolutely impossible. It was also proved that the walls of several ancient castles, as those of Sonderburg and Abo, reached the edge of the water at the present day, and therefore, had the water sunk, these foundations must have originally been laid below the level of the sea. Very ample proofs from other sources have also been adduced, that the level of the Baltic has suffered no change for eight hundred, or a thousand years.

But notwithstanding the proofs are quite positive that the hypothesis of Celcius can only be substantiated by deceptive arguments, drawn from progressive accumulations of solid matter in the water; still there are many intelligent men who maintain that the waters of the Baltic are suffering a constant diminution. So lately as 1821, several Swedish officers, belonging to the pilotage department, declared in favor of this opinion. The weight of evidence is, however, entirely opposed to the theory of Celcius, and there can be little doubt but the Baltic Sea has remained at its present level from time immemorial.—*Lyell's Geology*, vol. 1. p. 227.

We have been thus particular in this account, that the

geological student might observe how much difficulty sometimes occurs in deciding questions of this nature, and consequently how much experience and judgment ought to be exercised before any positive opinion is advanced on some geological points, in themselves apparently of the most simple kind. The great question, also, whether the waters of the ocean are diminishing, as has been maintained by several writers, is involved in the question of the Baltic; for since this sea communicates with all other seas, and oceans, its gradual depression would prove a corresponding diminution of the sea all over the earth. But from the above account there is no doubt, that the supposed sinking of the Baltic is entirely a deception, arising from alluvial accumulations brought down by rivers, and the occasional shifting of sand banks by the currents of that sea.

Delta of the Rhone in the Sea. We have seen that the Rhone deposits large quantities of sediment in the lake of Geneva, and have noticed with what crystalline transparency the waters of that lake are discharged to continue the same river towards the sea. But, says Mr. Lyell, "scarcely has the river passed out of the Leman Lake, before its pure waters are again filled with sand and sediment by the impetuous Arve, descending from the highest Alps, and bearing along in its current the granitic detritus [broken rocks] annually carried down by the glaciers of Mount Blanc." The Rhone, also, afterwards receives vast contributions of transported matter from the Alps of Dauphiny, and the primary and volcanic mountains of central France, so that when it reaches the Mediterranean, it discolors the waters of the sea to the distance of many leagues.

The advance of the delta of the Rhone into the Sea, is proved by many circumstances, and particularly by the facts that an island described by Pomponius Mela, an ancient Latin geographer, is now far inland, and that a location which was a harbor in 898, is now three miles from the shore. It is also known that Psamodi, which was an island in 815, is at the present time six miles from the sea

As the Rhone enters the sea by several mouths, at considerable distances from each other, a large tract of country is brought within its influence, and thus besides extending the land along the shore, marshes of great extent have, during the lapse of ages, been filled up by its annual deposites.

In the course of this river it receives the waters of a vast number of springs containing carbonate of lime in solution, and which mixing with the waters of the Rhone, is not deposited until it reaches the sea. Hence the Delta of this river, instead of consisting of loose incoherent sediment, like the deposites from most other rivers, consists chiefly of *solid rock;* the carbonate of lime acting as a cement to the sediment, when this exists, or in its absence, forming limestone nearly pure. This is a well ascertained fact, for large masses of this rock are quarried for various purposes, and are found to consist of sand consolidated by a calcareous cement, and mixed with broken shells. After the sand has been deposited, the waters still hold a portion of the carbonate in solution, which is thrown down in a purer state, and even sometimes in the form of crystalline masses. As an example, there exists a cannon in the museum of Montpelier, taken up from near the mouth of this river imbedded in *crystalline limestone.*

Thus we see that solid limestone is now constantly forming, in which are imbedded shells as in the ancient marbles, which some geologists have contended were thousands of years older than the creation according to Moses. This circumstance is important, and will be adverted to in another place.

In a late survey of the coast of the Mediterranean, the ships employed at the mouth of the Rhone were obliged to quit their moorings when the wind blew strongly from the south-west. Captain Smith, one of the officers on this service, states, that when the ships returned after such a wind, the new sand banks in the Delta were found covered with a great abundance of marine shells, which were swept there by the current caused by the wind. This circumstance appears to explain phenomena of some importance in geology. In some ancient strata it has been claimed that marine and fresh water shells alternate with each other, and hence it has been supposed that at least in such places, the sea had retired for a time, while fresh water occupied its place; after which the sea again resumed its former bed; and so alternately as often as the different kinds of shells were repeated. But it appears from the above statement, that the explanation of such appearances is very simple, and that it is unnecessary to believe that the ordinary course of nature was changed in order to produce such effects: for, at the mouth of the Rhone, a strong south-west wind only is required, to occasionally mix the shells of the sea with those which are brought down by the fresh water, or which live in its current.

Delta of the Po in the Adriatic. We have already described the effects which the Po has produced and is now producing in some parts of the country through which it passes. But we must notice more particularly the changes which this mighty torrent, assisted by the Adige, has produced at its delta in the Adriatic.

These two rivers, with numerous smaller streams, drain some of the loftiest ridges of the Apennines, together with one side of the great Crescent of the Alps. The combined influence of these rivers have produced an enormous increase of alluvial matter along the coast of that sea. From the northernmost point of the gulf of Trieste, where the river Isonzo enters, down to the south of Ravenna, there is an uninterrupted series of recent alluvial deposites, forming dry land, more than one hundred miles in length, and from two to twenty miles in breadth. There is evidence that this great alluvion has been formed within the last two thousand years. Adria, a city which gave name to the Adriatic, was originally a sea-port; it is now twenty miles from the sea. Ravenna and Spina were also built on the sea, but, at the present time, the first is four, and the last ten or twelve miles from the water.

Delta of the Ganges. The Ganges and the Burrampooter descend from Himmala mountains, the most lofty on the globe. The latter river may be considered as a branch of the former, and falls into it long before their united waters reach the sea. The Ganges is discharged into the bay of Bengal, which forms a vast indenture into the continent of more than two hundred miles in length. The Delta of the Ganges commences more than 200 miles from the Bay of Bengal in a direct line, and 300, if the distance be estimated along the windings of the river. That part of the Delta which borders on the sea, is divided by a vast number of rivers, or creeks, all of which are salt except those which communicate with the principal arms of the Ganges. This tract is famous under the name of *Sunderbunds*, being the common haunt of tigers and alligators. Its extent, according to the account of Major Rennell, is equal to the whole principality of Wales. Its base, bordering on the sea, is about two hundred miles in length, and, on each side, it is enclosed by an arm of the Ganges. Besides these, through which the water of this immense river is now discharged, there are six other great openings through the Delta into the sea, each of which has evidently at some ancient period, been the principal bed of the river. During the period of overflow the greater part of this vast Delta is covered with the water of the river, so that the Ganges appears to be flowing into a vast lake, instead of itself inundating, and sweeping a whole territory of India. So great is the quantity of mud and sand carried down by this immense current, at such seasons, and so vast the quantity of water it discharges, that the ocean is discoloured by it to the distance of sixty miles from its mouth.

In various parts of this delta great accumulations, or islands, are formed in the course of a few years, and perhaps as soon swept away, and similar ones formed in other places. Some of these, which are islands during freshets, Major Rennell states, are equal in extent to the Isle of Wight, and thickly inhabited. The people are, however, always in danger of being swept away by floods of uncommon height. In 1763 such an inundation happened, the water rising six feet above ordinary floods; and consequently the inhabitants of one of these districts of considerable extent, were, with their horses and cattle, totally engulfed, and perished in the water.

These examples of the effects of running water in changing the surface of the Globe are sufficient for the purposes intended. In all parts of the world, such effects are constantly taking place, to a greater or less extent.

The aggregate accumulation of solid ground by the formation and extension of deltas on the surface of the whole earth, must be very considerable during every year; and yet these effects are hardly appreciable in relation to the changes they produce on the entire surface of the globe. It is true, that the course of navigation is in a few instances obstructed, or changed, by these accumulations, but in general the same sea ports of which the earliest records of history give any account, are still accessible

Had these accumulations commenced at very remote periods as some have contended, and continued to the present time, it is quite certain that many lakes now existing would have become dry land, and that the deltas of rivers falling into the sea, would have been far more extensive than we find they are. All the facts, therefore, which are connected with the effects of rivers in the formation of dry land, tend to show that the present form of the earth has not existed more than a few thousand years, and that it has suffered no considerable changes from running streams, as one of the causes now in operation.

QUANTITY OF SEDIMENT IN RIVER WATER.

Having in the preceding pages given such an account of the effects of rivers in forming solid depositions, as our limits will allow, it is proper here to present the geological student with an account of the estimates and experiments, which have been made, to ascertain the quantity of solid matter water is capable of holding in suspension.

It is proper, however, that we should also state, that few, if any of these estimates, can be considered as more than approximations to the truth; still they are such as are quoted by the best writers, and are probably as accurate as any in existence at the present day. Major Rennell states that a glass of water taken out of the Ganges during the height of its annual flood, yields about one part in four of mud. "No wonder, then," says he, "that the subsiding waters should quickly form a stratum of earth, or that its delta should encroach upon the sea." The same writer who resided many years in the vicinity of the Ganges, computed with great care the quantity of water which that river discharges into the sea, and which by his estimate amounted, during a year, on an average, to *eighty thousand cubic feet, for every second of time.* When the river is at its greatest height during its annual inundation, and consequently its motion much accelerated, the quantity discharged per second, by the same estimate, was *four hundred and five thousand cubic feet.*

Mr. Lyell has made a computation of the quantity of solid matter carried down by the Ganges, taking as his data, the experiment of Major Rennell, and his estimate of the quantity of water it discharges. "If it were true," says he, "that the Ganges in the flood season contained one part in four of mud, we should then be obliged to suppose that there passes down every four days a quantity of mud equal in volume to the water which is discharged in the course of a day, or twenty-four hours. If the mud be assumed to be equal to one half the specific gravity of granite, (it however is more,) the weight of matter daily carried down in the flood season would be about sixty times the weight of the great pyramid of Egypt. If the Ganges discharges 405,000 cubic feet of water per second, which was the estimate of Major Rennell, then, in round numbers the quantity of mud discharged per second, would be 100,000 cubic feet, which being multiplied by 86,400, the number of seconds in 24 hours, would give 8,640,000,000 cubic feet of mud going down the Ganges per day. The weight of this (allowing as above) would be equal to that of 4,320,000,000 cubic feet of granite. Now about twelve and a half cubic feet of granite weigh a ton, but throwing out the half, the matter discharged by the Ganges every day is 360,000,000 of tons. This is sixty times the weight of the great pyramid of Egypt, which if solid is computed to weigh 6,000,000 of tons."

But although the Ganges may be supposed to transport a much greater quantity of mud, even according to its size, than any other river, still there can be little doubt but Major Rennell very far over-rated the quantity of solid matter its waters contained. The Rhine, when most flooded, has been computed to contain one part of mud in a hundred of water, and Sir George Staunton by several observations, calculated that the water of Yellow River, in China, contained earthy matter in the proportion of one part to two hundred. In this proportion he estimated that the waters of that river brought down 48,000,000 of cubic feet of solid matter daily.

According to the calculations of Manfredi, the celebrated Italian hydrographer, the average amount of sediment in all the running streams on the globe, is one part in 175. From such data, he estimates that it would take a thousand years to raise the general bed of the sea a single foot, provided none of this sediment was thrown back again upon the shores.

From what has been stated, the reader will observe that although a considerable number of experiments have been made on this difficult subject, there remains much more to be done before satisfactory results can be offered. It is however, certain, that great quantities of solid matter are transported by running streams; and with respect to lakes and ponds there can be no doubt, but they are gradually filling up, and that if the same causes continue which we have described, all these bodies of water will finally be replaced by dry land.

But there can be no possible estimate made of the time required for such an event, since the quantity of solid matter which streams transport, must be constantly decreasing in proportion, as lakes and ponds approach the level of the country in which they are. In a flat country therefore, a lake may remain for centuries without any appreciable elevation of its bottom.

The great depth of some lakes at the present day, when these circumstances are considered, is a good proof of the newness of the present order of things on the earth, and consequently, of the truth of the Mosaic history of its creation.

With respect to the level of the sea, it has been shown that no change has taken place in the Baltic, and we may also state at this place, that it will be seen hereafter, that the remains of Roman buildings show that the Mediterranean sea has not changed its level for the last 2000 years. We may therefore conclude, that either the quantity of matter carried into the sea has made no appreciable difference with its general level, or that as much solid matter is thrown on the land at one place as is carried into it in another

DESTRUCTION OF ROCKS.

The causes now described which have produced changes on the surface of the earth, are chiefly such as transport loose materials from one place to another. But there is another cause of change, which although noticed in the first part of this article, must be more particularly described. This is the *destruction of rocks.*

" If in contemplating," says Dr. Macculloch, " the towering peaks, and the solid precipices of an alpine region, braving the fury of the elements, and the floods of winter, the spectator is at first impressed with the character of strength and solidity, which nature here seems to have conferred on her works, it requires but a moment's reflection, to show that every thing around him bears the marks of ruin and decay. Here he learns to withhold his regret at the perishable nature of all human labors,—at the fall of the strong tower, and the solid pyramid, when he sees that the most massive rocks, those mountains which seem calculated for eternal duration, bear alike the marks of vicissitude and the traces of ruin."

"In these great revolutions, however, other agents must co-operate; and the first here to be considered is the power of frost. Expanding as it freezes, the water which has entered the fissures acts with irresistible force, and detaches those enormous masses, which in the seasons of winter and spring, daily fall from the mountains. In Greenland, it is said that these effects often take place with a noise emulating thunder; but if less conspicuous, they are sufficiently common in all alpine regions that are subject to the extreme vicissitudes of heat and cold."—*Geology, Vol.* i. p. 248.

To this cause, in a great measure, is to be attributed the ruin of sea cliffs, which on some coasts present such striking and singular appearances. The constant action of the ocean lashing the inferior parts of these cliffs, also produces its effects, and is often the cause of large masses being precipitated into the water. The perpetual rubbing of the smaller stones against the larger, on the borders of the sea, is another cause which in the course of time produces considerable effects; and hence all such stones have lost their angles, and become completely smooth and rounded.

Fall of Mount Grenier. The fall of a part of Mount Grenier, one of the calcareous mountains of Savoy, illustrates the effects of frost, and the gradual undermining of rocks by torrents. Mount Grenier is upwards of 4000 feet high, and rises abruptly above the plain on which it stands. The top, or cap, is an immense mass of limestone, 600 feet thick, below which are strata of a softer kind, and it is to the decay of the latter that the fall is attributed, the cap being undermined by the gradual erosion and removal of the under strata. The fall took place in the year 1248. The larger masses, says Mr. Bakewell, evidently came from the upper, or highest part of the mountain, and the velocity they acquired by the fall must have been at least 300 feet per second, before they reached the ground. As these immense masses struck obliquely against the base of the mountain, they thus acquired a projectile force which spread them far into the plain. These masses were in such quantity, and were projected to such distances, as to cover nine square miles of surface, and to entirely bury five parishes, together with the town and church of St. Andre. In the course of years the rains, or currents of water from dissolving snow, have furrowed channels between the larger masses of stone, and washing away part of the loose earth, have left an immense number of conical hills still remaining. So deep and vast was the mass of ruins which covered the town of St. Andre, and the other parishes, that except a small bronze statue, no individual article belonging to any of them has been found to this day.—*Bakewell's Geology.*

Fall of Rocks from the Alps. A part of a mountain near Servos, belonging to the Alpine range, and on the road to Chamouny, fell down in the year 1751. This continued several days, mass after mass being precipitated, while an immense volume of dust, the consequence of friction, by the sliding of the rocks on each other, rose so high, and was so dense as to have been seen at the distance of twenty-five miles. A succession of reports, like the firing of heavy cannon, announced the fall of these masses day and night. The aggregate amount thus precipitated was estimated by Donati at 3,000,000 of cubic fathoms, or fifteen millions of cubic feet, a quantity sufficient to form a large hill.

DESTROYING EFFECTS OF THE SEA.

Mr. Lyell has adduced many instances of the power of sea waves to move large masses of solid rock. In the Shetland Isles this effect has been quite surprising. In 1818, during a storm, a mass of granite, nine feet by six, was thrown by the waves up a declivity to the distance of 150 feet; and, in the winter of 1802, a mass of rock eight feet by seven, and five feet thick, was moved to the distance of ninety feet, by the same force.

The reader, who remembers the immense power which velocity gives a sea wave, as above illustrated, will be at no loss to comprehend why the strongest ships are sometimes reduced to fragments in a few minutes; nor will he wonder at the destroying effects which a wide ocean must produce on a coast, which is not guarded by a strong barrier of solid rocks.

Destruction of the Village of Mathers. The village of Mathers, on the east coast of Scotland, was destroyed by an inroad of the sea, in 1795. This town was guarded by a barrier of limestone rock next the shore, but during a storm the waves of the ocean broke through this barrier, and in one night destroyed and swept away the whole village. The sea penetrated 150 yards inland, where it has maintained its ground ever since.

Eastern Coasts of England. The eastern coasts of England are constantly suffering from the inroads of the sea. On the old maps of Yorkshire, many spots are marked as the sites of towns which are now sand banks in the ocean. A greater or less portion of the coasts of Norfolk and Suffolk, are every year swallowed up by the sea. The town of Sherringham, on this coast, exhibits a melancholy proof of this fact. With respect to this town, Mr. Lyell states, that at one point there is now a depth of water of 25 feet, (sufficient to float a frigate,) where only 48 years ago, there stood a cliff fifty feet high, with houses upon it. Further to the south are cliffs more than 200 feet high, more or less of which are every year precipitated into the ocean, in consequence of being undermined by the waves. The whole site of the ancient town of Cromer now forms a part of the bed of the German ocean, the inhabitants having gradually pulled down their houses and removed inland as the sea encroached upon them; and, from their present situation, they are in danger of being dislodged by the same cause. From this neighborhood, in the year 1822, a mass of earth and rocks was precipitated into the sea, to the extent of twelve acres, the cliffs being 250 feet high; and on the same coast, three ancient villages, several manors, and large portions of a number of parishes have, from the same cause, gradually disappeared, and been replaced by the ocean.

Since the time of Edward the Confessor, as appears by the records, the sea-coast town of Dunwich has lost in succession, a monastery at one time; at another, several churches; at another, 400 houses; and, subsequently, another church; the town hall and jail, together with many other buildings, all precipitated into the sea.

These are given as specimens of the devastating effects of the sea in different parts of the world, and, by which, it appears that if on the one hand, large tracts of coast are forming, and encroaching upon the ocean in one part of the world, as in the Baltic, and on the coasts of Italy, so on the other hand, the sea is encroaching on the land in other parts, probably to an equal extent.

In many instances, inundations from the sea have been the means of effecting, not only great changes in the surface of the earth, in a short period of time, but also of destroying vast numbers of human beings. On the coast of Holland these disasters have been peculiarly destructive, as well as on the coast opposite.

A considerable peninsula which lay between Groningen and East Friesland, and was thickly inhabited, was partly overwhelmed in 1277, and a considerable portion of the land carried away, with many houses and inhabitants. During the fifteenth century, other portions were destroyed by the same cause, and a part of the town of Forum, a place of considerable size, was swept away. In 1507, not only the remainder of Forum was ingulfed, in spite of the erection of dams, but also several market towns, villages and monasteries, were entirely destroyed, together with their inhabitants.

Further to the north, anciently lay the district of North Friesland. This was a peninsula; but in 1240, the sea destroyed the land next the coast, and thus formed an island called Northstrand. This island was originally of considerable extent, but the sea, from time to time, swept away small portions of it, until the inhabitants became so concentrated, that when the island was only four geographical miles in circumference, their number was still nine thousand. At last, on the night of the 11th of October, 1634, a flood from the sea swept over the whole island, and destroyed at once a great proportion of the inhabitants, all the houses, churches and cattle, carrying away even the land that had sustained them. By this dreadful calamity, there was swept away 1300 houses, with all the churches, 50,000 head of cattle, and more than 6000 people.

We might continue these accounts with regard to the changes which have taken place on the same coasts to great length; but our design being chiefly to give examples, rather than general details, we will here conclude this part of our subject.

DOWNS, OR SAND HILLS.

In some sections of country, the fine sand that is thrown up by the sea, is carried by the wind to considerable distances, and in such quantities as to cover the land entirely, and to fill up lakes and estuaries. Occasionally, also, there are sand plains at a distance from the sea, where vegetation seems never to have taken root, and where, consequently, there is nothing to prevent the sand from spreading in all directions by the force of the winds.

On the coasts of France and Holland, long chains of sand hills have been formed from the sea, which have effected important geological changes, by barring up the mouths of rivers and bays, and thus preventing the ingress of tides, and changing the course of currents.

On the north coast of Cornwall, in England, a considerable extent of country has been inundated by drifting sand and pulverized shells from the sea shore. Some of the hills thus formed are several hundred feet high. By the shifting of these sands, the ruins of several ancient buildings have been discovered, showing that these changes have been in progress for many centuries. In some places this sand has become so compact as to be employed for architectural purposes, the cementing agent being oxide of iron, which the water carries, in solution, from the upper to the lower strata.

But it is in the East, and especially on the borders of Egypt, that the devastating effects of sand has produced the most calamitous consequences. In Egypt, these are called *sand floods*, and of their effects De Luc has given the following statement:—

"The sands of the Lybian," he says, "driven by the west winds have left no lands capable of tillage on any parts of the western banks of the Nile, not sheltered by mountains. The encroachment of these sands on districts which were formerly inhabited and cultivated, is evidently seen. M. Denon informs us, in his *Travels in Lower and Upper Egypt*, that summits of the ruins of ancient cities, buried under these sands, still appear externally; and that but for a ridge of mountains, called the *Lybian chain*, which borders the left bank of the Nile, and forms, in the parts where it rises, a barrier against the invasion of these sands, the shores of the river, on that side, would long since have ceased to be habitable. "Nothing can be more melancholy," says Denon, "than to walk over villages, swallowed up by the sand of the desert, to trample under foot their roofs, to strike against the summits of their minarets, to reflect that yonder were cultivated fields, that there grew trees, that here were even the dwellings of men, and that all have vanished."

De Luc draws an argument from these *sand floods* in favor of the newness of the earth, and of the truth of the Mosaic history of the creation.

"If then," he continues, "our continents were as ancient as has been pretended, no traces of the habitation of men would appear on any part of the western bank of the Nile, which is exposed to this scourge of the sands of the desert. The existence, therefore, of such monuments, attests the successive progress of the encroachment of the sand, and these parts of the bank, formerly inhabited, will forever remain arid and waste."

"It is, therefore, not solely to her revolutions and changes of sovereigns, that Egypt owes the loss of her ancient splendor; it is also to her having been thus irrecoverably deprived of a tract of land, by which, before the sands of the desert had covered it, and caused it to disappear, her wants had been abundantly supplied. Now, if we fix our attention on this fact, and reflect on the consequences which would have attended it, if thousands, or only some hundreds of centuries had elapsed since our continents first existed above the level of the sea, does it not evidently appear, that all the country on the west of the Nile would have been buried under this sand before the erection of the cities of ancient Egypt, how remote soever that period may be supposed, and that in a country so long afflicted with sterility, no idea would even have been formed of constructing such vast and numerous edifices? When these cities, indeed, were built, another cause concurred in favoring their prosperity. The navigation of the Red Sea was not then attended with any danger on the coasts; all its ports, now nearly blocked up with reefs of coral, had a safe and easy access; the vessels laden with merchandise and provisions could enter them and depart without risk of being wrecked on these shoals, which have risen since that time, and are still increasing in extent." "Thus the reefs of coral which have been raised in the Red Sea, on the east of Egypt, and the sands of the desert which invade it on the west, concur in attesting this truth,—That our continents are not of a more remote antiquity than has been assigned to them by the sacred historian in the Book of Genesis, from the great era of the Deluge."

FORMATION OF CORAL ISLANDS.

It is but recently that any observations tending to interest or inform the naturalist, have been made on the production of *Coral Islands.* But the great extent to which these islands have been formed, together with the rapidity with which it has been said they are increasing, give this subject a considerable degree of interest, not only in respect to geology, but also as it regards commerce.

On this subject Dr. Macculloch says, "The production of the Coral Islands of the great Pacific ocean, which endanger this navigation and that of the Indian Archipelago, and are tending fast to destroy that of the Red Sea, is a fact completely distinguished from all other subjects of geological investigation. It also forms a most interesting branch of the present inquiries; and it is the more indispensable to examine it, because it has hitherto been unaccountably neglected by other geological writers."

"It is sufficient here," he continues, "to speak in the most general terms of a tribe of animals, for whose description, works on Zoology must be consulted. In a popular view, a coral is a calcareous structure, inhabited by numerous small animals or polypi; and each form of coral possesses its own species. Each, therefore, forms a sort of colony, the inhabitants of which are disposed in minute cells, which they construct themselves, thus producing the general structure, by their joint labors, as if al. were actuated by one design and one mind."

" This is the obvious appearance. But in reality the entire coral plant is one animal. A continuous animal structure pervades the whole, and the calcareous matter, in whatever form, must be viewed as the shell, being a secretion, or deposition of earth in its substance."—*Geology, vol.* 1. p. 337.

The coral insects, of which there are many species, belong to the class Polypi and order *Coralliferi*, of Cuvier. See Animal Kingdom, vol. iv. p. 387—95. They are a singular and curious tribe of animals, some of which are too minute to be examined by the naked eye.

The Coralliferi constitute that numerous suite of species which were formerly considered as marine plants, and of which the individuals are in fact united in great numbers to constitute compound animals, mostly fixed like plants; either forming a stem or simple expansion, by means of a solid internal substance. The individual animals are all connected by a common body, and are nourished in common, so that what is eaten by one goes to the nourishment of the general body of all the other polypi.—*Animal Kingdom*, ib.

The common coarse white coral, full of pores, may be considered as an aggregate of the shells, or habitations of one family of these animals. On inspecting a piece of this substance while growing, or building under water, when these animals are at work, small whitish protuberances may be seen projecting from these pores, which being touched, or on removing the coral from the water, are seen to contract and disappear, but re-appear again when the coral is returned to the water. These are the animals which construct the coarse coral only. Those which build the compact kinds, as the red, white, and black, and which (particularly the red) are so much valued for ornamental purposes, are of a different species from these, and are so exceedingly minute as to be of difficult detection.

Many species of this tribe are free, and swim with the current, but those which produce the mighty effects about to be described are fixed in their cells. *For an account of* *these species, see Parkinson's Organic Remains, and Cuvier's Animal Kingdom.*

It is for geography, not for a work of this nature, to describe the islands and rocks produced by the coral tribes. It is here sufficient to mention the islands south of the equator, between the West Coast of America, and New Holland, crowding the whole of that sea, under a rapid increase, accompanied by still more numerous rocks, destined perhaps to become the seats of vegetations, and the habitations of man; perhaps at length to form a continent in the Pacific Ocean. To these, abounding particularly between New-Holland, New-Caledonia, and New-Guinea, I may add those of the Indian Archipelago, including Cosmoledo, Chagos, Juan de Nova, Armante, Cocos, and the Maldive, and Laccadive islands.

When we consider the feebleness of the means, and the minuteness of the agents, the extent of these reefs and islands is a subject of equal curiosity and surprise. Among these, Tongataboo is sixty miles in circumference, and is elevated ten feet above the water. But this is but an insignificant work, when compared with the great coral reef on the eastern coast of New-Holland, which extends in an uninterrupted course the distance of three hundred and fifty miles. This, together with several islands of the same, form a continuous line of one thousand miles or more in length, varying from twenty to sixty miles in breadth. To form a just conception of such a production, we should imagine it exposed from the foundation. It is a mountain ridge, which bears comparison with many of the larger tracts of terrestrial limestone in height; the soundings in that sea being generally from 1000 to 1500 feet deep; and with respect to extent of range, it would far exceed any limestone formation known.—*Macculloch, vol.* i.—337.

But though we may be astonished at the vast productions of these diminutive animals, it is their instinct which ought still more to interest and surprise us. For, when we remember that in many other instances, numbers do compensate for individual weakness, and that there are myriads of millions of these constantly at work, our astonishment rather arises from a consideration of their numbers than the amount of their labors. And here we cannot but admire the beneficence of the Creator in having given the pleasures of existence to such hosts of instinctive beings, and though buried in the depths of the ocean, their enjoyments are not less than if watched by the inquisitive eye of man.

From the very low order of these animals in the scale of being, we should have little reason to expect they would exhibit any evident signs of intelligence; and yet as in other cases, we can here trace the most positive marks of design in the Great First Cause, in the adaptation of the means to the end proposed.

These animals cannot work above the water, and as they chiefly inhabit an ocean, where the wind constantly blows from one quarter, they raise their structure in a perpendicular direction on the windward side, so that when they come near the surface of the water, where the rolling of the sea would a part of the time leave them naked, the waves are thus broken and they can continue their labors to the leeward. The effect of this arrangement is the erection of a barrier on the one side, so that these little animals can work with facility and comfort on the other, and under similar circumstances, all the reasoning and experience of man would have answered no better purpose, than the instinct of these little worms.

After the windward side has been protected, the next part raised to the surface is at some distance to the leeward. The whole, when first seen, consists of a chain of detached rocks usually placed in a circular form, including an area of various dimensions, but often of several hundred feet in diameter. In the progress of the work, the intermediate parts, whether circular or straight, are gradually filled up, so that on the outside, the walls are perpendicular, and the water deep, but within, the water grows deeper from the margin towards the centre, producing a solid mass of rock, the upper part of which is in the form of a basin. This cavity is at first a kind of salt lake, but is gradually filled up by the labors of the animals, until finally the sea is so far excluded, that during calm weather the rain freshens the water in it, and thus at once end the labors and lives of these industrious creatures.

In process of time, when these animals continue their work around such a basin, so as to prevent the sea from dashing into it, and the rain has washed away all the salt, it becomes a pond of fresh water, forming a supply perhaps, for the otherwise perishing mariner, who happens to be wrecked on these bold shores. And this undoubtedly is but a part of that beneficent design and foresight, for which such myriads of these animals were brought into life.

The highest parts of these reefs being towards the wind,—at certain seasons of the year, when the tides are low, these parts will be exposed to the force of the waves, which will break off the most slender parts, and wash them to the leeward, where the animals are still at work, and by whom these fragments are wedded to the principal mass. In this manner, an island is raised permanently above the water, and by a continuance of the same process, considerable islands are gradually elevated above high water mark in the midst of the ocean.

It is not difficult to imagine how such islands may be clothed with vegetation. The seeds of plants are known to float thousands of miles, and still retain their vegetative powers. Such seeds taking root in the crevices of these rocks, produce plants, which by their annual decay, together with the decomposed coral, soon form a soil fit for others. These in their turn decay, and in that warm climate, where vegetation is luxuriant, there is formed, in a few years, a soil fit for shrubs and trees.

Many of these islands are only four or five feet above high water mark; and it is apparent, that the mode of formation above described, would require many centuries to elevate them to any considerable height. Indeed, it is not probable that the parts near the shore would ever acquire any additional elevation, since occasional high tides would carry away the vegetable matter deposited there. But as some of these islands are far above the level of the sea, we must look for some other cause of elevation besides the waters of the ocean, and the decay of vegetation. Tongataboo is ten feet above high water, at the water's edge, and even this is higher than can be accounted for from the causes described. But this is a slight elevation when compared with that of many others, for one of the Tonga islands, formed entirely of coral, is in some parts more than 300 feet high. It is hardly necessary to remark that this elevation cannot be accounted for by supposing a depression of the ocean, since this cause would have given all the other islands in that sea a similar height, and besides, it is well known that the sea has not materially changed its level for the last 2000 years We must therefore attribute the elevation of these islands to some force acting beneath them; and as we are unacquainted with any power, equal to such an effect, except that of volcanoes, so there can be little doubt but the force of submarine fire, was the active cause of their elevation. One of these islands, indeed, contains a volcano always on fire.

THE DELUGE.

No part of the Mosaic history has produced more ridicule, among infidels, or has been attacked with greater hopes of success, than that of the universal deluge.

"That the whole earth, (say these men,) was ever surrounded with water so deep as to cover all its mountains, is a supposition not only unphilosophical, but absolutely impossible. It is unphilosophical, because even admitting that there is a sufficient quantity of water in the sea to produce such a deluge, still no adequate cause can be assigned for the production of such mighty effects. But allowing a cause which might have moved the whole ocean out of its bed, and cast it upon the land, still such an effect could not have been produced as a universal flood, since it would have required many times more water than exists on the whole earth, to have covered all its mountains at the same time."

We shall not stop to answer these objections, but proceed to show, that notwithstanding these and many more have been urged against the probability of the Noachian flood, still no fact can be better established, since it has the concurrent testimony of sacred, natural, and civil history in its favor.

The period of the deluge is fixed by chronological writers at the year 1656, after the creation, corresponding to the year 2348 before the Christian era. These two sums make the period of the creation, 4004 years B. C. According to Mr. Blair, on the 10th day of the second month, which was on Sunday, Nov. 30th, B. C. 2347, God commanded Noah and his family to enter into the ark; and on the next Sunday, December 7, it began to rain, and continued to rain forty days, after which the deluge prevailed 110 days, making its continuance 150 days from the beginning. On Wednesday, May 6th, 2348 B. C. the ark rested on Mount Ararat. The tops of the mountains became visible on Sunday, July 19th, and on Friday, November 18th, Noah and all they that were with him came forth out of the ark.

Without reference to sacred history, we never could have known the *time* when this great flood happened—the fact itself, although we ought to require nothing more than the word of that history to establish its truth, is still capable of the strongest proof from the appearance of the earth's surface. Baron Cuvier, after having spent a large portion of a long life in investigating the natural history of the earth, comes to the following conclusions on the subject of the universal deluge,

"I can concur," says he, "with the opinions of M. M. De Luc and Dolomieu, that if there be any thing determined in geology, it is that the surface of our globe has been subject to a vast and sudden revolution, not longer ago than five or six thousand years; that this revolution has buried and caused to disappear, the countries formerly inhabited by man, and the species of animals now most known, that, on the contrary, it has left the bottom of the former sea dry, and has formed on it the countries now inhabited; that since this revolution those few individuals whom it spared, have propagated and spread over the lands newly left dry, and consequently it is only since this epoch, that our societies have assumed a progressive march; have formed establishments; raised monuments, and combined scientific systems."—*Cuvier Revolu. Globe*, 180.

The effects of that grand and awful cataclysm are still to be traced in every country, and in nearly every section of country on the globe. Vast accumulations of rounded, or water worn pebbles, huge blocks of granite, and immense beds of sand and gravel, are found in places where no causes now in operation ever could have placed them; and still that they have been moved is evident from the circumstances, or the places where they occur. "In the whole course of my geological travels," says Prof. Buckland, "from Cornwall to Caithness, from Calais to the Carpathians; in Ireland, in Italy, I have scarcely ever gone a mile without finding a perpetual succession of deposites of gravel, sand or loam, in situations that cannot be referred to the action of modern torrents, rivers or lakes, or any other existing causes. And, with respect to the still more striking diluvial phenomena of drifted masses of rock, the greater part of the northern hemisphere, from Moscow to the Mississippi, is described by various geological travellers, as strewed on its hills as well as its valleys, with blocks of granite, and other rocks of enor mous magnitude, which have been drifted (mostly in a direction from *north to south*,) a distance, sometimes many hundred miles from their native beds, across mountains, valleys, lakes and seas, by a force of water, which must have possessed a velocity to which nothing that occurs in the actual state of the globe, affords the slightest parallel." —*See Reliquiæ Diluvianæ.*

If it be inquired how it can be ascertained that blocks of granite have been transported from a distance, and that they do not belong to disrupted mountains in the vicinity, it is answered that there is a peculiarity in every formation or range of rocks or mountains, by which the mineralogist can readily distinguish them. Thus the calcareous rock of Gibraltar, and the iron ore of Elba, specimens of which every collection contains, are readily distinguished even by the most common observer from all other minerals. To the practised eye of a mineralogist, combined with the analysis of the chemist, no difficulty occurs in identifying any specimen with the rock to which it belongs.

On the secondary mountains of Jura, particularly on the slopes facing the Alps, a great many loose fragments of primitive rock, some of them containing a thousand cubic yards, occur. These are strewed over the surface, at the height of two thousand five hundred feet above the level of the lake of Geneva. They no where stand higher, or are more numerous than opposite to the largest, and deepest valleys of the Alps. They have undoubtedly travelled across the line of these valleys, their composition proving clearly, the mountain ridges from which they came. We may hence infer, that at the period of their transfer from the Savoy Alps, the lake of Geneva did not exist, otherwise they must have remained at its bottom, instead of being found on its opposite boundary mountain. —*Ure's Geology*, p. 362.

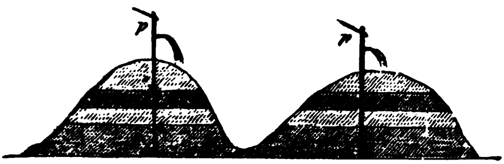
In estimating the transporting power of water, it must not be forgotten, as already noticed, that a solid, when immersed in a fluid becomes lighter by the weight of the bulk of the fluid which it displaces. Thus, if a rock be twice as heavy, bulk for bulk, as water, then when immersed in that fluid, it loses just one half its weight. A man may lift a stone under water with great ease, but if not aware of the above fact, he will be astonished to find that he cannot, with all his might, raise it above the surface.

There is no difficulty in conceiving that immense blocks of rock may be moved by water, since the weight lost by immersion, is in exact proportion to the bulk; and therefore if a little brook will move a pebble, by the same law, a great flood will transport a mountain. The blocks of granite found on the opposite side of the lake of Geneva, were probably carried there by the action of the deluge, after which the retiring waters scooped out the lake, and left both in the situation in which they are now found. Many of the plains on the north of Europe, exhibit on their surfaces, large blocks of granite, called *boulders*, with their sharp angles worn off, showing that they have been rolled from a distance. Their surfaces never exhibit the smoothness of sea-worn pebbles, nor do their forms show the effects of long-continued friction, like rocks which are found on the shores of the ocean, a proof that the catastrophe which forced them from their original situations was not of long continuance. Sir James Hall has even discovered the traces of such movements on rocks now in their original situations in the vicinity of Edinburgh. That district consists of hills and valleys, the surfaces of which are strewed with the wrecks of former rocks, which have been moved from their ancient positions by some mighty power. Channels, or furrows may be observed on the surfaces of solid rocks, across which these have been forced. The clay, covering the surfaces of these rocks, being removed, they are found to resemble a road along which many heavy bodies have been recently dragged, as if every heavy fragment had made a scratch of greater or less depth as it passed. These furrows are parallel to the general direction in which the diluvial current passed, as shown by the forms of the hills and valleys.

That the diluvial waters reached the summits of lofty mountains, is evident from the boulder blocks of Mount Blanc, being thrown over on the high acclivities of Mount Jura. Professor Buckland says, that the Alps and Carpathians, as well as every other mountainous region which he has visited, bear the same evidence of having been modified by the force of water, as do the hills of the lower regions.

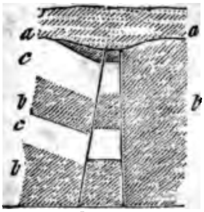
Besides the evidence which the situations of rocky masses exhibit of a great flood, there are proofs of the same, to be found almost everywhere among the hills and valleys. Thus many hills have been formed by the removal of the earth, which forms the valley between them, circumstances proving that such valleys did not always exist, but that the strata forming the two hills were once continuous.

Suppose that on digging wells, on two hills separated by a valley, there should be found a bed of gravel ten feet thick, then a layer of clay, then a bed of chalk, &c., and that these formations should correspond exactly with each other, both in respect to kind, direction and thickness; then the inference would be unavoidable, that these strata once continued through the valley, and that both the hills and valley were formed by the removal of the earth from the latter, and that this must have been effected by a stream of water now existing, or by a great flood. But in the cases to which we refer no such streams exist, nor from appearances ever did exist, there being no sources of water by which they could be supplied.



No adequate cause can therefore be assigned for such an effect, except it be the Noachian deluge. The adjoining cut shows the two hills; the correspondence of the strata through each, and the wells by which they are pierced. Such examples, it is believed, are of very common occurrence, and would often be observed were due notice taken of the strata when digging wells on opposite hills.

Immense beds of sand and water-worn pebbles are found deposited in places and situations which cannot be accounted for on any supposition, except that of a temporary and sweeping flood of waters.

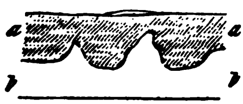


Mr. de la Beche, under the head of "*Erratic Block Group*," "Geological Manual," p. 157, has described and figured a deposition of gravel which occurs at Warren Point, near Dawlish, and which we copy as an illustration of the subject. The figure is a section of the point, and is a mixed example of a fault, and of transported gravel upon it, *b b*, conglomerates, or pudding stones, and *c c*, strata of the red sandstone formation, fractured or broken into faults, by the dykes *f f*, so that continuous strata are displaced as seen in the cut. Upon these fractured strata rests a bed of gravel *a a*, composed of chalk, flints, and green flinty sand, mixed with a few pebbles similar to those in the conglomerates *b b*. This sand has evidently been deposited since the fracture, for it rests quietly upon it, and appears never to have been disturbed since its deposition. The chalk and green sand of this district have once covered very considerable spaces, though the latter is now seen only on Haldon Hills, near this section, but separated from it by an intervening valley. There are many other dislocations so covered on the same coast, (Plymouth;) where these appearances can be observed with the greatest ease, especially at low water.

"It might be supposed," says Mr. De La Beche, "that these chalk flints and pieces of chert, (a flinty stone,) were merely the remains of superincumbent masses of chalk and green sand, which have been destroyed, by meteoric agents, the harder parts falling down on the top of the fracture. We can scarcely consider this physically probable. or even possible; for it supposes the removal of more than 600 feet of sandstone and conglomerate, (for not until that height above this section would the green sand and chalk come on,) without scarcely leaving any of the pebbles, or large masses of the red sandstone, while the flints and cherts, which belonged to the upper, and consequently first destroyed rocks, remain."

"Let us now consider," continues our author, "another class of appearances. Over the whole of this district, (Plymouth,) where transported gravel occurs, the surface of the rocks, (it being of no importance what they happen to be,) is drilled into cavities and holes, similar to those well known on the chalk of the east of England. The following sections will illustrate this.

a, *a*, gravel, principally of flint and chert, resting in a hollow of the red sandstone, *b*, *b*, between Teignmouth and Dawlish, the lines in the gravel following the outline of the cavity.



a, *a*, in the next figure, is gravel composed in a great measure of flints, among which are some large rounded pieces of silicious breccia, resting on cavities in pipe-clay.

"Other examples might easily be adduced, but these are here given, because the geological student can easily observe them. They seem to point to some general agent, which in its passage over the land, has produced similar effects on various rocks, forming cavities, and depositing fragments, transported from greater or less distances."

Mr. De La Beche further remarks, "that the form of the valleys in that district are gentle and rounded, and such as no complication of meteoric causes, that ingenuity can imagine, seems capable of producing; that numerous valleys occur on the lines of the faults; and that the detritus (broken rocks) is dispersed in a way that cannot be accounted for by the present action of mere atmospheric waters. I will more particularly remark," says he, "that on Great Haldon Hill, about 900 feet above the sea, pieces of rock which must have been derived from levels not greater than 700 or 800 feet, and even less, occur in the superficial gravel. They certainly are rare, but may be discovered by diligent search. I there found pieces of red sandstone, porphyry, and a compact silicious rock, not uncommon in the graywacke of the vicinity, where all the rocks occur at a lower level than the summit of Haldon, and where certainly they could not have been carried by rains or rivers, unless the latter be supposed to delight in running up hill."

In continuing this subject with respect to the lowlands of Sidmouth and Lyme, Mr. De La Beche says, "it may sometimes be possible, with the aid of ingenuity, to produce a case of transport by a long continuance of such natural effects as are now seen, but in other situations, such explanations seem altogether valueless, and unphilosophical.

Not only are gravels brought from various distances, but even huge blocks, the transport of which, by actual causes, into their present situations, seem physically impossible. Professor Buckland mentions that he found among the transported gravel of Durham, twenty varieties of slate and greenstone, which do not occur in places nearer than the lake district of Cumberland. Professor Sedgwick remarks that the boulders of Shap granite, which is so peculiar as not to be confounded with any other rocks in the north of England, are not only drifted over the hills of Appleby, but have been scattered over the plain of new red sand stones; rolled over the great central chain of England into the plains of Yorkshire;—imbedded in transported matter of the Zees; and even carried to the eastern coast of the Island.—*Ann. of Phil.* 1825.

Between the Thames and the Tweed, pebbles, and even blocks of rock, are discovered, of such a character that they have been considered, we believe, by all competent judges, as having been derived from the coast of Norway, where only similar rocks are known to exist.

Mr. Phillips states, that the *diluvial* accumulation in Holderness, on the coast of Yorkshire, is composed of a base of clay, containing fragments of pre-existing rocks, varying in roundness and size. The rocks from which the fragments appear to have been transported are found, some in Norway; others in the Highlands of Scotland, and in the mountains of Cumberland—others, in the north-western and western parts of Yorkshire; and no inconsiderable portion appears to have come from the sea coast of Durham, and in the neighborhood of Whitby. In proportion to the distance they have travelled is the degree of roundness they have acquired.—*Phillips' Illus. Geol. Yorkshire.*

In this country similar phenomena almost everywhere present themselves to the eye of the observer. Beds of water-worn pebbles, such as are now found only on the borders of the sea; and immense blocks of granite lying in situations to which it is evident they must have been transported, and where no causes now in operation could possibly have placed them, are not uncommon occurrences.

The whole of Long Island is either a diluvial or a tertiary formation, and in which bones are sometimes found. Near the east end of that island lies the skeleton of a whale, a mile from the shore. A part of the bones are, or were, a few years ago, in a good state of preservation. The same formations extend to various distances from the sea, along the coasts of New Jersey, Pennsylvania, Virginia, and the other maritime states, to Alabama. Through the greatest part of this immense tract, diluvian deposites, with shells, are found. In New Jersey, from ten to twenty feet below the surface of this formation, is found a greenish blue marl, containing various shells, as Ammonites, Bellemnites, Chama, Ostrea, Terebratula, &c. (These will be found figured and described towards the end of this volume.)

Boulders of various sizes are seen in many places. In East Lyme, Ct. near the road leading from Rope Ferry to Saybrook, at a location called Keeney's hill, there is a huge block of granite, weighing, by estimate, nearly four hundred tons. Any person, after a moment's consideration, would conclude that this rock must have been transported from a distance; for its present situation is in an open field, on or near the summit of a considerable hill, there being no rocks of the same, or indeed of any kind on the surface near it. On examining the neighborhood, however, the inquirer will soon find that it came from a granite hill, of small elevation, situated about two miles in a northwest direction, and therefore must have been moved towards the southeast, and this is confirmed by the direction of the hill on which the rock stands, and of the valley below. The erratic rocks of Europe have all been moved in the same direction.

Professor Hitchcock, in his report on the Geology of Massachusetts, appears to have examined the diluvial deposites of that state with much attention, and has shown that the current there, was also from the north and northwest, towards the southeast. "The conclusion," says he, "to which I have been irresistibly forced by an examination of this stratum in Massachusetts, is, *that all the diluvium, which had been previously accumulated by various agencies has been modified by a powerful deluge, sweeping from the north and northwest, over every part of the state, not excepting the highest mountains;* and that since that deluge, none but alluvial agencies have been operating to change the surface."

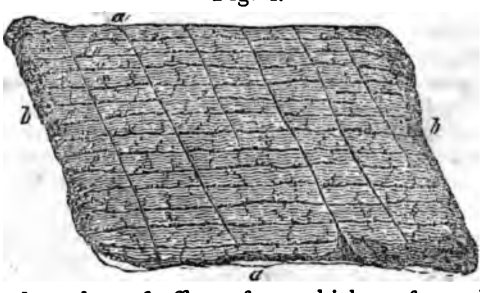
"The diluvium of Plymouth and Barnstable," he continues, "consists almost entirely of white sand, some pebbles, and a very large number of boulders of primary rocks. These boulders consist chiefly of granite, sienite, and gneiss, with occasional masses of graywacke conglomerate, common felspar and porphyry. They all correspond with the rocks found in place along that coast, in the vicinity of Boston and Cape Ann; and no one, it appears to me, can see the marks of degradation along that coast, who will not be convinced that a large portion of the pebbles and boulders of Plymouth and Barnstable counties, came from thence."—p. 142—3.

Some of the boulders are from ten to twenty, and even thirty feet in diameter, and frequently occupy nearly the whole surface, so that one can hardly persuade himself, when he examines them at a distance, that they are not genuine ledges.

In various parts of the state, the diluvium is piled up in elevations of various extent and height, leaving corresponding depressions. Near the extremity of Cape Cod, the hills and valleys thus formed, are of astonishing height and depth, the elevations being sometimes 300 feet; and yet these inequalities are obviously the results of currents of water, since they are precisely of the same shape of those seen in the dry beds of rivers.

Examples of the diluvial action, if not equalled in the magnitude of its effects, are still as apparent to the observer in almost every part of the state.

Fig. 4.



Another class of effects, from which professor Hitchcock not only concludes that a mighty current of water once swept over the surface of Massachusetts, but from which he also infers its direction, is the existence of grooves, furrows, and scratches upon the surfaces of the rocks that have never been moved from their places.

The adjoining sketch, fig. 4, exhibits a rock of this description, near the turnpike from Boston to Chelmsford, near the line between Bedford and Billerica, and not far from the sixteenth mile stone from Boston. The rock is intermediate between gneiss and mica slate. Its strata seams run in the direction of *a a;* and the grooves and scratches in the direction *b b.* The direction of these grooves is nearly north and south; and this is their general course in every part of the State, east of Hoosac mountain. Commonly, however, they run a few degrees east of south and west of north.

A great number of other instances are adduced, presenting similar phenomena, in different parts of the State, all of which correspond with the above, in respect to the direction of the furrows.

Mr. De La Beche, after having described the various facts which exist in many parts of Britain, indicating the transportation of rocks, stones, and sand, comes to the following conclusions. "The probability, therefore, as far as the above facts seem to warrant, is, that a body of water has proceeded from north to south over the British isles, moving with sufficient velocity to transport fragments of rock from Norway to the Shetland isles, and the eastern coast of England; the course of such a body of water having been modified and obstructed among the valleys, hills, and mountains, which it encountered; so that various minor and low currents having been produced, the distribution of detritus has been in various directions."

If the supposition of a mass of waters having passed over Britain be founded on probability, the evidences of such a passage, or passages, should be found in the neighboring continent of Europe, and the general direction of the transported substances should be the same. Now this is precisely what we do find. In Sweden and Russia, large blocks of rock occur out of place, in great numbers, and no doubt can be entertained, that they have been transported southward from the north. The same phenomena are observed in Germany, the Netherlands, and indeed in nearly every part of the old world, where observations have been made. The lower parts of the last named countries contain huge blocks of transported rock, which are proved by their mineralogical characters, to have been derived from the northern regions.

South of Germany and the Netherlands, various obstructions arise in the form of mountains; and if the supposition of a mass of waters be correct, it would be thrown out of its original course, in various directions, and from lofty mountain ranges, such as the Alps, there would be a re-action, and a back wave retrograding through the valleys, would leave deposites, perhaps in the form of small hills, as is often seen in various parts of the world. M. Elie de Beaumont has described, probably, the effects of such a backward action, in an immense quantity of debris which has been driven from the central chain of the Alps, outwards.

A question of importance now presents itself, with respect to the general changes which were produced on the surface of the earth by this moving mass of waters. Did the valleys exist as they do now, when this deluge began, or were they formed by its action? De Luc, Von Bush, Beaumont, and several other geologists of the first class, have presented the world with a detail of facts, from which they all infer that the great valleys existed previously to the catastrophe which tore the rocks from the Alps, and scattered them on either side of that chain of mountains. It is most probable that the same conclusion ought to be drawn, with respect to all other great valleys, there being no good reason to believe, that they were excavated by the waters which transported the rocks and sand banks above described. Still, as we have already noticed, there is no doubt but the mass of waters which moved rocks weighing hundreds of tons, often to the distance of many leagues, produced great changes on the surface of this globe, and that many, or perhaps most of the smaller valleys, as well as the beds of rivers, may be attributed to its effects.

From the facts and circumstances thus thrown together, there is sufficient evidence that the earth has been deluged by a flood of water, which in its course transported great masses of rock from one place to another; excavated valleys, formed hills of diluvial detritus, and finally left its effects on the surface of the globe, which are almost everywhere apparent at the present day. Geologists generally agree that this deluge could not have taken place at a very remote period of time; perhaps four or five thousand years ago, and therefore this period corresponds sufficiently near to that at which the Mosaic history states the Noachian deluge to have happened, to convince any unprejudiced mind that the effects of water above described, can only be imputed to that flood, an account of which is given in the book of Genesis.

Animals destroyed by the deluge. The animals supposed to have been destroyed by the deluge, and whose remains have been discovered in diluvial deposites, are the following. It is not certain, however, that the destruction of the whole list was contemporaneous, but the bones of all are found in superficial gravels, sands or clays, which believers in the Mosaic account consider as belonging to the effects of the general and punitive deluge.

1. *Elephas primigenius*, (Blumenbach,) Primitive Elephant. Remains found in various parts of Europe. Very common in Siberia, Russia, and most northern parts of Asia, where the tusks are uninjured, and are dug up and sold for ivory to a great extent. It is also found in the northern parts of North America. This is the *mammoth* of the Russians.

2. *Mastodon maximus*, (Cuvier,) Great Mastodon.—Found in Ohio, Kentucky, New York, and other parts of North America. It has tusks like the Elephant, but was a larger animal. It is the *mammoth* of the Americans. Of this animal, there are six species, differing chiefly with respect to size. The M. maximus is found only in North America. The other species occur in various parts of Europe, and in South America.

3. *Hippopotamus major*, (Cuvier,) Great Hippopotamus. Found in various parts of England, and in Bavaria.

Hippopotamus minutus. Little Hippopotamus. It is found in France.

4. *Rhinoceros.* Cuvier has determined four species of this animal in the fossil state, none of which belong to either of the three living species. These fossil bones are common in some parts of Europe, but none of them have been found in America.

5. *Tapirus giganteus.* The bones of the gigantic Tapir are found in many parts of France, Bavaria, and Austria.

6. *Cervus giganteus.* Great Elk. Found in Ireland, Silesia, banks of the Rhine, and near Paris.

7. *Cervus.* Several species of extinct deer are found in various parts of Europe.

Bos. The Ox. The bones of the ox tribe are common in several parts of Europe.

8. *Hyena.* The fossil remains of this animal, are also common in Europe.

9. *Equus.* The Horse. Common in many places.

10. *Megalonyx.* (Jefferson,) Green Briar. Virginia. Not yet found in any other place.

11. *Megatherium.* Buenos Ayres.

Historical proofs of the Deluge. Notwithstanding the abundant proofs, which, in the opinions of most geologists, the earth presents of a general deluge, there are still some respectable writers on that subject, who, giving no credit to the Mosaic history, seek out other causes, to which they attribute the effects generally assigned to that catastrophe.

It is a point of great importance in geology, to show clearly, that this earth was once drowned by a flood of waters, because if this be not a truth, few facts in the natural history of the earth can be depended upon, since few are better established, than that there was a deluge. This being in relation to our subject, merely a question of science, we at present claim nothing for the truth of the Mosaic history, as an argument in its favor.

The fact of a universal cataclysm is not only shown by the appearance of the earth, but by civil history, by tradition, and by the condition and number of its inhabitants.

The paucity of mankind, and the vast tracts of uninhabited land which are mentioned in the history of the primitive ages, show that the human race at present on the earth, are but of recent origin, and that they sprung from a small stock; and to this may be added that the great number of petty kingdoms and states in the first ages, concur to the same purpose.—*Horne's Introduction*, vol. i. p. 170.

The existing population in North America, is in itself sufficient to show the recent origin of the present race of man. Had the millions of people which existed before the deluge, continued to increase in the same ratio that the Americans have, during the last two hundred years, and this without reference to emmigration, is it probable that any part of this earth would now remain uninhabited? Were we to make an estimate of the number of inhabitants which North America will contain two thousand years hence, taking the last two hundred as data, where should we find a vacant spot, during the existence of such countless millions; and yet the present race have continued to increase, we suppose, for more than four thousand years. If there was no catastrophe which destroyed the great body of mankind, and had they continued to increase from the creation, is there not every reason to believe, nay, is it not quite certain, that their numbers would have been vastly more numerous than they actually are?

Pretended Antiquity of some Nations. It has been said, that several nations could trace their antiquity to periods before the historical date of the deluge. These pretensions, when carefully examined, have been found, in every instance, to be entirely groundless.

It is well known that the Hindoos claim the highest antiquity for their nation and their learning. Sir William Jones, who examined the authorities on which these high claims were founded, became convinced, that such pretensions were without the least foundation in truth. "We find," says that eminent scholar, "no certain monuments, or even probable tradition, (among these people,) of nations planted; empires and states raised; laws enacted; cities built; navigation improved; commerce encouraged; arts invented; or letters contrived, above twelve, or at most, fifteen or sixteen centuries before the birth of Christ." Indeed, it is known from the researches of those who have made the literature and antiquities of that nation a subject of study, that they possess no authentic history which dates anterior to the third or fourth century of our era.

There is a popular opinion that the Chinese are able to trace the history of their nation to a very remote antiquity; and yet, on examination, they do not pretend to possess any knowledge of their own nation, anterior to the eleventh century before the Christian era, and even this is probably, almost, if not entirely fabulous.

We shall notice further on this point, that the pretensions which the Egyptians have made to the great antiquity of their nation, appear to have been founded on their mode of reckoning time, by which a year consisted of a lunar month, or thirty days, instead of 365 days; and that the claims of the Chaldeans to profound science and remote antiquity, are equally unfounded. According to Berosus, they knew so little of Astronomy, the oldest of the sciences, as to consider the moon a luminous body, which sheds its own light, instead of borrowing it from the sun.

In fine, so far as examination has been made, the history, the arts, the antiquities, and the languages of all nations, concur to prove the comparatively recent origin of the present races of men.

Tradition proves the Mosaic account of the Deluge. A tradition of the deluge, in many instances very nearly coinciding with the account given of that catastrophe by Moses, has been almost universally preserved among the ancient nations. It is indeed a very remarkable fact concerning that event, that the memory, or traditions of most nations ends with some traces of its history, however imperfect. This is even the case with several of the nations recently discovered, and before unknown to the civilized world, and which therefore could not have derived this tradition from the history of Moses, or from the communication of travellers.

Without reciting, in detail, the abundant proof which authors contain on this subject, we must content ourselves by adverting to a few of these traditions.

Josephus affirms that Berosus, the Chaldean historian, has related the circumstances of a great deluge, in which all mankind perished except a few, and that *Noachus*, the preserver of the human race, was carried in an ark to the summit of an Armenian mountain. Josephus also testifies that Hieronimus, the Egyptian historian, who wrote the antiquities of the Phœnicians, and N'cholas of Damascus, together with other writers, in common with Berosus, speak of this same deluge. Likewise there is a fragment preserved of Abydemus, an ancient Assyrian historian, in which it is said, not only that there was a deluge, but that it was foretold before it happened, and that birds were sent forth from the ark three different times to see whether the waters had abated. This fragment also states that the ark was driven to Armenia. It is hardly necessary to observe how nearly these accounts agree with that of Moses, and yet it is by no means supposed, that they were derived from the sacred writings, but from the traditions of the nations among whom these historians resided.

Among the Greeks, Plato mentions the great deluge, in which cities were destroyed, and the useful arts lost

And Diodorus affirms that there was a tradition among the Egyptians, that almost all animals perished by a general deluge, which happened in Deucalion's time.

Now commentators and scholars inform us, that Deucalion's flood, and that of Noah's are the same. Plutarch, in his account of the sagacity of animals says, that a dove was sent out by Deucalion, which coming back to the ark again, was a sign that the flood continued, but afterwards flying away, proved that there was dry land.

Lucian mentions Deucalion's flood, and states that only a remnant of the human family was saved from its effects. He also says that the present race of man was not the first, but that all were destroyed, except Deucalion and his family, and that this destruction was caused by the wickedness of man.

Many more examples of a similar kind are noted by authors, but we shall only mention that traditions of the flood, more or less mixed with fable, are retained by the Hindoos, Burmans, and Chinese. The tradition of the latter refers not only directly to the deluge itself, but also to the cause of it, viz., the wickedness of man. Similar traditions are also traced among the ancient Goths and Druids, as well as among the recent Mexicans, Brazilians, and Nicaraguans; to which may be added the newly discovered people of Western Caledonia, the Otaheitans, before their conversion to Christianity and the Sandwich Islanders. *See Bishop Newton's works, and Horne's Introduction*, vol. i.

From these various facts it is manifest, that the heathen were not only acquainted by tradition with the fact of a universal deluge, but also with many of its circumstances, and that these traditions often bear a striking analogy to the account given by Moses.

In closing this part of our subject, we may remark, that few facts stated in history, can bring to its support so much concurrent testimony, as that of a universal deluge. The face of the earth almost everywhere records its effects, and often in the most eloquent and striking manner, so that the rocks themselves are everlasting witnesses against the folly of unbelievers. Profane history is not silent on this subject, but brings forward her testimony in quantity more than sufficient to establish an ordinary fact. Tradition, though blunted by fable, clearly testifies to the same truth. And, lastly, the Sacred Scriptures, written by the express command of Divine authority, have not only « ; scribed, in the most simple and lucid terms, this awful c.- tastrophe, but have explained the reason why such a calamity was brought upon our race

The Ark of Noah. It has been objected against the Mosaic history, with confidence, and undoubtedly often with considerable effect, that it is very improbable, Noah, at that period of the arts, could have constructed an ark of sufficient capacity to contain specimens of all the animals on the earth, together with his own family, and such a quantity of provisions as to sustain the whole for the term of 150 days. But this objection will instantly vanish when the dimensions of this vessel are considered.

The dimensions of Noah's ark were three hundred cubits in length, fifty in breadth, and thirty in height, and consisted of three decks, stories, or floors. Reckoning the cubit at a foot and a half, or eighteen inches, Dr. Hales has proved that the ark was of the burden of 42,413 tons, as we compute the tonnage of ships at the present day. A first rate man of war is between 2,200 and 2,300 tons, and consequently the ark had a capacity of stowage equal to eighteen such ships, the largest now in use. It might therefore have carried 20,000 men with provisions for six months, besides the weight of 1,800 cannon, and other necessary equipments and military stores for such an armament. Can it be doubtful, therefore, whether this vessel had sufficient capacity to contain eight persons, and about 200 or 250 pairs of four footed beasts, a number, to which, according to Buffon, all the various distinct species may be reduced, together with pairs of such fowls, reptiles, and creeping things, as cannot live under water, and provisions for the whole, even for a year.*

Was the Deluge Universal? We have stated at the

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* Dr. Hale's Analysis of Chronology, vol. i., p. 328. The reader who desires to pursue this subject, will find a good summary in Horne's Introduction to the Critical study of the Scriptures, vol. i. But the books which treat the subject more at large, and in connexion with Geology, are Howard's History of the Earth and Man, 4to. Buckland's Reliquiæ Diluvianæ. Cuvier's Theory of the Earth. Ure's New System of Geology, and Penn's Comparative Estimate of the Mineral and Mosaical Geologies.

beginning of this article that an objection had been raised against the truth of the Mosaic history, on account of there not being supposed a sufficient quantity of water now on the earth, to cover the mountains as there represented. At the epoch of the creation, the whole earth was surrounded with water, otherwise there is no meaning in the command, "Let the waters under the heavens be gathered together unto one place, and let the dry land appear." If it be objected that this was before the elevation of the hills and mountains, and that the earth at that time was a smooth ball, and therefore might be entirely covered by a thin stratum of water, it requiring much less to cover a smooth, than an uneven surface, still, until it can be shown to what depth the earth was then covered, it cannot be proved that there was not a sufficient quantity to cover the mountains as they now exist. As there have been no new creations, the quantity of water now existing, is undoubtedly the same that it was when it surrounded the whole earth. It is now chiefly collected into one continuous ocean, the depth of which is in general entirely unknown. Calculations, it is true, have been made, on the quantity of water the oceans, seas, and lakes contain, with a view of estimating the aggregate amount on the earth. But it is obvious, that not even an approximation to the truth can be offered on this subject, until more is known concerning the depths of the different oceans, than at present. Besides, it is not necessary to suppose that all the mountains were covered on the same day, or even week, for the deluge might have swept the earth from one country to another, in a manner similar to the great tides of the present day. The only difficulty in the way of such a hypothesis, is the length of time which the mountains continued covered where the ark rested. But as there is every reason to believe that the eastern portion of the globe was the only one then inhabited, and as the deluge was a punitive measure, brought on by the wickedness and violence of man, we may reasonably suppose that it began first, and continued longest in the countries where he dwelt. Perhaps the "windows of heaven" were opened only over that devoted portion of the earth, and from thence the flood swept in all directions to other parts. It is certain that all parts of the earth which have been examined, contain monuments of a sweeping deluge; and that the mountains in various countries were covered by it, is proved not only by the removal of great masses of rock from their places, but also by the organic remains of quadrupeds and fish, found buried at great heights above the sea, and under such circumstances as to show that they were deposited there by water.

It is not however supposed that in every instance where such remains are found far above the sea, they were deposited by the deluge, as it will be seen in another place, that limestone, and other stiata containing shells, have been elevated by subterranean forces.

The universality of the deluge is sufficiently proved, therefore, by the appearance of the earth, and that it covered the mountains, at least many of them, there is good reason to believe, independently of the assertions of Scripture, though the physical evidence on this point is perhaps not conclusive.

Were all the animals existing in the primitive world preserved in the ark? It is certain that there once existed quadrupeds on the earth, which are unknown at the present time, and which it is nearly as certain do not anywhere exist. The remains of these extinct species, as we have already shown, are found in almost every part of the world. Did these races perish at the time of the deluge, or did they gradually become extinct, before or since, that catastrophe?

Many fossil bones are in such a state of preservation, as to prove that their races were in existence at no very remote period. This is especially the case in cold climates, as in Siberia, where the tusks of elephants are undecayed. Still, *time* produces the decomposition and total destruction of all organized substances, when exposed to the atmosphere, or buried in the ground, and among the Siberian bones, there are some which show its effects much more than others. These, therefore, we may suppose, other circumstances being equal, are the most ancient. But in general, the Siberian bones of quadrupeds, as well as those found in other countries, and attributed to the flood, appear to be of about the same antiquity, and besides, these remains, or those of similar species, wherever found, appear to have been buried under similar circumstances. The kind of deposite in which they are found is everywhere similar, and apparently of the same age, and hence geologists have generally come to similar conclusions with respect to their antiquity, and the manner in which the animals were destroyed. A sudden, violent, and general catastrophe, appears to have destroyed these ancient races, and at the same time, to have buried them in its effects. The deposites in which the bones are interred, are what geologists term *diluvial*, that is, belonging to the deluge. This is the latest formation, with the exception of the *alluvial*, which is constantly deposited at the present time.

Taking these circumstances in connexion, it is thought that there are sufficient reasons to conclude, that the lost species of quadrupeds became totally extinct at the epoch of the general deluge, the history of which is given by Moses, and that they perished by the same catastrophe which destroyed every individual of the human race, except Noah and his family.

A comparison of the bones of the fossil species, with those of present ones, show that they generally were of a different species. Hence we must come to the conclusion, that *not* all, or every species of quadrupeds existing before the deluge, were preserved in the ark, but that many races perished by its waters.

The divine command to Noah, that he should take into the ark "of every living thing, of all flesh, two of every sort," must therefore be understood as a *universal term*, with a *limited signification*, as is often the case in scripture language, and particularly with respect to the word which we translate *all*. Thus Dr. Hammond, in his note on Cor. i. 13, says that this word is not always to be taken in its utmost extent; "but according to the use in like phrases, in all languages, wherein the universal sign, affixed, either to persons, or times, or places, or things, signifies only a greater number, but not *all*, without exception."

In like manner, Schleusner observes that the word *all*, *every*, in scripture, is often employed indefinitely, to signify *various—of different kinds;* and often, also, to denote many, a great number.

In the narrative of the deluge, this word is repeatedly employed in this indefinite manner. Thus, Gen. vi. 17, "And behold I, even I, do bring a flood of waters upon the earth, *to destroy all flesh wherein is the breath of life, from under heaven.*" And in another verse, "for *all* flesh had corrupted his way upon the earth." Now it does not appear that it was the intention of the Almighty, literally to destroy all flesh, since Noah and his family, together with the animals which he took into the ark, were saved; nor does it appear that every individual had corrupted his way, for "Noah found grace in the eyes of the Lord."

Precisely similar language is used with respect to the animals to be taken into the ark. Thus, verse 19, "And every living thing, of all flesh, two of every sort shalt thou bring into the ark." Now no one will contend that the fish of the sea were intended to be included in this command, and yet the terms employed "every living thing," would include these, equally with terrestrial animals.

The terms of the Mosaic history, therefore, give us liberty to conclude, that *all* the antediluvian species, without exception, were not admitted into the ark; and consequently, we may consider the extinct species, whose bones are found in the earth, as exceptions to the general terms of the divine command, without the least violation of the intended meaning of the sacred scriptures.

The more ancient bones, or those of the same species which are more decayed than others, we may suppose belonged to animals which died natural deaths, before the time of the catastrophe which destroyed the remainder of the race; while those in a similar state of preservation, and found under similar circumstances, may be considered as having belonged to animals which perished by the same catastrophe.

VOLCANOES AND EARTHQUAKES.

Having, in the preceding pages, given such a history of the changes produced by *water*, as our limits would allow, we now come to those which have been produced by *fire*, as the great cause of volcanic phenomena, the most tremendous and startling exhibitions, of which the experience of man can conceive.

The effects of water, in changing the form of the earth, we have seen, are, with a few exceptions, gradual, and sometimes so slow, as even to require centuries to produce any considerable results. The changes produced by earthquakes, on the contrary, are often as sudden as they are calamitous and fearful, sometimes in a single hour, or even in a moment, not only reducing to fragments the most solid and costly monuments of man, but also mutilating the face of the earth itself—tearing down mountains—elevating islands in the depths of the ocean, or burying whole territories under inundations of liquid fire.

Geography of Volcanoes. It is a striking circumstance, in the history of volcanoes and earthquakes, that these awful exhibitions of nature have hitherto been almost entirely confined to certain regions of country. At present the Andes of South America are among the best defined of these regions. Beginning with Chili, in the 46° of south latitude, and proceeding north to the 27° of the same latitude, we shall find a line of volcanoes so uninterrupted, that hardly a degree is passed without the occurrence of one of these agents in an active state. About twenty are enumerated within that space, and there is no doubt but many more exist, some of which are dormant, and perhaps some have become extinct. How long an interval of rest entitles a volcano to be considered as extinct, is not determined. Those which have always been inactive since the era of history, may perhaps be so considered. The volcano of Ischia, in Italy, was silent for a term of 1700 years, after which it again commenced a series of eruptions.

The volcanoes of Chili have their chimneys pierced through mountains of granite, thus exhibiting the effects of a degree of force, of which man, without the existence of such phenomena, could have nowhere gained the least conception. Villarcia is one of the principal volcanoes of this district. It is so elevated as to be visible at the distance of 150 miles, and burns without intermission. Every year the inhabitants of this province experience shocks of earthquakes. In 1822, the whole coast of Chili, to the extent of 100 miles, was elevated several feet by a subterranean convulsion, of which we shall give an account hereafter.

Proceeding to the north, where the Andes attain their greatest elevation, we find in the province of Quito, Cotopaxi, Antisana, and Pichinca, all of them in an active state, and frequently emitting flames. Tunguragua, is also in the same district. This mountain, in 1797, threw out a deluge of mud, which filled valleys a thousand feet wide, and six hundred deep, forming barriers by which rivers were dammed up and lakes formed. North of Quito, in the provinces of Pasto and Popyan, occur six other volcanoes; and in the provinces of Guatimala and Nicaragua, which lie between the isthmus of Panama and Mexico, there are no less than twenty-three volcanic mountains, all of them situated between the 10° and 15° of north latitude, some of which are constantly in an active state.

This great volcanic chain, after being thus extended from south to north, nearly in a direct line, is continued through a great part of Mexico from west to east. Here are five active volcanoes, known by the several names of Tuxtla, Oribaza, Popocatepest, Jorullo and Colima. Still north of Mexico, in the peninsula of California, there are at least three, and according to some, five burning mountains.

Thus we see that this volcanic chain extends nearly in an uninterrupted course from Chili to the north of Mexico, a distance of nearly 4000 miles.

Another continuous volcanic range, of nearly equal extent, begins at the Aleutian Islands, belonging to Russian America, and by a circuitous route, passes to the Molucca Islands. Through this whole extent, earthquakes of the most terrific description are common.

But our limits will not permit the enumeration of all the volcanic tracts described by authors. Besides those already mentioned, Kamtschatka has seven burning mountains; the island of Java contains thirty-eight great volcanoes; the Molucca Islands contain several, and among them that of Sumbawa, which, in 1815, suffered one of the most tremendous eruptions recorded in history. The Islands of Jesso and Niphon, and Sumatra, contain more or less volcanoes; and from the Caspian sea to the Azores, is a volcanic range. Of Sicily and Italy, it is hardly necessary to speak in this enumeration, since the descriptions of Etna and Vesuvius, of Herculaneum and Pompeii, are well known, and are sufficient to indicate the volcanic disposition of that part of Europe. The West India Islands have occasionally suffered great calamities from this cause; and Iceland contains many burning mountains, among which is Skaptar Jokul, which, in 1783, suffered an extraordinary eruption, which we shall describe.

The whole number of volcanoes known is about 200. See *Von Hoff's Geology*, vol. ii, *and Lyell's Geology*, vol. i. *Article "Geography of Volcanic Regions."*

General Characters and Geological Connexions of Volcanoes. The forms of volcanic mountains are generally so peculiar as to be distinguished from all others. They are commonly of considerable height, and sometimes very lofty. When solitary, they are of a conical form, and more or less truncated, that is, bearing the appearance of having been cut off at the top. When active, or but recently extinguished, the truncation has within it a cavity of greater or less size, called the *crater.*

The accurate form of a perfect crater is an inverted conoid, and on Cotopaxi and Teneriffe, they are surrounded by walls of lava, but most commonly this part is composed of ashes which have fallen down during eruptions. The size of the crater does not necessarily bear any proportion to that of the mountain. In some mountains both the size and shape varies with every eruption.

Proximity of Volcanoes to the Sea. In nearly all instances, volcanoes are seated near the sea, or in the vicinity of a large body of water, and it was formerly thought that proximity to the water, was absolutely necessary to their action; nor is it certain that this is not the case. The only exception to this general fact, is Jorullo, one of the burning mountains of the Andes, which is situated more than a hundred miles from the ocean, nor does it appear that any considerable body of water is near it. It has, however, been suggested, from some circumstances observed with respect to this mountain, that it may possibly communicate with the sea by a deep fissure.

In many instances, volcanoes have thrown out mud or water, instead of lava, and ashes; and in some instances, fish of various kinds have been found in the water thus emitted, though no previous suspicion had existed, of a communication between the mountain and the sea.

VOLCANIC ERUPTIONS.

The action of most volcanoes is periodical, or intermitting, though this is not the case with all. Vesuvius and Ætna are sometimes dormant for a series of years, but Stromboli, in the vicinity of the former, has been constantly burning, ever since two hundred and ninety-two years before the Christian era, being upwards of two thousand years. Jorullo has continued to emit flames ever since 1759, at which time it was elevated from the plain on which it stands. But Vulcano suffered no eruption for eleven centuries, and we have already noticed that Ischia lay dormant for seventeen hundred years.

The appearances which attend volcanic eruptions, are various. In some instances, flames issue suddenly and silently from the cone, affording only splendid picturesque phenomena. But in others, the scene is the most terrific and appalling of which the imagination can conceive. For these descriptions we must, however, refer to particular eruptions, an account of which will follow.

The eruptions of Vesuvius and Ætna, these mountains being in the midst of a highly cultivated people, are best described. Indeed, from the time of Pliny, to the present day, these have been the subjects of interesting and learned dissertations.

In general, the first appearance of an eruption consists in a column of smoke rising to a great height, and then spreading out in the form which Pliny compared to that of a pine tree. This is followed by explosions from the craters; by trembling of the earth, or perhaps by its alternate rising and falling; the whole being attended by a rumbling, subterranean sound, forming both an eruption and an earthquake. Flame is then seen to issue from the cone, attended by red hot stones, often thrown to the height of several hundred feet, producing in the night, those brilliant and terrific phenomena, so often described. During the emission of the black smoke, and before the flame issues, there are often the most vivid flashes of lightning, which add greatly to the splendor of the scene. After these phenomena have existed for a longer or a shorter time, the melted lava, rising to the edge of the crater, flows over it, and runs down the side of the mountain into the plain below. This is in the form of a torrent of liquid fire, often narrow, but sometimes many miles in width. It sometimes proceeds rapidly, but more often slowly, the last portions of lava passing over the first, in small cascades. Sometimes, or from some mountains, there is much smoke, and but little lava; while from others, or at other times, the crater vomits rivers of melted matter, without smoke or flame.

The eruption of lava is often followed by showers of ashes, which consist of finely divided particles of lava, and which are often wafted by the wind, to the distance of several hundred miles.

The quantity of matter ejected by some volcanoes, is astonishingly great. Brieslak, an Italian geologist, calculated that the quantity of lava which flowed from a volcano in the island of Bourbon, in 1796, amounted to 45,000,000 of cubic feet; and that the quantity from the same, in 1787, was 60,000,000 of cubic feet; and during one eruption from a mountain in Iceland, the lava flowed about ninety miles, having a width of at least twenty miles, and in some places, a depth of several hundred feet.

PARTICULAR ERUPTIONS.

We shall describe a few volcanic eruptions, selecting only those which have been the subject of peculiar, or scientific interest, or which have produced extraordinary effects, either with respect to the destruction they have caused, or the quantity of lava they have ejected.

Eruptions of Vesuvius. The most ancient eruption of this Italian mountain, of which there is any particular description, was in A. D. 79, at which time the cities of Herculaneum and Pompeii were destroyed. It does not appear that any lava, or melted matter was emitted at this eruption; the ejected substances being sand, ashes, and mud. But it is certain that this mountain had previously emitted lava, since the streets of these cities are paved with this substance. The first stream of lava, of which there is any account, was in 1036, being the sixth or seventh eruption on record. From this period, all the eruptions which have taken place, are recorded, and many of them described by scientific men, and at great length.

Some of them produced considerable changes, not only in the form and appearance of the mountain itself, but also of the country in the vicinity. That of 1538, elevated the land along the coast of Naples many feet, destroyed many villages, and produced Monte Nuovo, which is still

440 feet in height. A description and figure of this mountain will be given hereafter.

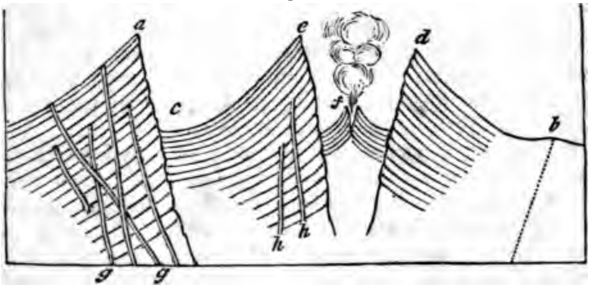
From about the end of the 18th century to 1822, the great crater of Vesuvius had been filling up gradually, with lava which boiled up from below, so that the bottom of the cavity presented a kind of rocky plain covered with blocks, crags, and hillocks of volcanic matter. But during the latter year, in the month of October, the form and appearance of the ancient crater was entirely changed. The explosions at that time were so violent during twenty days, as to break up, and throw out the whole of that accumulated mass, leaving an immense gulf, or chasm, about three miles in circumference, and in some parts 2000 feet deep. At the same time about 800 feet in height, of the original cone or top of the ancient crater, was carried away by the explosions, so that Vesuvius became reduced in height from about 4200 to 3400 feet.—*Forbes in Ed. Journal, and Scrope in Jour. of Science.*

In ascending the mountain, its sloping sides are found to be covered with loose materials intermixed with each other without the slighest order, and just as they fell from the crater. But on arriving at the crater itself, the beholder is surprised to find that every thing is there arranged in the most perfect symmetry, and that the materials are disposed in regular undulating strata. These consist of alternate layers, composed of lava, sand, ashes, and scoria, lying in distinct beds, and alternating with each other. These have resulted from the different colors, and coarseness of these materials, and which severally remain in the same situation and succession as they fell from the air during the different eruptions.

In some parts of the crater, are seen dykes, or veins of more compact matter intersecting the above described strata. These are on the outside of the cone, and being harder than the volcanic matter through which they have passed, they have resisted decomposition, and therefore project above the surface.

These have undoubtedly been formed by the filling up of open fissures with liquid matter forced up from below. At what period they were formed is unknown, but if such fissures are formed by the cooling, and consequent shrinking of the crater, after an eruption, it is probable that at the next eruption, these are filled with the fused matter, so that some of these veins may be formed at every eruption.

Fig. 5.



In the adjoining diagram, fig. 5, from Lyell's Geology, these veins or dykes, are represented, as also is the cone and crater of Vesuvius, and a part of the ancient Somma, as they appeared in 1828. *a*, Mount Somma, or the remains of the ancient cone of Vesuvius; *b*, the Pedamentina, a terrace-like projection, enclosing the base of the recent cone of Vesuvius on the south side; *c*, Atrio del Cavallo, so called, because travellers leave their mules there, when they prepare to ascend to the cone, on foot; *d e*, the crater of Vesuvius left by the eruption of 1822; *f*, a small cone in the bottom of the crater, thrown up in 1828. In the bottoms of many craters there are several of these small cones, which are constantly emitting steam, or smoke, and sometimes throw up lava; *g g*, dykes intersecting the ancient strata of Somma; *h h*, dykes intersecting the recent cone of Vesuvius.

Immense volumes of steam, or aqueous vapor, are evolved from the craters of volcanoes, during eruptions. These vapors, being condensed by the surrounding atmosphere, often fall down in torrents of rain. The rain precipitates the volcanic dust from the air, and sweeps that along which had fallen on the declivity of the mountain, until a torrent of mud is produced. Such torrents are as much to be dreaded as the inundations of mud which are sometimes thrown from the volcano, and with the exception of the heat, are more disastrous than burning lava, being much more rapid in their descent. In 1822, one of these mud streams descended from Vesuvius, and after destroying a district of cultivated ground, suddenly flowed into the villages of St. Sebastian, and Massa, where filling the streets, and some of the houses, it suffocated seven persons.

Destruction of Pompeii and Herculaneum. These cities were overwhelmed, and destroyed in the year A. D. 79, and most probably either by an alluvion of mud, such as we have just described, or by an emission of the same kind of matter from the mouth of the volcano.

It has been supposed, that it was by an eruption of lava that these cities were destroyed; but Lippi, an Italian writer, has shown that many facts presented by their ruins are incompatible with this opinion. Thus the casts, or impressions of persons which still remain, especially of a woman, found in a vault at Pompeii, cannot be accounted for on the supposition of flowing melted lava, nor of falling volcanic ashes, for the first would have utterly destroyed the form of the body, and the second could not have reached through the roofs of the buildings.

"There is decisive evidence," says Mr. Lyell, "that no stream of lava ever reached Pompeii since it was first built, although the foundations of the town stand upon the old lava of Mount Somma, several streams of which have been cut through in making excavations. At Herculaneum, the case is different, although the substance which fills the interior of the houses and vaults, must have been introduced in a state of mud, like that found in similar situations in Pompeii: the superincumbent strata differ wholly in composition and thickness. Herculaneum was situated several miles nearer to the volcano, and has, therefore, been always more exposed to be covered, not only by showers of ashes, but by alluvions, and streams of lava. Accordingly, masses of both have accumulated on each other *above* the city, to a depth of nowhere less than seventy, and in some places 112 feet. The tuff or mud, which envelops the buildings, consists comminuted volcanic sand mixed with pumice. A mask imbedded in this matter has left a cast, the small lines and angles of which are quite perfect, nor did the mask present the least indication of heat."

These cities were both seaports, and Herculaneum is still near the shore, but Pompeii is at some distance from it, the intervening land having been made, at various times, by volcanic matter.

Herculaneum was discovered 1713, by the accidental circumstance of a well being dug, which came directly upon the theatre, where the statues of Hercules and Cleopatra were found. These cities are mentioned by ancient authors, as being among the seven flourishing towns of Campania; they were originally settled by Greek colonies.

Both at Herculaneum and Pompeii, temples have been found with inscriptions, commemorating the event of their rebuilding after having been overthrown by an earthquake. This earthquake happened in the reign of Nero, sixty-three years after the Christian era, and sixteen years before the catastrophe by which they were finally destroyed.

It is supposed that about one-fourth of Pompeii is uncovered, presenting streets, walls, temples, houses, and monuments of art, many of them in the same condition as they were nearly 2000 years ago. Being covered with a deluge of mud, even the paintings have been preserved, and the wood remains in a perfect state. In some instances, the walls of the buildings are rent, probably by the earthquake which happened before the fatal eruption, but the edifices chiefly remain entire.

Circumstances of great interest and curiosity are everywhere indicated among these ruins. Columns have been found lying upon the ground half finished, showing that the workmen were driven from their labors; and the temple for which they were designed, remains unfinished. In some places the pavement in the streets has sunk down, but, in general, it remains entire, consisting of great flags of lava, in which two immense ruts have been worn by the constant passage of wheel carriages. When the hardness of this stone is considered, the continuity of these ruts, from one end of the town to the other, is not a little remarkable, for there is nothing like it in the oldest pavements of modern cities.

Only a very small number of skeletons have been found in either city, and it is therefore certain, that most of the inhabitants had time to escape, and also to take with them most of their valuable effects. In the barracks of Pompeii, were the skeletons of two soldiers chained to the stocks; and in the vault of a house, in the suburbs, were the bones of seventeen persons, who appear to have fled there to escape the shower of ashes. They were found enclosed in indurated tuff or mud, which flowed from the mountain. In this was preserved the cast of a woman, perhaps the mistress of the house, with an infant in her arms. Though her form was impressed in the rock, nothing but her bones remained. To these bones a chain of gold was suspended around the neck, and rings with precious stones, were found on the finger-bones of the skeleton.

The writings scribbled by the soldiers on the walls of the barracks are still visible; and the names of the owners, over the doors of their houses, are often easily read.

The colors of fresco paintings on the stuccoed walls, in the interior of the buildings, are frequently almost as vivid as if they were just finished. Some of the public fountains have their pavements decorated with shells, laid out in patterns, still retaining, in all respects, their original condition; and, in the room of a painter, who was, perhaps, also a naturalist, was found a large collection of shells, comprising a great variety of the Mediterranean species. These were in as good a state of preservation as if they had remained the same number of years in a museum.

The wooden beams of the houses at Herculaneum are black on the exterior, but when cleft open, they appear to be nearly in the state of ordinary wood, and the progress made by the whole mass towards the state of lignite, [mineralized wood,] is hardly appreciable. Even small substances, of vegetable origin, are often found in a state of entire vegetation. Fishing nets are abundant in both cities, and often quite perfect; and in a fruiterer's shop were found vessels full of almonds, chestnuts, and walnuts, all in perfect shape. And what is still more extraordinary, in a baker's shop was discovered bread, with the name of the maker stamped upon the loaf, thus, Eleris Q. Crani Riser. On the counter of an apothecary was a box of pills, converted into a fine earthy substance, and, by its side, a small cylindrical roll, evidently prepared to be cut into pills. *Lyell's Geol.* vol. i. p. 350—360. *Forbes' Ed Journal, Jan.* 1829.

Eruptions of Etna. Etna appears to have been periodically active from the earliest times of history, for Diodorus Siculus mentions an eruption of it, which caused a district of country to be deserted by its inhabitants before the Trojan war; and Thucydides informs us that between the time when Sicily was colonized by the Greeks, and the commencement of the Peloponnesian war, that is, in 431 B. C., there had occurred three eruptions of this mountain.

But, notwithstanding notices of this mountain were recorded thus early, the first eruption which has been particularly described, was the great one of 1669. An earthquake, previous to this eruption, had levelled many of the villages and towns in the neighborhood, and at the commencement of which, an extraordinary phenomenon happened in the plain of St. Lio. Here a fissure, six feet wide, and of an unknown depth, opened in the ground, with a loud, terrific, crashing noise, and ran in a tortuous course nearly to the top of Etna. Its direction was from north to south, and its length twelve miles. This fissure, as it opened, emitted vivid flashes of light. Five other parallel fissures of considerable length, afterwards opened, one after the other, emitting smoke, and giving out the most horrid bellowings, which were heard to the distance of forty miles.

This case may, perhaps, explain the manner in which the dykes were formed in the cone of Vesuvius, already described and figured, for the light emitted by these fissures would seem to indicate, at least in some instances, that they were, to a certain height, filled with glowing lava.

The lava, during this eruption, having overwhelmed and destroyed fourteen towns, some of them containing three or four thousand inhabitants, at length arrived at the walls of Catania, a populous city, situated ten miles from the volcano. These walls had been raised sixty feet high, towards the mountain, in order to protect the city, in case of an eruption. But the burning flood accumulated against the wall so as to fill all the space around and below that part, and finally poured over it in a fiery cataract, destroying every thing in that vicinity.

From Catania, the lava continued its course until it reached the sea, a distance of fifteen miles from its source, in a current about 1800 feet broad, and forty feet deep. While moving on, its surface was, in general, a mass of solid rock, or cooled lava, and it advanced by the protrusion of the melted matter, through this hardened crust.

As an illustration of the intense heat of volcanic matter, the Canon Recupero relates, that in 1766, he ascended a small hill, composed of ancient volcanic matter, in order to observe the slow and gradual manner in which a current of liquid fire advanced from Etna. This current was two and a half miles broad; and, while he stood observing it, two small threads of lava, issuing from a crevice, detached themselves from the main stream, and approached rapidly towards the eminence where he and his guide were standing. They had only just time to escape, when they saw the hill on which they had stood a few minutes before, and which was fifty feet high, entirely surrounded, and, in about fifteen minutes, entirely melted down into the burning mass, so as to be incorporated with, and move on along with it.

Discovery of Ice on Mount Etna. A remarkable discovery of a great mass of ice, on Mount Etna, was made in 1828. In that year, in consequence of the protracted heat of the season, the supplies of ice at Catania and the adjoining parts of Sicily, failed entirely, and the people suffered considerably for the want of an article, considered as necessary to health as well as comfort in that hot climate.

In this dilemma, the magistrates of Catania directed search to be made for some crevice or natural grotto, on Mount Etna, where drift snow might possibly still be preserved. During this search it was discovered that near the base of the highest cone there lay a vast mass of ice, covered by a lava current. At what period this current was emitted is unknown, nor can it be conjectured what proportion of the ice was melted by the burning matter, but it appears that nothing but the flowing of the lava over this glacier, can account for its preservation.

A large number of workmen were immediately employed to quarry this ice for the use of the Catanians; but, it is said, that its hardness rendered the expense of obtaining it so great, that there is no probability of a similar undertaking, unless under similar circumstances.

VOLCANOES IN ICELAND.

Iceland is both a volcanic country, and a country of volcanoes. A considerable proportion of its surface is covered with ancient or modern lava, and it is now subject to the most dreadful calamities from this source.

With the exception of Etna and Vesuvius, the most complete chronological records of volcanic eruptions are those of Iceland. From these it is ascertained, that from the 12th century, there has never been an interval of more than forty years, and rarely more than twenty, without eruptions and earthquakes in some part of that country. Single eruptions of Mount Hecla have sometimes continued for six years. In many instances the whole island has been convulsed by earthquakes, during which mountains were rent asunder, hills sunk down, and rivers have deserted their former channels.

Eruption of Skaptar Jokul. In 1783, this volcanic mountain suffered one of the most extraordinary eruptions recorded in history, both with respect to the quantity of lava it threw out, and the calamities it occasioned.

The river Skapta, a considerable stream, was for a time completely dried, by a torrent of liquid fire from this mountain. This river was about two hundred feet broad, and its banks from four to six hundred above the level of the water. This defile was not only entirely filled to a considerable extent by the lava, but it also crossed the river by the dam thus formed, and overflowed the country beyond, where it filled a lake of considerable extent, and great depth.

This eruption commenced on the 11th of June, and on the 18th of the same month, a still greater quantity of lava rushed from the mouth of the volcano, and flowed with amazing rapidity, sometimes over the first stream, but generally in a new course. The melted matter having crossed some of the tributary streams of the Skapta, completely dammed up their waters, and caused great destruction of property and lives by their overflow. The lava, after flowing for several days, was precipitated down a tremendous cataract, called Stapafoss, where it filled a profound abyss, which that great water-fall had been excavating for ages, and thence the fiery flood continued its course.

On the third of August, a new eruption poured forth fresh floods of lava, which taking a different direction from the others, filled the bed of another river, by which a large lake was formed, and much property and many lives destroyed.

The effects of this dreadful calamity may in some measure be imagined when it is known, that although Iceland did not, at that time contain more than fifty thousand inhabitants, there perished nine thousand human beings by this single eruption, making nearly one in five of the whole population. Part of them were destroyed by the burning lava itself, some by drowning, others by noxious vapors which the lava emitted, and others in consequence of the famine, caused by the showers of ashes which covered a great proportion of the island, and destroyed the vegetation. The fish also, on which the inhabitants depended, in a great measure, for food, entirely deserted the coast.

The quantity of lava which Skaptar Jokul emitted during this eruption, was greater than is recorded of any other volcano. The two principal branches or streams of lava, flowed chiefly in different directions. The length of the smallest was forty miles, and of the other fifty miles. The breadth of that branch which filled the Skapta, was from twelve to fifteen miles, and the other about seven miles. The ordinary depth of each was about 100 feet, but in narrow defiles it was more than 600 feet deep, and in many places from 200 to 300.

Allowing that the united breadth of this vast lava stream was 20 miles, and the whole length 90 miles, then this mountain, at a single eruption, threw out a quantity of lava which covered a surface of 1800 square miles, an area equal to the fourth part of the State of Connecticut, and nearly one half the size of Rhode Island.

When it is considered that the depth of the whole might average 150 feet, we may go into calculations concerning the quantity of matter thrown out, but we can have no conception of the force required to elevate such a stream of melted rock through the crust of the earth.

Eruption of Jorullo, in 1759. Jorullo is situated in the interior of Mexico, about 100 miles from the nearest sea. This mountain, as already stated, affords the only known instance of a volcano, at a distance from some ocean. It also affords an instance of the production of a new volcanic mountain, within the memory of man.

In June, 1759, subterranean sounds of an alarming kind were heard by the inhabitants of this district, and these were followed by earthquakes, which succeeded each other for two months. In the month of September, flames were seen to issue from fissures in the ground, and from the same place, red hot rocks were thrown to an immense height. Soon after, six volcanic cones were formed of lava and the fragments of rock, thrown up from the earth, in the same neighborhood. The least of these was three hundred feet in height. In the midst of these cones, rose Jorullo, which was formed in the same manner, and soon rose to the height of 1600 feet by the accumulation of lava and fragments of rock. The small cones ceasing their action, Jorullo became the great outlet of volcanic matter, and continued to emit lava and large fragments of primitive rock, for many months. Jorullo has continued to emit flames ever since its formation.

Volcano of Sumbawa. Sumbawa is one of the Molucca Islands; and the mountain from which occurred, on some accounts, the most extraordinary volcanic eruption of which any accounts have been recorded, is called Tomboro.

This eruption commenced on the 5th of April, 1815, but was most terrific on the 11th and 12th of that month, nor did it cease entirely, until sometime in the following July. The explosions so much resembled the firing of heavy cannon at a distance, that the people of many vessels at sea, supposed there was a great naval engagement within hearing, but could not imagine what nations were engaged.

The commanders of some ships, and of several English forts, gave orders to prepare for battle, though they were several hundred miles distant from the mountain. At Sumatra, these tremendous explosions were distinctly heard, though not nearer than 900 miles from Tomboro. They were also heard at Ternate, in the opposite direction from Sumatra, at the distance of 720 miles from the mountain.

So immense in quantity was the fall of ashes, that at Bima, forty miles from the mountain, the roof of the English Resident's house was crushed by the weight, and many other houses in the same town were rendered uninhabitable from the same cause. At Java, 300 miles distant, the air was so full of ashes, that from this cause at mid-day, it is said the darkness was so profound, that nothing like it had ever before been experienced, during the most stormy night.

Along the coast of Sumbawa, the sea was covered with floating lava, intermixed with trees and timber, so that it was difficult for vessels to sail through the mass. Some captains, though at a long distance at sea, mistook this mass for land, and sent out their boats in order to ascertain the safety of their situations. The sea, on this and the neighboring coasts, rose suddenly to the height of twelve feet, in the form of immense waves, and as they retired, swept away trees, timber, and houses, with their inhabitants. All the vessels lying near the shore were torn from their anchorings, and cast upon the land. Violent whirlwinds carried into the air men, horses, cattle, trees, and whatever else was in the vicinity of the mountain. Large trees were torn up by the roots, and carried into the sea. But the most calamitous part of the account still remains; for such were the tremendous effects of the burning lava; the overflowing of the sea; the fall of houses; and the violence of the whirlwind, that out of 12,000 inhabitants on this island, only twenty-six individuals escaped with their lives, all the rest being destroyed in one way or another.

The whole island was completely covered with ashes, or other volcanic matter. In some places, the bottom of the sea was so elevated, as to make shoals, where there was deep water before; and in others, the land sunk down, and was overflown by the sea.

The details of this awful calamity were collected, and published by Sir Stamford Raffles, then Governor of Java, who required all the residents in the various districts under his authority, to send him a statement of the circumstances which fell under their several observations.—*See Raffles' Hist. of Java; and Brande's Quart. Jour.* vol. i.

EARTHQUAKES.

Having thus given a short history of a sufficient number of volcanic eruptions, to acquaint the geological student with the phenomena, and of the tremendous as well as calamitous effects of these mighty agents, we will next refer to the subject of earthquakes, as resulting from the same cause.

Earthquake of Calabria. "Of the numerous earthquakes," says Mr. Lyell, "which have occurred in different parts of the globe, during the last 100 years, that of Calabria, in 1783, is the only one of which the geologist can be said to have such a circumstantial account, as to enable him fully to appreciate the changes which this cause is capable of producing in the lapse of ages. The shocks began in February, 1783, and lasted nearly four years, to the end of 1786." The importance of the earthquake in question, arises from the circumstance, that Calabria is the only spot hitherto visited, both during and after the convulsions, by men possessing sufficient leisure, zeal, and scientific information, to enable them to collect and describe with accuracy, the physical facts which throw light on geological questions.—*Lyell*, vol. i. p. 412.

Authors who witnessed the phenomena of these convulsions, are quite numerous. Among them, it is said that Pignataro, a physician, who resided at the centre of the earthquakes, and who kept a register of the number and force of the shocks, is among the most correct. The Royal Academy of Naples, also sent a commission from their own body to Calabria, accompanied by artists, with instructions to describe and illustrate by drawings, the effects of these terrible convulsions; and Sir William Hamilton, who surveyed this district before the shocks had ceased, has added many facts not recorded by others. Our limits will, however, allow only a very brief summary of the facts, from these several sources.

The subterranean concussions were felt beyond the confines of Sicily; but if the city of Oppido, in Calabria, be taken as the centre, a circle around it, whose radius is twenty-two miles, would include the space which suffered the greatest calamities. Within this circle, all the towns and villages were almost entirely destroyed.

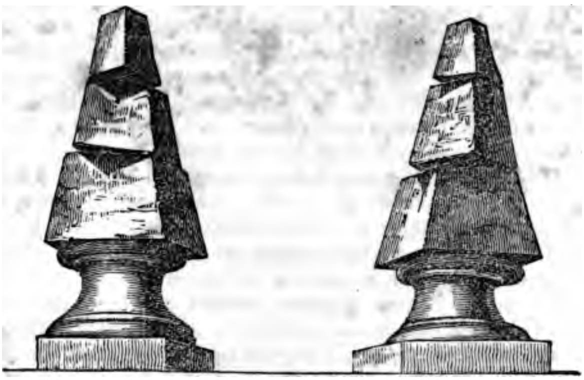
The first shock, which took place on the 5th of February, 1783, threw down, in the space of two minutes, a greater part of the houses, within the whole space above described. The convulsive motion of the earth, is said to have resembled the rolling of the sea, and that in many instances, it produced swimming of the head, like sea-sickness. This rolling of the surface, like the billows of the sea, was like that which would have been produced by the agitation of a vast mass of liquid matter under the ground.

In some walls which were shattered, the separate stones were parted from the mortar so as to leave an exact mould where they had rested, as though the stone had been carefully raised from its bed in a perpendicular direction; but in other instances, the mortar was ground to powder between the stones, as though they had been made to revolve on each other.

It was found that the swelling, or wave-like motions, and those which were called *vorticose*, or whirling, often produced the most singular and unaccountable effects. Thus, in some streets, in the town of Monteleone, every house was thrown down, except one, and in some other streets, all except two or three; and these were left uninjured, though differing in no respects from the others.

In many cities all the most solid edifices were prostrated, while those which were slightly built, escaped; but, in others, it was precisely the reverse, the massive buildings being the only ones that remained standing.

Fig. 6.



But, perhaps, the most singular effect was that produced on a pair of obelisks, at the convent of St. Bruno, where the different stones composing these monuments, were moved on each other, in a manner altogether unaccountable, unless, indeed, it can be supposed that the earth, where each stood, underwent a rapid gyratory motion. The shock which shook the convent, is said to have been of that kind which writers describe by the term vorticose, or whirling. The annexed cut, fig. 6, will convey an idea of these effects.

The pedestal of each obelisk remained in its original situation and place; but the separate stones were turned partly around on each other, as represented in the figures; some of them being moved eight or nine inches out of their places, but none were thrown down.

It appears from the statements, that in many instances, where the ground was fissured, the motion must have been from below, upwards, for these fissures opened and closed alternately, as though the ground, in that particular spot, had been violently lifted up with a force from below, by which a fissure was formed, but, the force ceasing instantly, the ground again assumed its former position, and the fissure closed. Perhaps the escape of some gas or steam through the fissure, produced this effect.

In many instances, these fissures were so wide as in an instant to swallow up men, trees, and even houses, and when the earth sunk down again, it closed upon them so entirely, as not to leave the least vestige of what had happened, nor were any signs of them ever discovered afterwards. In the vicinity of Oppido, the centre of these convulsions, many houses were precipitated into the same great fissure, which immediately closed over them; and, in the same neighborhood, four farmhouses, several oil stores and dwelling-houses were so entirely ingulfed, that not a vestige of them were seen afterwards.

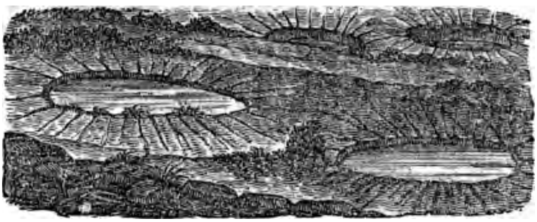
In some instances, these chasms did not close. In one district, a ravine, formed in this manner, a mile long, 100 feet broad, and thirty feet deep, remained open; and in another, a similar one remained, three-quarters of a mile long, 150 feet wide, and 100 feet deep; in another instance, there remained such a chasm thirty feet wide, and 225 feet deep.

In various places, the ground sunk down, and lakes were formed, which, being fed by springs, have remained ever since. The convulsions also removed immense masses of earth from the sides of steep hills into the valleys below, so that, in many instances, oaks, olive orchards, vineyards, and cultivated fields, were seen growing at the bottoms of deep hollows, having been removed from the side hills of the vicinity. In one instance, a mass of earth 200 feet thick, and 400 feet in diameter, being set in motion by one of the first shocks, travelled four miles into the valley below.

The violence of the upward motion of the ground was singularly illustrated by the inversion of heavy bodies lying on the surface, and which can hardly be accounted for, except on the supposition that they were actually thrown to a considerable distance into the air. Thus, in some towns, a considerable proportion of the flat paving stones, were found with their lower sides uppermost. Mr. Lyell accounts for this effect, by supposing that the "stones were propelled upwards by the momentum which they had acquired, and that the adhesion of one end of the mass being greater than the other, a rotary motion had been communicated to them." But it is difficult to conceive how a whirling motion, so rapid as to produce such an effect, could have been communicated to a whole town, without producing some consequences still more extraordinary.

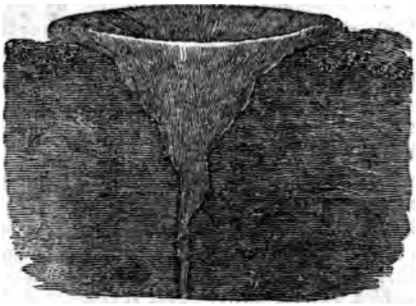
In the plain of Rosarno, a different effect was produced from any yet described. This plain consists of an alluvial soil, which, after the commencement of the earthquakes, was found covered with circular hollows, containing water, and around the hollows, were fissures radiating from their sides in every direction, as represented by fig. 7.

Fig. 7.



These were, for the most part, about the size of carriage wheels, but sometimes larger or smaller. When filled with water to within a foot or two of the surface, they appeared like wells, but more commonly they were filled with dry sand, sometimes with a concave, and at others with a convex surface. On digging into the earth, these cavities were found to be funnel-shaped, the moist loose earth in the centre, indicating the tube through which the water had ascended. The annexed cut, fig. 7, is intended to represent a section of these inverted cones, when the water had disappeared, leaving nothing in it but dry micaceous sand. This sand appeared to have been brought up from beneath by the water which was sometimes found over the sand.

Fig. 8.



But our limits will not allow the description of other effects and appearances, which this dreadful calamity produced, some of which are equally curious and inexplicable.

We must not, however, close this account without reference to an incident connected with the destruction of human life, as well as to the number of responsible beings which were suddenly called to the world of spirits, by this appalling act of a mysterious Providence.

The Prince Scilla had persuaded many of his people to betake themselves to their fishing boats, as a place of safety, on the first indications of an earthquake, which in that volcanic country are so well understood, and which create so much alarm. The Prince himself had set the example, by going on board of one of these boats. On the fifth of February, when the first violent shock happened, many of these people were sleeping in their boats near the shore, while others were on the shore, at a place little elevated above the sea. With this convulsion the earth rocked, and suddenly there was precipitated a great mass of rock from Mount Jaci, on the plain where the people had taken refuge, and immediately after the water rose to a great height above its ordinary level, and swept away the sleeping multitude. The wave then instantly retreated, but soon after returned again with increased violence, bringing back many of the people, and animals, which it had carried away. At the same time every boat in the vicinity was overwhelmed, or dashed against the beach, and thus destroyed. The Prince, who was an aged man, with

1400 of his people, were thus swept away, and perished in the sea.

The number of human beings who were destroyed by this series of earthquakes, was estimated by Sir William Hamilton, at about 40,000, besides which nearly 20,000 more died by epidemics, which were occasioned by insufficient nourishment, and the noxious vapors arising from the new lakes and pools of water, which this terrible catastrophe occasioned,—thus making the whole number that perished 60,000.

In countries where volcanoes exist, and which are also subject to earthquakes, experience has taught, that the earthquakes cease, or become harmless, so soon as an eruption from the mountain commences. On the supposition that the earth constantly contains within it an ocean of lava or melted matter; that earthquakes are caused by some disturbance of this liquid; and that volcanoes are its chimneys, or outlets when thus disturbed, this fact would admit of an easy explanation. In another place we shall bring forward many circumstances, to show that this theory may be true, and shall only remark here, that the Calabrian earthquakes may be brought as an item in support of this doctrine, for neither Etna nor any of the Italian volcanoes, suffered the least sign of eruption during these destructive convulsions.

Earthquake of Lisbon. This great earthquake happened in the month of November, 1755, and with respect to the wide extent to which it was felt, exceeded all others of which there is any account.

The first intimation of its approach was a loud subterranean noise, somewhat like distant thunder, and immediately afterwards, the city of Lisbon was shook with such violence as to prostrate nearly all its houses. The wretched inhabitants, with so short a warning, were unable to take the least precaution for their safety, so that in about six minutes 60,000 people perished.

The sea at first retired, and laid bare the bed of the harbor, after which it immediately rolled back, in an immense wave, rising fifty feet at least, above its ordinary level. The largest mountains in Portugal were shaken to their foundations, and several had their summits rent in a manner which struck every beholder with astonishment.

But the most extraordinary and calamitous effect which was produced at Lisbon, was the sinking of a quay, together with the thousands of inhabitants with which it was covered. This work was built entirely of marble, and just finished at an immense expense; and on it, after the first shock, a vast concourse of people had collected as a place of safety, having left the city to escape the fall of the houses. But it proved the most fatal spot in the vicinity, for at the next shock the earth opened and instantly swallowed up the whole quay, with the multitude which had there assembled, and so completely were the whole retained by the closing of the earth, that not a single dead body ever rose again to the surface. A great number of small boats and other vessels, near the quay, filled with people, as a place of safety, were also precipitated into the yawning vortex, and it is stated that not a single fragment of any of these boats were ever seen afterwards. It was believed that the water where the quay stood was unfathomable, but its depth was afterwards found to be 600 feet.

The immense area over which this earthquake was felt, is very remarkable; for not only was every part of Spain and Portugal convulsed, but the shocks were perceived with greater or less intensity in England, Holland, Italy, Norway, Sweden, Germany, Switzerland, Corsica, the West Indies, at Morocco and Algiers in Africa, and in a part of South America. At Algiers the shock was so violent as to throw down many buildings; and a village, not far from Morocco, was swallowed up, and 10,000 inhabitants perished. A great wave from the sea swept nearly the whole coast of Spain. At Cadiz its height is said to have been sixty feet, and its devastations in proportion.

The shock was also felt by ships far at sea, and, in several instances, the concussion was such as to make the people suppose their vessels had struck on a rock. In one instance it is said that the people on board a vessel off the West Indies, were thrown up a foot and a half from the deck. This circumstance may be accounted for from the inelasticity of water, so that a violent and sudden movement of the bottom of the ocean, would be communicated to the surface and to the ship, through the medium of the fluid, with nearly the same force as though the vessel had been on the ground itself.

Islands raised from the Sea. Numerous instances are recorded of the elevation of islands, of greater or less extent, from the bottom of the sea.

Writers of antiquity have mentioned several such instances. The elder Pliny says that the celebrated islands of Rhodes and Delos, according to tradition, are sea born, and that, after these, several smaller islands rose up from the bottom of the same sea. Strabo also asserts, positively, that Hiero was produced in the midst of flames, and both Plutarch and Justin relate, that the formation of this island was attended with much fire, and a great boiling of the sea.

But we are not entirely dependent on the ancients for facts of this kind, many instances of the elevation of islands having been witnessed in later times.

Captain Tillard, of the Royal British Navy, was an eye witness to the rising of an island from the ocean, in 1812.

At some distance off the coast of St. Michael's, one of the Azores, an immense body of smoke was observed to issue from the water, and from the midst of the smoke, there suddenly burst forth a black column of cinders, ashes and stones, in the form of a spire. This was accompanied by vivid flashes of lightning from the thickest part of the volcanic smoke, and the whole was surrounded by occasional waterspouts.

The water at this place was thirty fathoms deep, and after the volcanic phenomena had lasted four days, the crater began to appear above the surface of the water, and soon became twenty feet high in the midst of an island 400 feet in diameter. At this time the cliffs of St. Michael's were shattered by an earthquake, and the island continued to rise until it became at least 200 feet above the level of the sea.

This island was named Sabrina, after Captain Tillard's ship. It did not, however, long continue visible, for being formed chiefly of ashes and cinders, and not by the elevation of the solid rocks, it was soon swept away by the waves of the ocean.

Aleutian Islands. In the year 1806, there arose from the sea a new island, among the Aleutian group, north of Kamtschatka. This, according to Langsdorf, who afterwards visited the spot, was four geographical miles in circumference; and the geologist, Von Bush infers from its not having subsided, that it does not, like Sabrina, consist of ejected volcanic matter, but of solid rock, thrown up from the bottom of the sea.

In 1814, another island was added to the Aleutian group, from the bottom of the sea. This was much larger than the former, and its highest part was elevated to the astonishing height of 3000 feet above the level of the sea.

In 1820, a new island was thrown up among the Ionian group, on the coast of Greece.

In 1757, eighteen small islands were elevated from the sea, in the vicinity of the Azores.

In 1783, the same phenomenon happened on the coast of Iceland.

Many other instances of sea born islands are recorded, but we need not extend this list, our chief object being to show that islands are elevated from the ocean by the force of volcanic action.

Elevation of Land by Volcanic Power. In November, 1822, there happened a series of subterranean convulsions on the coast of Chili, which continued three months, and which shook that part of South America to the extent of 1400 miles from north to south. On the morning after the first shock, the whole line of coast along Valparaiso, to the distance of 100 miles, was found to have been raised above its former level. Mrs. Graham, who was present, and who writes this account, states that on the morning of the 20th, the wreck of an old ship, which lay at a small distance from the shore, but which could not be approached, on account of the depth of the water, was now easily accessible. She also found the former bed of the sea, along the shore, laid bare, with muscles, oysters, and other shell fish, adhering to the rocks on which they grew, and abundance of fish, dead and on dry land. At Valparaiso, the elevation of the land was found to be three feet, but at other places, the rise was from four to five feet.

Formation of Monte Nuovo. Monte Nuovo, or New Mountain, was chiefly thrown up on the night of the 29th of September, 1538. Its situation is in the neighborhood of Naples, a region everywhere volcanic.

The site of the present Monte Nuovo was formerly a little town, where invalids resorted on account of the thermal baths which existed there. On the evening above mentioned, after many previous shocks of an earthquake, the ground opened in the form of a wide fissure, which ran towards this town, with a tremendous noise, accompanied with the discharge of pumice stones, blocks of lava, and ashes. At the same time a gulf, of considerable extent, opened in the suburbs of the town, by which many houses were swallowed up. The sea also retired, leaving its bed naked along the shore.

The fissure which had reached the town, continued to discharge volcanic matter for 36 hours, during which time, its quantity was such as to form the mountain in question.

Fig. 9.

The annexed drawing, fig. 9, will show the form of this mountain. No. 1, the mountain. No. 2, a part of the crater. Its height has been lately determined to be four hundred and forty feet above the level of the bay of Naples. Its base is eight thousand feet, or nearly a mile and a half in circumference, and the depth of the crater, four hundred and twenty-one feet from the summit, so that the bottom of the crater is only nineteen feet above the level of the sea.

No lava flowed from this crater, but the matter ejected, which fell down and formed the mountain, consisted of masses of ancient lava, ashes, pumice, and slaty stones. These blocks of ancient lava, prove the volcanic origin of the ground below the present mountain.

We have thus given such an account of volcanoes, earthquakes, and the elevation of islands and land, by subterranean fire, as our limits will allow.

The design of these facts, is not merely to satisfy the curiosity of the reader, but, as will be seen in the sequel, to account for phenomena which the earth presents, by showing an analogy between the effects of known and unknown causes. Thus, the earth almost everywhere indicates, by the position of its strata, that its crust has been disturbed by subterranean forces; and marine remains show that a great proportion of the dry land has once been under the sea. That these changes have been effected by the same cause which elevates islands from the sea, at the present day, we shall endeavor to show in another place.

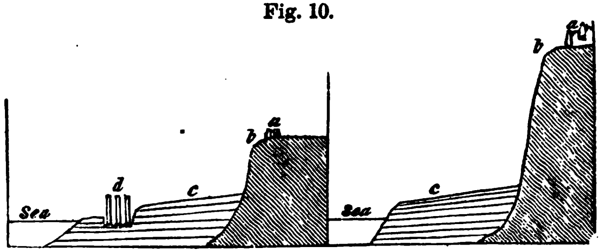
Temple of Jupiter Serapis In a few instances, it is known that portions of land have several times changed their level, with respect to that of the sea; and of which the following is an interesting and curious example.

The temple of Serapis, a celebrated monument of antiquity, is situated on the little bay, called Baiæ, within the bay of Naples.

A geological examination of the coast of Puzzuoli, along this bay, shows that the land has been elevated about twenty feet, at a period not very remote, so that, without the evidence presented by the temple, there is sufficient proof that the land in the vicinity has changed its level.

If the coast along the shore, between Naples and Puzzuoli, be examined, it will be seen that the tract of fertile land which intervenes between the present shore, and the high, rocky cliffs, was evidently once under the water, and that the ancient shore was near these cliffs.

Fig. 10.



The inland cliff near Puzzuoli, is in many places about eighty feet high, and quite perpendicular. At its base, the new deposite attains the height of twenty feet above the sea. This consists of sedimentary matter, mixed with marine shells, showing that it was formed under the water.

The annexed cut, fig. 10, from Mr. Lyell, will explain the situation of this coast in 1828. *a*, on the right, shows the situation of antiquities, on a hill south of Puzzuoli; *b*, ancient cliff, now inland; *c*, terrace composed of marine deposites of recent date. *a*, on the left, represents the remains of Cicero's villa, at the north of Puzzuoli; *b*, ancient cliff, now inland; *c*, terrace composed of recent marine deposites; *d*, temple of Serapis.

The soil of these level deposites is considered so valuable, that a wall has been built for its protection against the washing of the sea; but, in some places, the wall has been thrown down, so that the strata are exposed. These consist of alternate layers of mud and pumice, enclosing abundance of marine shells. One stratum contains large quantities of the remains of ancient art, as tiles, and pieces of Mosaic pavement.*

The remains of the works of art are found below, as well as above the marine shells. Among the shells are the Cardium, Donax, Buccinum, and Ostrea. (These will be found, figured and described, towards the close of this volume.)

Now, there are no tides in the Mediterranean, by which these shells could have been cast upon the shore; and the remains of ancient buildings at other places, show that there has been no change in the level of this sea, for the last two thousand years; hence, we must conclude, that the land along this coast has been elevated about twenty feet above its former level.

But in addition to the above evidence, the remains of the temple of Serapis show that the edifice has undergone several changes of level, when compared with the sea.

With respect to this temple, Mr. Lyell, who has lately visited the spot, says, "It appears, from the most authentic accounts, that the three pillars, now standing erect, continued down to the middle of the last century, half buried in the new marine strata above described. The upper parts of the columns being concealed by bushes,

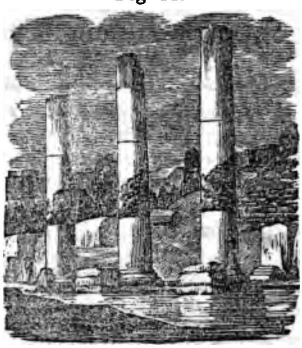
* Ancient Mosaic pavement consists of small pieces of stone, generally marble, of different colors, arranged in figures, sometimes representing groups of men and animals, in commemoration of some historical event. These are cemented so as to form a continuous solid mass. The floors of ancient churches and temples were often thus made.

had not been discovered, until 1750, when they were seen to form part of a splendid edifice. On examination, the pavement was found still entire, and upon it lay a number of magnificent columns, a part of which were of African breccia,* and a part of granite. The original plan of the building could be traced distinctly: it was of a quadrangular form, seventy feet in diameter, and the roof had been supported by forty-six noble columns, twenty-four of which were of granite, and the rest of brecciated marble. The large court had been surrounded by apartments, supposed to have been used as bathing rooms; for a thermal spring, still employed for medicinal purposes, continues to flow from just behind the ruins, and the water of this spring, it is said, was conveyed to the chambers by marble conductors."—*Lyell*, vol. i. p. 453.

Since the discovery of these remains, many antiquaries have entered into elaborate discussions, on the question to what deity this edifice was consecrated; but from its situation and construction, there is more reason to suppose that it was a bathing house, than a heathen temple.

But our object will be to show what geological changes these antiquities indicate.

Fig. 11.



The annexed cut, fig. 11, represents Serapis, as it now appears, reduced from the drawing of Mr. Lyell. These pillars are forty-two feet in height, and their surfaces are smooth and entire to the height of about twelve feet above the pedestal, the reason of which will appear directly. Above this, is a zone, twelve feet in length, where the marble has been pierced by a marine perforating shell fish, called by Cuvier, Lithodomus. It is a species of the Mytilus of Linnæus and the Modiola of Lamarck.

* Breccia is a rock composed of broken, angular pieces of stone, generally of various colors, cemented by the hand of nature. The pillars of the capitol, at Washington, are of this kind of marble.

These animals enter the stone by a small orifice, which they make themselves when quite young, and as they increase in size they enlarge their habitations in proportion. They are nourished by the sea water, which is admitted through the small aperture. These animals have not the power, or perhaps inclination, to leave their cells; hence their houses, during life, become their tombs at death.

The limestones on the shores of the Mediterranean, are frequently full of the excavations of these animals. The genus Pholas, also contains some species which penetrate rocks. Both are figured under the articles "Multivalves" and "Bivalves," towards the end of this volume. These animals cannot pierce silicious rocks, such as granite.

As these animals cannot live, except when immersed in salt water, we must infer that these pillars were for a long time submerged, and that, during part of that period, their lower portions were covered up by the rubbish already mentioned, while their upper ends reached above the water. This accounts for the reason why their middle portions only, are perforated by these animals. On the pavement of the temple lie several columns, broken in pieces. These are perforated on their fractured ends, as well as on other parts, showing that they had lain under water for a long time after they were broken.

The platform of the temple is at present just under the water, and the upper part of the perforations on the standing columns is at least twenty-three feet above the water, from which it is clear that these columns must have continued for a long time immersed in the water, while in an erect position, after which they must have been raised, by the rising of the ground, to their present elevation.

Thus it appears that the temple of Serapis was first depressed by the sinking down of the ground where it stands, so that the water of the sea surrounded these pillars about twenty feet above its present level; after which it was again raised to its present situation, by the elevation of the coast. It is hardly necessary to say, that the cause of these changes, was undoubtedly the same which has produced the elevation of islands, and the sinking down of the ground in other places.

SEAT AND THEORY OF VOLCANOES.

It was formerly believed that the seat of volcanoes was superficial, and that the heat which fused the rocks, and sent them forth in the form of lava from the mouths of volcanoes, was owing to the combustion of mineral coal. It is a sufficient refutation of this hypothesis, that were the whole interior of the earth composed of coal, it must have long since been exhausted in the vicinity of ancient burning mountains. Also, that no geologist ever supposed coal to exist below granite mountains, which are often pierced by volcanic apertures.

The cause of volcanoes has also been attributed to the spontaneous ignition of pyrites, or metallic sulphurets.

With respect to this theory, in the first place, there is no evidence that the interior of the earth is composed of the sulphurets of the metals, nor is this in the least degree probable; and second, were this ascertained to be the case, and could the theorist contrive to perpetuate its ignition, or to make it occasional, as circumstances required, still it would fail to account for the phenomena of earthquakes and volcanoes. But lastly, the products of volcanoes are not such as would result from the ignition of the sulphurets of the metals. This is sufficient.

Since the great discovery of Sir H. Davy, that the earths and alkalies are the oxides of metallic substances, it has been proposed to account for volcanoes and earthquakes, by the admission of water to these metallic elements.

This theory may be thus stated. If pure potash or soda be deprived of its oxygen, there remains a brilliant silver-white metal, so light as to swim on the surface of water.

These metals have an affinity of oxygen so strong, that when thrown on water, the fluid is decomposed, the oxygen being absorbed by the metal so rapidly as to occasion a degree of heat, which sets the hydrogen on fire. Thus by throwing these metals on water, combustion is excited, and the oxides of potassium, and sodium, or in other words, pure potash or soda is formed.

Now if we suppose that at the creation, the elements of things were formed in a distinct and separate state, and that the condition of the earth's surface at the present time is owing to the exercise of chemical affinities, then we might consider the interior of the earth, at the present time, to be composed of elements in their simple and uncombined state. This being admitted, the earth at a certain depth consists of the bases of these earths, and alkalies in their uncombined and metallic forms; for, being excluded from any substance containing oxygen, there has been no opportunity since the creation, for these substances to combine and form compounds. It is well known to chemists, that the metallic bases of the alkalies may be kept in their elementary state for any length of time, by excluding them from the air, or by immersing them in naptha, a substance containing no oxygen. Hence, as combustion is excited when these metallic bases come in contact with water, (if the above suppositions be true,) there exists an analogy, by which it has been thought the phenomena of earthquakes might be accounted for, by the admission of water to these substances.

There are, however, insuperable difficulties in this hypothesis. Carbonate of lime is one of the most abundant materials of which the crust of our earth is composed. This, in the opinions of many geologists, had its origin in organized remains, being the product of sea shells, consolidated in a manner, which it is unnecessary here to explain. It is quite certain that a great portion of limestone is really the product of moluscous animals, of which the coral reefs, and the mountains of shells, are a sufficient proof. If, therefore, lime is the product of organized beings, it was not created in an elementary form, and therefore cannot produce the fire of volcanoes by the union of its elements, though *calcium*, its base, may excite flame by contact with water.

Silex, or flint, another substance which enters largely into the composition of the earth, and of which the primitive rocks are chiefly composed, does not possess an inflammable base, and therefore cannot be supposed to participate in causing any igneous phenomena.

The specific gravity of the earth, also, being at least five times that of water, shows that it is not composed, principally, of substances lighter than that fluid.

Besides, the phenomena of earthquakes and volcanoes, even admitting the interior of the earth to be composed of metallic elements, are not such as could be accounted for by the admission of water to these substances; nor are the products of volcanic action, in the form of lava, pumice, and ashes, such as would result from the oxygentation of metallic elements. This theory, therefore, has not even plausibility in its favor.

In the present state of geological knowledge, it is not to be expected that any theory which can be proposed, will account for every circumstance connected with earthquakes and volcanoes. But that which explains the greatest number of these phenomena, is founded on the hypothesis of a "central fire," that is, a mass, or masses of lava, or melted matter, deeply seated towards the centre of the earth. The two hundred volcanoes, existing in different parts of the globe, are the chimneys, or occasional outlets of this ocean of liquid fire.

When this mass is disturbed, as by the admission of water, an earthquake is the consequence, and this becomes more or less disastrous, according to the degree of internal commotion. When the pressure of the steam, into which the water is converted, becomes excessive, then the lava is forced up one of the chimneys, and poured forth on the surface of the earth, and thus a volcano is produced, and at the same time the internal pressure is relieved.

The hypothesis of a central fire, under various modifications, appears to be the prevailing doctrine of the geologists of the present day. "If," says Mr. Lyell, "we suppose a great number of large subterranean cavities, at the depth of several miles below the surface of the earth, wherein melted lava accumulates, and that water, penetrating into these, is converted into steam; this steam, together with the gases generated by the decomposition of melted rocks, may press upon the lava, and force it up the duct of a volcano, in the same manner as it drives water up the pipe of a geyser. (The geyser is described under 'Silicious Springs.') But the weight of the lava being immense, the hydrostatic pressure, exerted on the sides and roofs of such large cavities, and fissures, may well be supposed to occasion, not slight tremors, such as agitate the ground before an eruption of the geyser, but violent earthquakes. Sometimes the lateral pressure of the lower extremity of the high column of lava, may cause the more yielding strata to give way, and to fold themselves into numerous convolutions, so as to occupy less space, and thereby give relief, for a time, to the fused, and dilated matter. Sometimes, on the contrary, a weight equal to that of the vertical column of lava, pressing on every part of the roof, may heave up the superincumbent mass, and force lava into every fissure, which, on consolidating, may support the arch, and cause the land above to be permanently elevated. On the other hand, subsidences may follow the condensation of vapor, when cold water descends through fissures, or when heat is lost by the cooling of the lava."

If this globe, towards its centre, is composed of an igneous fluid, then we might expect that the nearer we approach it, or the deeper we descend below the surface, the higher we should find the temperature, and many experiments tend to prove that this is actually the case.

Baron Fourier, who has investigated this subject with much attention, concludes, "that the rays of the sun penetrate the globe, and occasion annual and diurnal variations in its temperature, but that these periodical changes cease to be perceptible at a certain depth under the surface. Below that depth, the temperature caused by the sun has long ceased to have any influence. If, therefore, it is found that the temperature of the deep recesses of the earth become perceptibly greater, in proportion as we recede from its surface, it is impossible to ascribe this increase to the influence of the sun, and consequently it can proceed only from the primitive heat of the earth, and with which it was originally endued. It has long since been conjectured that the heat of the earth increased in some proportion to the distance of descent from its surface; but it is only within a short period, that experiments have been instituted, for the purpose of ascertaining whether this conjecture was well founded, and if so, to determine the ratio of increase. With this view, many mines have been accurately examined, and the fact of a gradual increase of temperature downwards, has been found general.

In the mines of Cornwall, England, Capt. Lean made the following experiments and observations, in the month of December.

At the surface, the temperature of the air was 50° Fahrenheit. At 120 feet below the surface, the air was 57°. At 600 feet below, temperature of the air 66°, of water 64°. At 962 feet below, air 70°, do. water 74°. At 1200 feet below the surface, air 78°, water do. 78°.

These, with other experiments in different mines, seemed to show that the increase of temperature downwards was nearly in the ratio of one degree, for every sixty-five feet.

From M. Cordier, who has written a treatise on this subject, we learn that the number of mines in which experiments have been made is about forty. These mines are situated in France, England, Switzerland, Peru, Saxony, and Mexico. The whole number of experiments made are about 300, some being on the air of the mines, some on the water, and others upon the rocks, or earth.

From all these observations, made apparently with such caution as to prevent the possibility of any considerable error, M. Cordier derives the following conclusions.

1. "If we reject a certain number of observations as uncertain, all the rest indicate, in a manner more or less certain, that there exists a remarkable increase of temperature, as we descend from the surface of the earth towards the interior. It is reasonable, then, to admit this increase.

2. "The results collected at the observatory at Paris, are the only ones that can be depended upon with certainty, for obtaining a numerical expression of the law of this increase. This expression gives fifty-one feet as the depth which corresponds to an increase of one degree, in the subterranean temperature. And we would remark, in passing, that, according to this result, the temperature of boiling water, under the city of Paris, would be at the depth of 8,212 feet, or about a mile and a half.

3. "Among all the other results, a small number only afford numerical expressions of the law sought for, sufficiently approximate, to be taken into account. These expressions vary from 104 to twenty-four feet for one degree of increase; their average, in general, indicates an increase more rapid than has generally been admitted. Their average has so much the more weight, as embracing the results of many series of long continued observations.

4. "Lastly, in grouping together, by countries, all the results, admissible on any principle, I am led to present a new and important idea, to wit, that the difference between the results collected at different places, are referable not solely to the imperfection of the experiments, but also to a certain irregularity in the distribution of subterranean heat in different countries."

M. Cordier describes at length, the manner of making experiments on this subject, in order to prevent local errors, and from all that himself and others have done and written, he draws the following inferences.

1. "Our experiments fully prove the existence of an internal heat, which is natural to the terrestrial globe; which depends not on the influence of the sun, and which increases rapidly with the depth.

2. "The increase of subterranean heat in proportion to the depth, does not follow the same law throughout the globe. It may be twice, or even thrice as great in one country as in another.

3. "These differences are not in a constant ratio to the latitude or longitude.

4. "Finally, the increase is certainly much more rapid than has heretofore been supposed; it may be as great as twenty-seven, or even twenty-four feet for a degree, in some countries. Provisionally, however, the mean must not be put lower down than forty-six feet."

We must therefore consider it as proved beyond all doubt, that, below the crust of the earth, there exists either a mass of burning lava, or some other cause, by which there is perpetually maintained a considerable degree of heat; and there is reason to believe that a very high temperature exists towards its centre.

That the internal temperature is caused by a melted mass, such as we have supposed to exist, is not, it is believed, incompatible with any known phenomenon, but, on the contrary, certainly accords with many of the effects already specified.

But there are other effects which are unaccountable, except on such a hypothesis; and one of these is the connexion, which has often been observed to exist, between one volcano and another, and also between earthquakes and volcanoes. If there exists in the earth an extensive igneous fluid, communicating with the open air only by means of volcanic apertures, we should expect, that when this fluid by any means was set in motion, the surface of the ground would partake of such motion, and that in case this fluid should be pressed for want of room, it would be forced out at these apertures.

Now, the wave-like motion of earthquakes is a phenomenon almost universally observed, and even where the shock is slight, it produces nausea, like sea-sickness. This motion is inexplicable, if the earth is composed of solid unyielding strata; but if we suppose its crust rests upon a fluid, liable to agitation, the solution becomes natural and easy. This motion may be strikingly illustrated by covering a dish of quicksilver with sand or soil, and then giving the vessel a slight agitation.

The connexion between volcanoes and earthquakes has been so generally observed, that no one at the present day denies that their causes must be the same. Earthquakes precede volcanoes, and when a wave of the lava reaches an aperture, there happens an eruption, and the earthquakes are diminished in force, or cease entirely, because the internal pressure is thus relieved.

In proof of this connexion, the elevation of all new islands, and the formation of all new volcanoes, and most commonly the eruptions of old ones, are preceded by, or accompanied with earthquakes, especially where the latter have some time lain dormant. The elevation of Sabrina, of the Aleutian Island, of Monte Nuovo, and the formation of Jurullo, together with what is generally known of Vesuvius and Etna, are examples.

It is true that, in some instances, earthquakes happen, both at great distances from volcanoes, and in their vicinities, without any eruption. But, when this is the case, the most calamitous consequences are produced, because the confined matter which causes the earthquakes cannot escape. This was the case, as already noticed, with respect to the earthquakes of Calabria, which destroyed 60,000 people, there being no eruption either of Etna or Vesuvius It is probable that this was prevented by the masses of cooled lava, by which these apertures were clogged. The great earthquake of Lisbon was also unattended by volcanic eruptions.

When the shocks commenced, which ended in the elevation of Monte Nuovo, it was expected, of course, that an eruption of Vesuvius would ensue, but instead of this, after the earthquake had continued with great force for twenty-four hours, the earth opened with a tremendous noise, and, throwing out blocks of lava, pumice, and ashes, formed that mountain in 1538. Vesuvius, with a single slight exception, had remained dormant from 1306, and showed no signs of commotion during the elevation of Monte Nuovo. Now, had there been less resistance at the crater of Vesuvius, than there was on the plain, there would have been an eruption, and no new mountain would have been formed. But Vesuvius continued torpid until 1631, during which period Etna was peculiarly active, suffering frequent and terrible eruptions. This circumstance affords a strong argument in favor of a subterranean communication between these two mountains, Etna occasionally serving as an outlet for the elastic fluids and lava, a part of which would otherwise be emitted at Vesuvius, and, perhaps, the latter, in its turn, answering the same purpose during the torpid state of the former.

Again, the earthquake of Lisbon, as already stated, was felt in all parts of Europe, and also in Africa and South America, as well as by ships sailing in the intermediate seas. Now it cannot be reasonably supposed, that a subterranean convulsion could be communicated by the mere vibration of the earth, to the distance of so many thousand miles, and especially from one side of the Atlantic to the other, under the ocean. If there existed no other evidence than this, of an interior fluctuating medium below the crust of the earth, it would be more philosophical, as well as reasonable, to infer that such a one did exist, than to believe that the earth was capable of transmitting a vibratory motion, however strong, to the distance of one fourth of its circumference.

Finally, another proof of the existence of an immense mass of igneous matter under the surface of the earth, is the quantity of lava emitted by some volcanoes. Many instances might be adduced, but we will here only refer to that of Skaptar Jokul, in 1783, an account of which has been given. There the quantity of lava covered a surface equal to ninety miles long, and twenty broad, making an area equal to 1800 square miles. The depth or thickness was generally about 100 feet; but, in some places, to a considerable extent, 600 feet deep. Perhaps, therefore, it would not be an over estimate to call the average depth 150 feet. This quantity, if consolidated, would, by calculation, have formed a massive globe of about six miles in diameter.

Now if the matter of this eruption came from the immediate vicinity of the mountain, it is plain that the strata under it, for six miles in extent, must have been thrown upon the surface, and a cavity produced of a proportionate size; but this is highly improbable, if not absolutely impossible, from the very nature of the case, because if we suppose a cavity, or definite space, whence the lava proceeded, we must also suppose it constantly full of igneous matter, at least in the neighborhood of the aperture, otherwise it would not have flowed from the crater. For, we cannot believe that in a cavity of such dimensions, steam, or any other elastic body could have operated in such a manner as to throw out all, or the greatest part of its contents.

From all we have adduced on this subject, we cannot but conclude, that the phenomena of earthquakes and volcanoes, indicate the existence of an ocean of melted lava, constantly existing at an unknown depth under the surface of the earth, and that these phenomena may, in most of their varieties, be accounted for by such a hypothesis, and by no other which has yet been proposed. It is, therefore, reasonable to infer that such a mass of igneous matter does actually exist.

ELEVATION OF CONTINENTS FROM THE SEA.

The occurrence of sea shells, and the remains of marine animals, at a distance from any existing ocean, is a fact of common observation. Some of these remains are deeply buried in solid strata, while others are found in alluvia near the surface. We have noticed in the preliminary part of this work, that such remains excited the attention of the earliest geological observers, and that for want of a more philosophical mode of accounting for these phenomena, they were then considered, not real shells, but the products of *plastic nature.*

A great proportion of Italy is covered by an alluvial soil, containing sea shells, and occasionally the remains of quadrupeds, both of living and extinct species, such as the elephant, hippopotamus, rhinoceros, mastodon, &c. In this country, in the state of New-York, of Ohio, and indeed throughout the great valley of the Mississippi, fossil shells are found; and, as in Italy, there occurs also the remains of ancient quadrupeds.

The theory, long since suggested, that the great lakes of North America, are the deeper beds of an inland sea, which once covered a great extent of land, a part of which is now dry, has undoubtedly many circumstances in its favor, and indeed may be considered as a well founded geological fact. In this instance, if, as some geologists suppose, this ancient sea has been drained by the bursting of some barrier, it is a circumstance which will account for the appearance of shells not situated higher than the bed of the former sea. But it is believed that in many places, marine organic remains are found, much more elevated than any reasonable hypothesis could have placed the bed of the former sea. The situations of these cannot, therefore, be accounted for on the supposition that they were left by the retiring waters.

In Italy, besides the more common marine remains of shells and small fish, there are found the bones of whales and dolphins, and sometimes entire skeletons of these fish occur at the elevation of 1200 feet above the sea.

The bones of whales, thus found, are in a high state of preservation, and are often incrusted with oyster shells, a good proof that they have not been transported, and that the sea for a long time remained over them, after they had been denuded of their flesh.

But it will be seen by the following extract from Cuvier, that such appearances are much more common than has been supposed.

"The lowest and most level lands," says he, "when penetrated to a great depth, exhibit nothing but horizontal strata, consisting of various substances, almost all of them containing innumerable productions of the sea. Similar strata, similar productions, compose the hills, even to a great height. Sometimes the shells are so numerous, that they form, of themselves, the entire mass of the stratum. They are almost everywhere so completely preserved, that even the smallest of them retain their most delicate parts, their slenderest processes, and their finest points. They are found in elevations, above the level of every part of the ocean, and in places to which the sea could not now be conveyed by any existing causes. They are not only enveloped in loose sands, but are incrusted by the hardest stones, which they penetrate in all directions. Every part of the world, both the hemispheres, all continents, all islands of any considerable extent, exhibit the same phenomena. They have, therefore, lived in the sea, and have been deposited by the sea; the sea therefore, must have existed in the places where it has left them."

When we find in many parts of the world, stratified rocks, forming the summits of the highest mountains, elevated many thousands of feet above the level of the sea, and when we suppose that the objects we are contemplating, were once covered by water, we are strongly impressed with the changes which the relative levels of the water and land must have undergone. And when we find the remains of shell fish imbedded in these strata, we cannot hesitate to admit that these rocks have once been covered by the ocean. When, lastly, we observe that those beds, which must once have been horizontal, are now vertical; that they are inclined, broken, bent, and dislocated in innumerable ways, we are forcibly led to conclude that their present distance from the sea has been accompanied by violent alterations in the form of the surface, and that it has been produced by the action of enormous powers.—*Macculloch*, vol. i. p. 86.

Allowing that these strata have once been under the sea, and which, from the circumstances, is proved beyond all doubt or controversy, the question to be examined, is, whether the ocean has retired to a lower level, or whether the land, by some enormous force, has not been elevated above the water.

The phenomena of shells in strata were once attributed to the Mosaic deluge, but we need not, at the present day, employ arguments to show the impossibility of such an origin. 150 days was too short a period to have produced such effects.

It has been ascertained that some of the Peruvian mountains contain sea shells, at an elevation of fourteen thousand feet above the level of the sea, and that the nature of the strata in which they are contained, is such as to show that these mountains must for a long period have been submerged. Hence it is plain that no hypothesis connected with the deluge, can explain this fact.

Now if the sea has retired in a gradual manner from such a height, within a period of five or six thousand years, its level ought now, at this rate of depression, to be at least four thousand feet lower than it was two thousand years ago, but facts, with respect to the Baltic and the Mediterranean, tend to prove, that since the Christian era, the ocean has not changed its level, in any appreciable degree.

There is, therefore, not the least probability, or even possibility, that marine organic remains situated above the sea, or imbedded in strata at a distance from it, can be accounted for by any supposition connected with the depression of the waters of the ocean.

If now we examine the facts and arguments tending to show that the land has been thrown up from the bottom of the sea, we shall find that the evidence amounts to little less than absolute demonstration that this has been the case.

In the first place, strata composed of fragments of rocks of any considerable size will take the horizontal direction. It is true that deposites of fine matter, as clay, and sand, from water, will at first take the impression, or form of the bottom when this is uneven, but if the strata be of any considerable thickness, the layers will assume a horizontal level. But we shall find, on examination, that very few stratified rocks in any part of the world, have preserved their coincidence with the horizon. On the contrary, they are inclined at various angles, and are sometimes even quite vertical; clearly evincing that they have been disturbed, and dislocated by some violence, since their formation.

"If," says Dr. Macculloch, "the highly inclined position of strata were not itself a proof of their elevation, evi dences of motion are found in a great number of phenomena. In their curvatures we find proofs of disturbance; we find even more decided evidence to the same purpose in their fractures. But when we see that these fractures are accompanied by a separation of parts which were once continuous, that one portion of a stratum occupies a higher or lower place than another, and that this separation is often attended by a difference in the angle of inclination of the separated parts, we have every proof that can be desired, of an alteration in the horizontal position of stratified rocks, since the period when they were consolidated."—*Geology*, vol. i. p. 88.

In the kind of materials, of which many inclined strata are composed, we have additional evidence of their elevation.

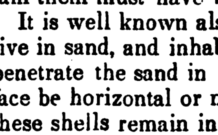
We have stated that depositions of sediment from water will at first take the form of an uneven bottom; but we need not stop to prove, that fragments of rock of any considerable size, will not rest on the sides of steep declivities, but will roll or slide down by their own gravity. Now, "it is notorious," says Dr. Macculloch, "that the conglomerates which form such conspicuous strata in many countries, and which prevail chiefly at the boundary which separates the strata called secondary, from the primary, are often found in positions, not only highly inclined, but absolutely vertical. As the materials of these are often of such bulks as to weigh even many hundred pounds, it is evident, that the original position of the strata which contain them must have been horizontal."

It is well known also, that certain marine worms which live in sand, and inhabit straight tubular shells, invariably penetrate the sand in a vertical direction, whether the surface be horizontal or not. If the strata remain undisturbed these shells remain in the position seen at Fig. 12.

Fig. 12.

And it needs little reflection to see that a concave, or dish-formed shell, when it sinks in water, must reach the bottom with its convexity downwards, and hence in all recent formations, such shells are always found in this position. But in the inclined strata, of which we are speaking, such tubular shells are found making various angles with the horizon, though they preserve their perpendicularity with respect to the strata: as represented at *b*. Fig. 13, while had the strata been pierced after its disturbance, it would have been in the direction of *c*. The concave shells, under like circumstances, are found to have changed their positions, their cavities being no longer upward, but inclined according to the position of the strata. On the same subject Dr. Ure says, "the erection of subaqueous strata into primitive mountains and plains, was evidently accompanied with universal disruption. Innumerable fragments of both the upborne, and upbearing rocks, were tossed about and washed down into the congregated waters, along the precipitous shores, and over the beds of the primeval ocean. These shattered fragments becoming agglutinated by their own pulverulent cement, soon recomposed continuous strata, which bear internal evidence of the violence which gave them birth. Thus were formed the *transition* rocks of geologists, mineral masses which denote the passage between the upright primitive, and the horizontal secondary strata, between those of inorganic and organic evidence."

Fig. 13.



The convulsions which after a long interval caused the deluge, have dislocated many of these conglomerates, so

Fig. 14.

that strata of rounded pebbles assuredly agglutinated in a horizontal position, are now found standing in upright walls. Thus the famous pudding-stones of Valorsine in Savoy, are a kind of graywacke schist, containing rounded fragments of gneiss, and mica-slate, six or seven inches in diameter. That stones previously rounded by attrition, should build themselves up into a nearly perpendicular wall, as seen at Fig. 14, and stand steadily thus, till fine particles of hydraulic cement should have time to envelop and fix them in their places, is an absurd and impossible supposition. It is therefore demonstrable that these pudding-stone strata were formed in horizontal, or slightly inclined beds, and erected after their accretion. Such effects would be produced, in the convulsive emergence of the pebbly banks out of the primeval ocean, either at the deluge, or by some preceding catastrophe. There are mountains 10,000 feet high, in the Alps, formed of firmly conglomerated pebbles.

Another and most striking proof that the rocks have been elevated by some force acting beneath them, is exhibited by primitive mountains in various parts of the world.

Here we find granite in the centre, with stratified rocks, as gneiss, mica-slate and clay-slate, leaning against its sides, sometimes nearly in a vertical position. Now as these stratified rocks must have been deposited on a horizontal level, or nearly so, and surely not in the highly inclined positions in which they are found, it is evident that their original positions must have been changed, and their inclinations caused by the same force which elevated the primitive mountains.

Under the article "Classification of Rocks," this subject is illustrated by a wood cut, to which the reader is referred.

It thus appears sufficiently evident, that at least a great proportion of the habitable earth was formed in strata under the sea; and that subsequently to its being consolidated chiefly in the position and form of horizontal layers, it has been violently elevated above the water, by some tremendous subterranean power. Hence the strata are found oblique, dislocated, and rent asunder in nearly every part of the world; and from this cause it is, that the sea and land have exchanged places, and the mountains have been elevated; but to the same cause, even to the destruction of that continuity and harmony which seems to have existed in the form of the primitive globe, we must attribute many of the greatest conveniences and comforts which the present earth affords.

Had no disturbing forces interposed, there is reason to believe that the inferior strata, now in many places elevated into hills and mountains, would for ever have been concealed from the knowledge of man; for was the earth everywhere covered with horizontal strata, lying in regular layers, one upon another, the same kind of formations would everywhere exist; and of which we should know nothing below the depth of actual excavations. *Metallic veins*, *salt*, and *coal*, would afford no indications of their existence at or near the surface. There would have been no mural precipices, or mountain declivities, or outcroppings of strata, by which the geologist, or practical miner, would be enabled to judge of the interior. Nor would there have been any spring of water issuing from the surface of the earth, for it is the inclination of the strata which directs the water to the surface, and its unevenness which allows it to break forth in the form of springs. In plain level districts, no water rises to the surface. In these, and many other examples which might be noticed, we cannot but see the traces of benevolence and design, even in the "wreck of matter," which this earth everywhere displays; and which, at every step, forces us to acknowledge, not only the Power, but the Wisdom and Kindness of the Almighty Builder of this our habitation.

With respect to the agent which has thus thrown mountains and continents from the depths of the oceans, and has dislocated the framework of the globe, we can conceive of none except *volcanic*, of sufficient power to produce such effects. It is true that no continents or extensive mountains, have been elevated from the sea, since the historical era, but we have a sufficient number of examples of the effects of this power, even during the present age, to show that the established order of nature would not be changed by the elevation of a continent, The elevation of land to the extent of a hundred miles on the coast of Chili; the rising of the Sabrina island out of the ocean; and of the Aleutian islands on the coast of Kamtschatka, out of the same; the changes made by the force of volcanoes in the neighborhood of Naples, and the effects of the earthquakes of Calabria and Lisbon, (all of which we have described in the preceding pages,) afford analogies by which it is not unreasonable to conclude, that it was the same kind of force which broke in pieces the crust of the primeval globe, and raised the habitable earth from the ocean's bed.

At what period of the creation these great changes took place, we must remain in ignorance, but it is improbable that they were all effected at the same time. On the contrary, the appearance of the strata seem to indicate a succession of revolutions at different, and perhaps remote periods from each other. These revolutions appear to have been before the creation of man and animals, and probably by such means did the Wisdom and Benevolence of the Creator prepare a place for their reception and comfort.

CLASSIFICATION OF ROCKS.

The most simple division of rocks is into Primitive or Primary, and Secondary. The first consisting of those which are supposed to have been originally formed, such as granite and its associates, and the second such as were formed by the disintegration, or destruction of these. In the early state of geological knowledge this was the received classification. In the first kind no organic remains, as plants or shells, are found, and hence they were supposed to have been formed before the creation of organized beings. In the secondary, these remains exist sometimes in great abundance. To this classification the celebrated Werner added the Transition class, which consists of the larger fragments of the primitive, and which is *intermediate* between this, and that usually called secondary.

At present, there are a considerable variety of classifications, some of which are too prolix and complicated for a popular work, while others are forbidding on account of the technical language in which they are written.

Perhaps the best which we can adopt, as embracing all the others, without their minute subdivisions, is the following:

1. PRIMARY.
2. TRANSITION, OR INTERMEDIATE.
3. SECONDARY, comprising,
   a. THE LOWER SECONDARY SERIES.
   b. THE UPPER SECONDARY SERIES.
4. TERTIARY.
5. BASALTIC, AND VOLCANIC ROCKS.
6. DILUVIAL, AND ALLUVIAL DEPOSITES.

PRIMARY ROCKS.

These compose the great frame, or groundwork of the globe. They form the most lofty mountains, and at the same time extend downward below all other formations. One of the principal rocks of this class is *granite.* This is a *compound* rock, being composed of three distinct minerals aggregated into a solid form. These are *quartz, felspar,* and *mica.* Quartz has commonly a white color, a glassy lustre, and does not divide into layers when broken. It often forms a large proportion of the granite. Felspar has a yellowish, or milk white color, and when broken, often divides into layers of considerable thickness, with smooth shining faces. Mica is also sometimes white, but more commonly of a dark green color. It consists of thin flexible leaves, adhering slightly together, and easily separable by the nail. This is well known under the name of isinglass, and when in large plates is used for economical purposes, as the dead-lights for ships, windows, for stoves and lanthorns, &c. Granite never consists of strata, or layers, like gneiss and mica-slate. These minerals differ greatly in their respective proportions in different rocks. They also differ widely with respect to size, some granites being composed of crystals, or grains, a foot in diameter; while in others the grains are no larger than those of sand.

The other Primitive rocks, are *Gneiss, Mica-slate, Clay-slate, Primitive Limestone, Porphyry,* and *Sienite;* to which some add several others.

This whole class is generally crystalline in its structure, and never contain the fragments of other rocks, or any organized substance.

Gneiss, and mica-slate are composed of the same materials as granite, but differently arranged. They are also generally composed of much smaller grains than granite. In gneiss the felspar and quartz are aggregated closely together, forming strata, or layers, between which intervene scales of mica. Hence gneiss is a *stratified* rock, and when broken at right angles with the strata, presents a striped appearance, the quartz and felspar being nearly white, while the mica is deep green or black.

Mica-slate is chiefly composed of quartz and mica, the felspar being in only small quantities, or in some instances nearly absent. The quartz is commonly in fine grains, and the mica usually predominates, or at least is much the most apparent. Some specimens of this rock appear to be almost entirely composed of small scales of mica, closely adhering together.

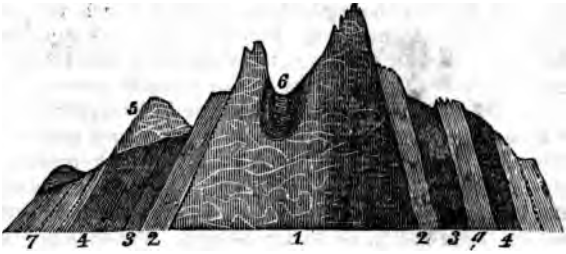
Mica-slate differs from gneiss in containing a less proportion of felspar, and in being more distinctly stratified, or slaty in its structure. It is readily divided into layers, or tables, by means of wedges, and is extensively employed for economical purposes, especially for flagging the side walks of cities.

Gneiss is intermediate between granite and mica-slate in its structure, and is often found interposed between these rocks, lying over the former, and under the latter. Indeed these rocks pass by insensible degrees into each other, the granite gradually becoming stratified runs into gneiss, while the gneiss becoming fissile forms mica-slate. These three are called *granitic* rocks, and form together a great proportion of the solid crust of our globe.

The adjoining wood cut from Daubuisson, represents the most common relative positions of granite, gneiss and mica-slate, as they occur on the earth.

The centre or middle mass, 1, projecting high above the side strata, is *granitie*. The flanking planes, 2 2, are *gneiss*, appearing as though they had been elevated to their present situation by the tremendous force which lifted up the granite. The *mica-slate*, 3, 3, is seen resting against the gneiss. The two latter rocks have the appearance of once having been in a horizontal position,

Fig. 15.



the mica-slate being superincumbent on the gneiss, and this on the granite, and we shall see in another place that this was undoubtedly the case. *g* is a great bed of *quartz*, included in the micaceous beds, and being much less subject to the disintegration by the weather, rises above the mica. 4 4, are beds of clay-slate, or roof-slate, on the outside of the mica-slate. 5, is an overlaying mass of *porphyry*, resting on the mica and clay-slate. 6, a small bed of mica-slate, resting between the central peaks of granite, with the strata bent and sloping in opposite directions, forming a dish-like cavity. Above 7 is seen a bed of clay and gravel in strata, lying nearly horizontal on the upright edges of the clay-slate, demonstrating their subsequent and independent formation.

In many instances there is sufficient proof exhibited by the rocks themselves, that the primitive strata were once in a horizontal position, and that they owe their present vertical position to a force exerted from below, and by which the granite, being elevated, has raised up the once superincumbent rocks, and given them their various inclinations. This subject has already been examined under "Elevations of Continents from the Sea."

Clay-slate. Roof-slate. This rock is exceedingly fissile, and being divided into thin plates, is in very general use for the roofing of houses; its appearance, therefore, is too generally known to need description.

This is the most distinctly stratified of all the primitive rocks, and it is a singular circumstance, that its strata are commonly very highly inclined,—sometimes nearly, or quite vertical. This rock is associated with granitic rocks, being often superincumbent on mica-slate.

Primitive Limestone. This is called *primitive*, to distinguish it from the *secondary*, or that which has been more recently formed; for limestone is of all ages from that which is now forming at the mouth of the Rhone, to that which has the antiquity of the granitic mountains.

Primitive limestone is crystalline in its structure, and is found associated with granite, gneiss, and mica-slate, being often intermixed with the latter, or alternating in layers with it. No organic remains are found in this rock, and hence, like granite, it is supposed to have been formed before the creation of living beings. When white and pure, it is known in the arts, under the name of *statuary* marble, of which the finest specimens of ancient as well as modern sculpture are made. It is found particularly in Italy, Switzerland, and the Grecian Archipelago. The Carara marble is a primitive limestone.

Secondary Limestone contains shells and other organic bodies—is compact, and not crystalline in its structure, and is associated with secondary rocks. Thus may the two kinds be distinguished.

Porphyry derives its name from a Greek word, signifying *purple*, because the first rock to which this name was applied had a purple color. At present, however, any rock having a compact, or paste-like base, with imbedded crystals, is called by this name, whatever its color may be.

Porphyry has the appearance of having once been in the form of a soft paste, into which crystals of various kinds, but most commonly felspar, have, by some unknown means been introduced. When associated with granite, porphyry is considered a primitive rock, but is sometimes secondary, and sometimes volcanic. It may, perhaps, be considered as the connecting link between granitic rocks, and those of igneous origin.

The columns of some of the most ancient and splendid edifices were made of porphyry, of which the remains are still in existence. The great hardness of this rock; the high polish which it is capable of bearing, and the variety and beauty of the colors which it often presents, afford a combination of qualities for splendid and enduring architectural purposes, which is found in no other mineral body. But the labor of forming pillars of thirty or forty feet in height, and five or six feet in diameter, of this material, such as the ancients constructed, is much too great and expensive for the present age.

Porphyry, though not an uncommon rock, seldom occurs in extensive formations like granite and limestone.

Sienite. This rock is composed of quartz, felspar and hornblende. It may be considered as a granite in which the mica is replaced by hornblende; it, however, sometimes contains small portions of mica. Its structure is granular like that of granite, and its prevailing color is yellowish white, mottled with black, giving it a gray appearance. The city of Boston contains many magnificent columns of sienite. It is associated with granite, into which it gradually passes, as the mica takes the place of the hornblende.

IGNEOUS ORIGIN OF GRANITE.

It was formerly believed that granite was of aqueous origin, that is, that the materials of which it is composed were first dissolved in water as preparatory to their assuming that solid and crystalline form, which we see at the present time. Now chemistry has long since taught us that no substance in the laboratory of art, nor so far as is known, in that of nature, ever assumes the crystalline form until it has been dissolved in some kind of fluid; and indeed a single consideration would seem to show, beyond all question, the necessity of such solution, for otherwise there could be no motion among the particles of which the crystal is formed, and without motion it is equally certain that these particles never could take their places according to the laws of affinity, or in other terms, never could assume crystalline forms.

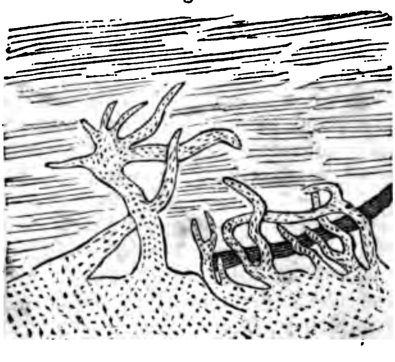
The kind of fluid in which the particles are dissolved, it is obvious, must depend on the kind of substance. Thus some substances are soluble in water, others in acids, and others in caloric. Now, although the materials composing granite are scarcely soluble by any artificial means, still there is no doubt but under a very high temperature, with the combined aid of pressure, they would be soluble in water, or in caloric alone, and the phenomena, as we shall see, afford conclusive evidence that the latter was the solvent, and that the materials composing granite were once in a melted state.

The igneous origin of granite is satisfactorily proved, from the phenomena of its veins:—from the calorific effects of these veins on the walls of the rocks, through which they have protruded;—from the intrusion of granitic matter between the strata of various rocks through which such veins have been forced, and lastly, from the passage of known igneous rocks into granite.

The igneous origin of trap rocks has long been acknowledged by all competent geologists, but the general agreement that granite had the same origin is only of recent date. The proofs however of the origin of both are nearly the same.

Under the "*Origin and phenomena of Trap Rocks*," it will be seen that dykes or veins of basalt often protrude through the strata of other rocks, and that where they come into contact with these strata, the effects of heat are always apparent. The illustrations by diagrams, also prove that these veins, or dykes, were forced through the fissures, or spread between the strata of the rocks, while the former was in a soft or semifluid state. The same phenomena are found to attend veins of granite which traverse other rocks, there being every indication that these veins were forced up from below in an ignited and softened state.

Fig. 16.



The diagram **Fig.** 16, will show the manner in which granite sometimes traverses stratified rocks. This drawing is from Dr. Macculloch's representation of granite veins passing through gneiss at cape Wrath in Scotland. These veins, it may be observed, intersect each other in various directions, and are curiously branched and contorted. The mass of granite below the stratified gneiss, is also apparent, and as the veins end before reaching the surface of the gneiss, we cannot but infer that they were forced up in a softened state from the underlaying granite with which their trunks are incorporated. Similar instances, that is, of granite veins traversing stratified rocks, and also rocks of granite, are known to occur frequently and in various parts of the world. In Europe such cases were formerly considered singular and important phenomena, and as they went to prove the igneous origin of granite, they were described with great prolixity and exactness. But the progress of observation has shown that granitic veins are quite common, and that particularly in mica-slate, examples may be seen in almost any place, where circumstances allow the rock to be examined a few yards below the surface, and often on the surface itself.

In this country, Prof. Hitchcock of Amherst College, in his Report of the Geology of Massachusetts, has described and figured many such cases; some of which we shall take the liberty of inserting at this place.

Fig. 17.

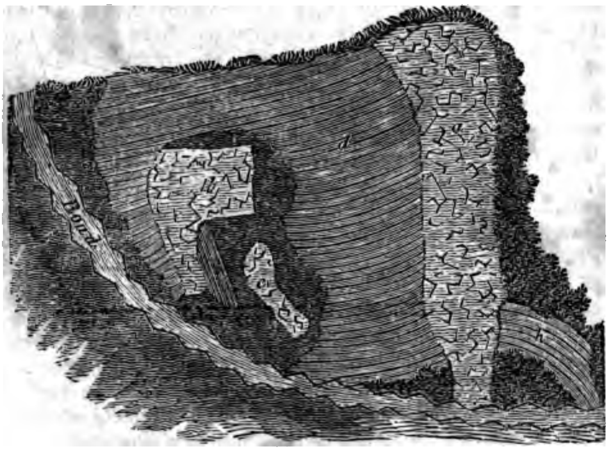


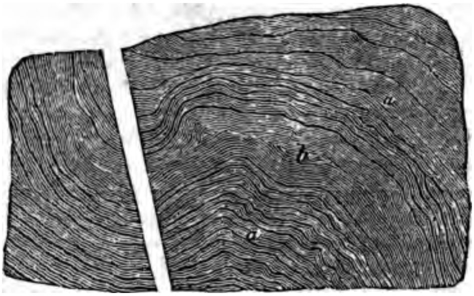
Fig. 17, (fig. 11, in Prof. Hitchcock's work,) represents a vein of granite protruding through strata of hornblende slate. It occurs at Ackworth, New Hampshire, and is a remarkable locality of beryls, rose quartz, and crystallized mica.

"As the traveller approaches this spot," says the author, "he will observe while several miles distant, a remarkable conical half-naked peak, chiefly of white granite, shooting up about 300 feet above the surrounding country. This is the hill represented below, (Fig. 17,) as seen on its north-western side, along which the road passes. The prevailing rock in the vicinity is gneiss; but in this elevation it is chiefly hornblende slate, traversed by an enormous granite vein, *a*, and exhibiting at least two protruding masses, *b*, and *c*, of granite. The vein varies from one half, to four rods in thickness, and the mass *b*, is four or five rods across: *c*, is only ten feet wide. The general direction of the laminæ of the slate is north and south, and the dip from 15° to 20° east: but we have here the most decisive marks of its having been irregularly upheaved, and disturbed by the protruding granite. Near the foot of the hill, the slate is bent upwards, so that the chord of the curve is several rods long. But it is a curious fact, that the axis of the elevating force seems not to have coincided with the direction in which the vein was erupted. For the highest point of the curve of elevation, near the foot of the hill, is to the right of the vein at *h;* and as we ascend the hill we find the slate curved upwards near the vein more and more, as is shown by the drawing. Indeed, the granite of the vein seems to lie on the elevated edges of the slate; so that the lower side of the vein dips north-easterly; and does not cut the slate perpendicularly. These facts would seem to evince, that the vein made its way through the slate, not along the line of the greatest pressure, but on the north side of it; probably because there the slate yielded most readily. We may suppose the melted granite below to have gradually elevated the slate, until at length it burst its way laterally through the rock. Such cases, I believe, do sometimes occur in existing volcanoes.

"The masses of granite *b*, and *c*, are probably other examples in which the molten matter bursts its way laterally through the slate. And it is an interesting fact in regard to the mass *b*, that in some places it still projects over the slate several feet, forming in fact an overlaying mass. Instances of this kind I have rarely met with in the granite of New England." Page 480.

Fig. 18, also from Prof. Hitchcock's work, represents a nearly perpendicular ledge of mica-slate in Conway, Mass. The strata as shown by the drawing, are much contorted, indicating disturbance during their deposition, or while they were in a soft and yielding state. *a*, *a*, are strata of com

Fig. 18.



mon mica-slate: *b*, is a stratum of amphibolic slate. The whole surface exhibited is fifteen feet long and eight feet high. Through this ledge runs a vein of fine grained granite a foot wide.

"The object of giving this sketch," says Prof. Hitchcock, "is to show that this vein has produced no derangement of the mica-slate: for the different particles of that rock occupy the same relative position on the different sides of the vein. Hence the vein was introduced subsequently to the consolidation of the slate; and probably it was injected into an open fissure."

PASSAGE OF GRANITE INTO BASALT.

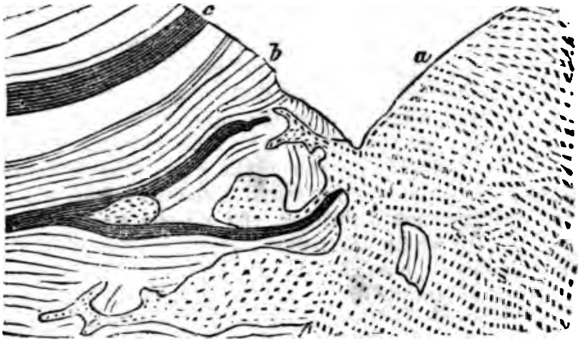
Dr. Hibbert describes the manner in which granite has gradually passed into basalt in one of the Shetland islands. The basalt extends from the island of Mickle Voe northwards to Roeness Voe, a distance of twelve miles. On the west of this there is a considerable mass of granite, and the transition from the one into the other is thus described. "Not far from the junction we may find, dispersed through the basalt, many minute particles of quartz. This is the first indication of an approaching change in the nature of the rock. In again tracing it still nearer the granite, we find the particles of quartz dispersed through the basalt, becoming still more numerous and larger, an increase of magnitude even extending to every other description of particles. The rock may now be observed to consist of separate ingredients, of quartz, of hornblende, felspar, and greenstone; the latter substance, (greenstone,) being a homogeneous commixture of hornblende and felspar. Again, as we approach still nearer the granite, the disseminated portions of greenstone disappear, their place being supplied by an additional quantity of felspar and quartz. The rock now consists of three ingredients, felspar, quartz, and hornblende. The last change which takes place, results from the still increasing accumulation of quartz and felspar, and from the proportionate dissemination of hornblende. The hornblende eventually disappears, and we have a well characterized granite, consisting of two ingredients, felspar and quartz." *Ed. Journal of Science*, vol. i. p. 107.

We see, from these examples, that granite has been forced from below into the fissures of other rocks which were superincumbent, consequently, which were deposited after the granite was formed. In several instances it may be observed also, that the granite does not reach the surface, by which it is proved that these veins could not have entered from above, a theory long maintained by those who claimed that granite was of aqueous origin. Besides, the indications of fusion which these veins present, the passage of granite into basalt, a rock which all agree bears the marks of fire, is additional evidence that they had a common origin.

But if we consider granite veins to have forced their way from below, in a state of igneous fusion, then we might expect, that when the mass came into contact with stratified rocks, the strata would be separated, and that the fluid matter would run between them, at least to a short distance, and especially near the surface, where the pressure would present little resistance to the separation of the strata. Now this is precisely what is known to have happened in numerous instances, one of the most striking examples of which occurs at Glen Tilt, in the Grampian mountains in Scotland.

At this place, veins of red granite are seen branching out on the northern side of the glen, from the principal mass, and meeting the slate and limestone which forms the southern side. The granite veins run in all directions, intermingling with, and disturbing the strata of the other rocks, in such a manner as to prove, not only that the granite was in a fluid state at the time of its intrusion, but also, that it was forced up with great violence

Fig. 19.



The diagram, Fig. 19, from Dr. Macculloch, represents the appearance of these rocks. "The granite at this locality," says Mr. Lyell, "often sends forth so many veins as to reticulate the limestone and schist, the veins diminishing towards their termination to the thickness of a leaf of paper, or a thread. In some places fragments of granite appear entangled, as it were, in the limestone, and are not visibly connected with any larger mass; while sometimes, on the other hand, a lump of the limestone is found in the midst of the granite;" *a*, granite, *b*, limestone, *c*, argillaceous schist.

The ordinary color of the limestone at Glen Tilt is lead blue, and its texture large grained; but where it approximates to the granite, particularly where it is penetrated by the smaller veins, the crystalline texture disappears, and it assumes an appearance exactly resembling hornstone. This change was undoubtedly produced by the heat of the intruding granite.

These facts and circumstances are considered sufficient to show the igneous origin of granite, though an abundance of others of a similar nature might be adduced from authors.

GRANITE OF DIFFERENT AGES.

All the older geological writers believed that granite was the primitive rock of our globe, and the one on which all others reposed. They also considered this rock as everywhere of a similar age, the idea of successive formations of granite having never until recently been advanced. These opinions were founded on the general facts, that this rock lies beneath all others, and that it contains no organic remains, which facts even at the present day we must acknowledge to be generally true. More extensive observations have, however, shown many exceptions to these facts, there having been discovered instances where granite not only penetrates through, and reposes on stratified rocks, but also where the rocks invaded by it contain organic remains. Thus Dr. Macculloch describes a considerable mass of granite in the Isle of Sky, which is incumbent on limestone, and shale. The limestone at some distance from the granite contains shells, but in its immediate vicinity, no shells appear, the limestone being converted into pure crystalline marble. This change, as well as the destruction of the shells, is attributed to the heat of the granite at the time of its protrusion.

In different part of the Alps, similar phenomena occur, where, according to the observations of Beaumont, and others, granite is seen penetrating through secondary strata, which contain belemnites, and other fossil organic remains.

In Norway, also, Von Bush discovered a mass of granite overlaying a bed of secondary limestone, containing a variety of fossil shells.

These and other instances of the kind, must however be considered as exceptions to a general rule, there being no doubt, but the granite which universally forms the deeper portions of the crust of our globe, is the eldest of our rocks.

DIFFERENCE BETWEEN IGNEOUS ROCKS.

After having shown that granite, as well as greenstone, is an igneous rock, the inquiry naturally arises why these two rocks differ so widely in appearance, if indeed they have had the same origin? This is a question which our present knowledge does not enable us to answer with any degree of certainty, nor indeed do geologists profess to do more than offer plausible conjectures to account for these differences.

The composition of greenstone is *hornblende* and *felspar*, that of granite is *felspar*, *quartz*, and *mica*. The crystals in the greenstone are commonly small, often too minute to be distinguished by the naked eye, while those of granite are generally of considerable size, often many inches in diameter.

Some geologists have supposed that the difference in the size of the crystals, might be accounted for by the difference in the time of cooling, since chemistry, in some instances, has shown that the same materials will form large crystals when cooled slowly, and small ones when cooled suddenly. It has been conjectured, therefore, that the trappean rocks were erupted under the sea, and that the pressure of the water, and the rapid abstraction of the heat, by its agency, has caused the difference in texture. But if we admit that the granite was fused at a greater depth, and in larger quantities, and account for the difference of texture on these conditions, still it is difficult to conceive why such conditions should produce such changes in the compositions of the two rocks, the greenstone containing little or no mica, or quartz, while the granite contains only an occasional portion of hornblende.

If we compare granite, and the varieties of trap, with the volcanic products of the present time, or with those of ancient, extinct volcanoes, we shall find, in general, little analogy, either in appearance or composition, between them. No volcano, either ancient or modern, has ever been known to emit either granite or trap; though the latter and some volcanic products have considerable affinity.

It is possible that future observations may throw light on this subject, but, at present, though geologists generally agree that granite, trap, and lava, were all once in a state of fusion, yet no one has given any satisfactory theory to account for the differences they present in appearance, texture, and composition.

TRANSITION, OR INTERMEDIATE ROCKS.

Next in order to the primitive are the Transition rocks. The term transition comes from the Latin *transitio*, in reference to their removal, or change of place. These rocks are above the primitive, on which they rest.

This formation is composed of the larger fragments of all the primitive rocks, consolidated into continuous masses. The manner in which the transition rocks were formed, appears to be sufficiently obvious. At the time when the waters were gathered into one place, to form the sea, or when the primitive rocks were thrown up from the ocean, the disruptions and dislocations consequent upon these mighty movements, reduced the highest parts of the primitive to fragments, which falling down upon the sides of the mountains, covered them with their ruins; and these becoming agglutinated by the pulverulent cement, produced by the friction of these fragments, formed the rocks in question.

In the course of their consolidation, organized beings of the lowest orders, such as sea shells, falling in their crevices, were there imbedded; and thus it is proved that these rocks were formed after the creation of organized beings. That they were formed next after the primitive rocks, is proved by their lying immediately on them.

The rocks belonging to this class are *Graywacke*, *Transition Limestone*, *Slate*, and *Sandstone*.

Graywacke. This uncouth word, which we have borrowed from the Germans, the French geologists have exchanged for the term *traumate*, which signifies *fragmentary*.

Graywacke is a slaty formation, which includes the fragments of many other rocks. These fragments vary in size, from that of the head to the smallest grains. Sometimes it consists almost entirely of rounded pebbles, cemented together by sand and oxide of iron. It is then called *conglomerate*, and no longer retains its slaty character. When the grains are small, and it is stratified, it becomes slate; and when not stratified, it passes into sandstone. The Rhode Island coal mine is in a graywacke formation.

Transition Limestone. This is an abundant rock, being that which is employed in making quicklime for mortar, and also, in many countries, as a building stone. Many of the common variegated marbles belong to this formation. Some specimens are finely colored, and bearing a high polish, form beautiful slabs for tables and fireplaces.

This rock sometimes underlays large sections of country, and in other instances rises into extensive ranges of mountains. The great caverns which are described as existing in different countries, and which often contain the remains of animals, are of this class.

Some transition limestones contain abundance of marine organic remains, and hence must have been formed under the ocean. In other instances no fossil relics are found, but the rock is composed of angular, or water-worn fragments, consolidated by a calcareous cement. The presence of such fragments will always distinguish the transition from the secondary limestones.

In England and Wales, this is a very extensive and important formation, and contains not only vast quantities of organic relics, but various metallic ores. "In Derbyshire," says Mr. Bakewell, "where the different beds of limestone have been pierced through by the miners, the average thickness of the three uppermost, is 160 yards; the beds are separated by beds of trap, or basalt, resembling ancient lavas."

Slate. Clay slate, although often associated with primitive rocks, as already noticed, is also found with those of the transition class. But we have already given a sufficient description of this rock.

Porphyry. This is also, sometimes a transition rock, being so considered when it is found associated with rocks of this class.

Sandstone. This rock, as its name indicates, consists chiefly of sand, cemented into a solid form. It often contains water-worn pebbles, angular pieces of other rocks, as granite, fragments of slate, nodules of quartz, &c., being evidently made up of the ruins of former rocks. Its color is commonly red, owing to the oxide of iron it contains, and which serves as a cement to the grains of sand of which it is composed.

Sandstone, by an uninterrupted continuity, passes into graywacke. The only difference appears to be, that the latter rock is commonly stratified, and of a darker color, not having, like the sandstone, a tinge of red. Where the graywacke is not of a slaty structure, it become sandstone.

SECONDARY ROCKS.

The secondary rocks have, by some, been divided into the lower secondary, and upper secondary, the second being superincumbent on the first: but as it is difficult to determine where the lower series terminate, and the upper one commences, we shall follow the more simple method of considering the whole as merely secondary formations. The same difficulty, indeed, is applicable to the termination of the transition series, and the commencement of the secondary. The chief differences being, that the secondary is not so generally composed of fragments, shows less of the crystalline structure, and contains organic remains of known existing species; while the transition class is more fragmentary; more crystalline, and contains few or no shells, known to be recent, or living.

The principal secondary formations are *Coal, Secondary Limestone, Chalk, Oolite, and Sandstone.*

The last named rock, we have placed among the transition series; and undoubtedly that which is composed, in considerable proportion, of the fragments of other rocks, belongs there; but many sandstone formations appear more properly to be arranged as secondary rocks. The actual inquirer will often find himself at a loss to determine, from the position of strata, with respect to each other, which are the transition, and which the secondary; because, in many instances, the secondary, as well as the tertiary, to be next described, will be found lying immediately upon the primitive. This arises from the fact, that no formation of the secondary series extends to every part of the earth. Did the different formations cover the earth entirely, as the coats of an onion surround each other, there would exist neither doubt nor difficulty on this subject; for then the same characters would identify the different classes, in all parts of the earth, and each could be known, merely by its depth under the surface. But instead of this, it is quite common, even in countries of no considerable elevation, to observe the primitive rocks projecting above the surface, or lying only a few feet beneath the soil. It is, therefore, only in certain parts of the earth, that the relative positions of strata can be determined, as a whole, for it is obvious, from what we have stated, that in some places, the newest formations overlay the oldest, without the intervention of any other. In such situations, however, as afford opportunities for observing the several strata lying superincumbent, the same relative positions are found everywhere to exist, or to exist so uniformly as to lead to definite general conclusions.

Coal. This well known substance affords several varieties, differing in color, from dark brown to jet black, and containing variable proportions of carbon and bitumen, with more or less impurities.

The English mineral coal, is stated by mineralogists to contain from fifteen to forty per cent. of bitumen, and from forty to eighty per cent. of charcoal.

Black, or common coal, is found in regular strata, or beds, from a few inches, to several yards in thickness. Several beds commonly occur under each other, being separated by strata of clay or sandstone. These series of strata are called *coal fields*, or *coal measures.*

Coal Fields. Every coal field has its peculiar series of strata, which vary in thickness from those of any other. The coal beds are also separated by deposites, which differ in thickness, in kind, or in arrangement, from those of other formations. Hence each coal field is a distinct and independent deposite, and is in no way connected with any other coal field, with respect to the sources whence their materials were originally derived. Hence they are all of limited extent, and most commonly basin-shaped concavities, which have the forms, and so far as can be ascertained, the appearance of once having been lakes, or ponds of greater or less depth and extent. In some of the large coal fields, the original formation of the lake cannot be traced, but in many smaller ones, it is distinctly ascertained.

The number of coal beds, and the various intervening strata through which the shafts of some coal mines pass, often amount to great numbers. In a coal field belonging to Lord Dudley, in Staffordshire, a shaft was sunk to the depth of 939 feet. The beds passed through in this shaft, which the miners distinguish by different names, are sixty-five. The number of beds of coal, are eleven, of which five are above the principal bed, called the *main* coal, and five below it. The main coal is about three hundred feet below the surface. and consists of thirteen different beds, lying close to each other, but separated by their layers of slate-clay. Its thickness is about twenty-seven feet.

To convey an idea of the regularity of these strata, we here give the names of a few of them, and the succession in which they occur, beginning with the lowest.

		thick.			thick.
1	Slate-clay,	90 ft.	9	Gravel,	6 ft.
2	Limestone,	30	10	Coal,	9
3	Slate-clay,	230	11	Slate-clay,	27
4	Coal,	2	12	Slate-clay,	6
5	Slate-clay,	120	13	Coal,	6
6	Coal,	15	14	Slate-clay,	21
7	Slate-clay,	8	15	Coal, (main,)	29
8	Coal,	10	16	Bituminous shale,	7

See "*Origin of, and Searching for Coal.*"

Secondary Limestone. This is also called *carboniferous*, and *mountain limestone.* Its texture is compact, and not crystalline, like the primitive limestone before described. Its prevailing colors are gray, or yellowish white, but it is sometimes bluish or black. This formation is sometimes extensive, underlaying large districts, and rising into considerable mountains. The hills of this formation often present mural, or wall-like precipices, and rocky, uneven dales.

It is considered a more recent rock than transition limestone, and is often composed, almost entirely of marine shells, sometimes only slightly adhering together. It also contains the bones of animals, chiefly of extinct species, but sometimes of those now living, and which are never found in the transition class. It is often difficult, however, to distinguish this rock from transition limestone, into which it insensibly passes.

Rock Salt. Although this salt cannot properly be classed as a rock, yet as it forms considerable beds, and is, withal, an important article, it is proper to describe its geological bearings and associations.

In its impure state, as it is raised from the mine, rock salt is in large solid masses, of a crystalline structure, with a reddish or bluish color. When pure, as it sometimes occurs in the mine, it is perfectly colorless and transparent, like the best flint glass.

Rock salt is found at various depths below the surface. At Cheshire, in England, where vast quantities are raised, the first bed is one hundred and thirty feet deep, and seventy-eight feet thick. This is separated from the next bed by a stratum of clay-stone, thirty feet thick. The lower bed has been penetrated one hundred and twenty feet, but has not been sunk through.

The principal known deposites of salt, are those of Cardona, in Spain; those of Hungary, and Poland; that of Caramania, in Asia; the extensive formations of Germany and Austria; those on each side of the Carpathian mountains, and those of South America.

According to the traveller Chardin, rock salt is so abundant in Caramania, and the atmosphere so dry, that the inhabitants sometimes build their houses of it.

Origin of Rock Salt. At Posa, in Castile, there is a deposite of rock salt, within the crater of an extinct volcano; and in the island of Sicily, there exists more or less of the same mineral, in such situations as to indicate that it has been formed by the evaporation of sea water, by volcanic heat. But if subterranean heat has in a few instances produced salt by evaporation, still the situation and appearances of these formations generally, are such as to preclude any rational supposition, that they have been formed in this manner.

The most natural hypothesis that has been offered, to account for the existence of this salt, especially in certain situations, is that which attributes it to the gradual evaporation of pools, or lakes of salt water left by the ocean, when it retired from the present continents, in consequence of their elevation. This theory, too, might be considered as receiving strong support from the fact, that in some of the Polish mines, sea shells, the claws of crabs, and vegetable impressions have been found.

But on the contrary, most salt mines are entirely without any organic, or other remains, by which any gleam of light is thrown upon the history of their origin. Were these formations the solid matter, left by the desiccation of salt lakes, we should suppose that fossil sea animals, as well as shells, ought to be found everywhere, and in abundance. Another, and still stronger objection to this hypothesis, is the great purity of subterranean salt, when compared with that obtained by the evaporation of sea water.

With the exception of foreign impurities, such as clay and sand, rock salt is nearly pure muriate of soda; while sea water, by evaporation produces *muriate of magnesia*, and *sulphate of soda*, besides muriate of soda. The mode in which rock salt is disposed in the earth, is also against the hypothesis of evaporation. That of Cheshire, instead of being in strata, is found in distinct concretions.

To these difficulties, it may be added, that the depth of sea water required to produce some of the larger masses of rock salt, must not only have been unfathomable, but incomprehensible. The salt hill of Cardona is 663 feet in height, and is solid muriate of soda. Now, according to the experiments of Dr. Marcet, 500 grains of salt water, yielded 21 1-2 grains of solid matter, of which 13.3 parts were muriate of soda. From 10,000 parts of sea water, Dr. Murray obtained 220 parts of common salt. According to such data, if the salt of Cardona was formed in a lake, by evaporation, the water not only yielded pure muriate of soda, but must have been more than 27,000 feet, or more than five miles in depth.

Finally, this subject appears to be one of great difficulty, for although geologists have made the theory of these formations a matter of much interest and inquiry, no rational hypothesis concerning them has yet been proposed.

Gypsum. Sulphate of Lime. This is known under the name of Plaster of Paris, and is so common as to need no description. This substance, like rock salt, is seldom found in extensive formations. It occurs both with primitive and secondary rocks, and, from the species of shells it sometimes contains, has been considered a fresh water formation. Beds of gypsum commonly alternate with those of marl and limestone.

The greatest deposite of gypsum described, is that of Paris, which extends about twenty leagues. At Montmatre, near Paris, two formations of this substance may be observed; the lower is composed of alternate beds of little thickness consisting of gypsum, often crystalline, alternating with lime and clay-marls. The upper formation is the most important and remarkable. It is about sixty-five feet thick, and, in some places, lies immediately under vegetable mould. This is especially interesting, from the number and variety of organic relics it contains, and from its being the chief source whence the celebrated

Cuvier drew the skeletons of so many extinct species of animals.—*See Organic Remains.*

Chalk. In England, chalk is a very important formation, both on account of its extent and its perfectly distinctive characters. It is also found in France, Ireland, Spain, Germany, Italy, and Poland; but it is a singular fact, that no deposites of chalk have been found beyond the limits of Europe. In the New World, through the whole extent of the two Americas, not a specimen of chalk has been found.

The chemical properties of chalk are those of carbonate of lime, viz., lime 56; carbonic acid 44=100. When well burned, chalk is said to make as good quick-lime as the hardest marble. In the Isle of Wight, the harder kinds are employed as building stones; and, at Dover, chalk is used in the construction of docks, or other masonry, which is covered by the water. Some very ancient buildings are constructed of this material, and among them the abbey of St. Omar, in France, which is said still to retain all its beautiful Gothic ornaments in great perfection.

With respect to the antiquity of chalk, it is considered a more recent formation than coal, and between it and the tertiary, or newer secondary formations.

Beds of chalk generally contain nodules of flint and organic remains, especially those of shells, sponge, star-fish, madrepores, &c.; but some beds are entirely without flints. Countries underlaid with chalk are generally far from being flat or level, but, on the contrary, are remarkable for their undulations of surface, the hills having smooth rounded outlines, with deep indentations, or hollows, in their sides.

Thickness of Chalk Beds. Chalk beds vary in thickness from a few inches to 1000 feet or more. At Dover, the beds containing flints are about 500 feet thick, and those without flints 140 feet thick. At Culver cliff, in the Isle of Wight, where these beds are disposed vertically, and where Mr. Coneybeare says there is the best opportunity afforded to ascertain their thickness, this has been found about 1300 feet. But, generally, this formation in England varies from 600 to 1000 feet in thickness.

Oolite. This is also called *Roestone*, because it is composed of small globules resembling the roe of fishes. It has generally a yellowish brown, or ochery color. It is a variety of common limestone, from which it does not differ in composition. These globules do not, however, in all cases, compose the entire mass; sometimes they appear to be imbedded in solid limestone, and, in other instances, they are wanting entirely.

In England, this formation is superincumbent on chalk, and often contains shells and other organic remains. It is employed as a building stone. St. Paul's church and Somerset house being constructed of this material. It is, however, said not to be a durable stone.

With respect to the manner in which these globules were formed, Mr. Bakewell remarks, that it is not yet ascertained whether they have resulted from a tendency to crystalline arrangement, or whether they are of animal origin. We should think neither would account for them; but that they were formed in springs, or rather running water, containing lime, by a gradual deposition of carbonaceous particles on a small nucleus, as a grain of sand, kept in agitation by the stream.

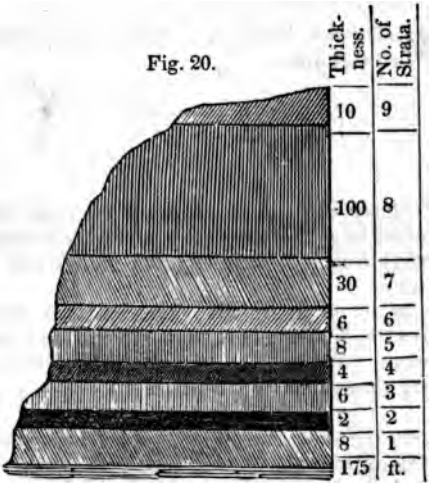
Lias. This name is said to be a corruption of the word *layers*, because this rock is usually stratified. It is one of the Oolitic group, and passes by insensible shades into Oolite. It is an argillaceous limestone, usually found in the conformable position. It retains a uniform mineralogical character throughout a great portion of England, France, and Germany. It is often rich in organic remains, and especially of the saurian reptiles.

In this country it is described by Dr. Hildreth as existing on the Little Muskingum, in Ohio. Color yellowish white when exposed to the air, but grayish white when taken from the bed; structure compact, fracture conchoidal, with an earthy surface; adheres to the tongue; composition, carbonate of lime, with a little carburet of iron. In properties and appearance it approaches nearly to chalk.

Dr. Hildreth says, "that it stands the weather without exfoliation, and would make a most beautiful building stone."

The associations of this rock, in Ohio, will be seen by the diagram, fig. 20.

Fig. 20.



Order of the series ascending.

1. *Limestone;* compact, dark, and in strata, from six inches, to two feet in thickness. This bed is eight feet thick.

2. *Bituminous Coal,* very pure; structure slaty; three feet thick.

3. *Water lime,* in thin beds reposing on the coal. Thickness, six feet.

4. *A Chloritic rock;* color deep, almost verdigris green. Four feet thick.

5. *Lias,* which we have already described.

6. *Calcareous tufa.* It is porous, as if pierced in all directions by small worms. Six feet thick.

7. *Hard sparry limestone,* of a light dove color, tinged with brown. Thirty feet thick.

8. *Sandstone,* the lower part in strata of a few inches thick, and contains some fossil remains. 100 feet thick.

9. *Argillaceous*, loamy soil, rich, and covered with timber. Ten feet thick.

TERTIARY STRATA.

The *Tertiary*, or third formation, as the name indicates, was deposited after the secondary, and may be considered as proceeding from the disintegration of this and the primary series.

With respect to its relative antiquity, the tertiary is newer than chalk, and older than the Diluvial and Alluvial deposites. When these, therefore occur in the series the tertiary formations are between the chalk and the diluvium.

The Tertiary strata consists of beds of clay, sand, marl, pudding-stones, and the newer limestone deposites, such as are found in the Paris basin, and in the Isle of Wight. These formations often contain abundance of fossil shells and plants, together with the bones of fish and quadrupeds. The famous locality of fossil fish at Monte Bolca, in Italy, is in tertiary strata.

In North America this formation is very extensive, reaching without interruption along the sea coast from Long Island to Louisiana and extending in some parts several hundred miles inland. It consists of sand and clay often mixed with an abundance of sea shells. The valley of the Connecticut is in a considerable proportion of the same formation, consisting of sand and clay, though the shells are absent. The whole of Long Island, Martha's Vineyard, and Nantucket are also tertiary formations. In general, tertiary strata show no marks of disturbance, being deposited since the lower rocks were disrupted.

VOLCANIC AND BASALTIC ROCKS.

These owe their origin to volcanic fire, and have been either ejected from burning mountains, or forced up to the surface of the earth in a melted state by volcanic action. Some of these rocks occasionally cover all the formations hitherto described, and as volcanoes are still active, they may and indeed do, cover the most recent deposites of sand and gravel.

This division is known under the name of *unstratified* rocks, which also includes granite. Many geologists suppose that granite also had an igneous origin; and this indeed appears to be the prevailing opinion of the ablest writers of the day.

Basaltic or Trap rocks, including also those formed of lava, cover the other formations, in a very irregular, and uncertain manner. In France, large districts of country are buried under ancient lava, and the northern parts of Great Britain abound with basaltic rocks.

The word *trap*, is said to come from the Swedish *trappa*, which signifies a stair, or step, because rocks of this kind often separate in such a manner as to form stairs.

The application of this term is far from being definite, some geologists meaning by it such unstratified rocks as basalt, greenstone, porphyry, and their associates; while others have confined it to such rocks as are chiefly composed of hornblende, whether stratified or not. The former application of this term is undoubtedly the most common and appropriate.

The most important volcanic rocks are Basalt, Greenstone, and Lava.

Basalt. The color of this rock is dark grayish black, or brownish gray. It is found in large shapeless masses, or in columnar prisms, with from three to nine faces. These columns are of all sizes, from a few inches to several feet in diameter, and sometimes four hundred feet in height. They are composed of joints, or blocks of the same angular shapes, resting one upon another. The texture of basalt is fine grained, or compact, and it often contains other minerals imbedded in it, such as felspar, quartz, mica, leucite, and oxide of iron. It also exhibits hollow cavities, or vesicles, apparently formed by bubbles of air during its fusion. The Giant's Causeway in the North of Ireland, is composed of basaltic columns.

Greenstone. This is a compact, hard, tenacious rock of a dark grayish color, with a greenish tinge. It is essentially composed of hornblende and felspar. This rock occurs in beds of greater or less extent, sometimes forming extensive ranges of mountains. In this country greenstone is a common rock. The range of mountains on the west side of the Connecticut, reaching from New-Haven to Northampton, is of this rock. In some places, their height is several hundred feet. These rocks, as will be seen in another place, are undoubtedly of volcanic origin, having been elevated to their present situation through fissures, by the force of subterranean fire.

Lava. This term comes from the Gothic, and signifies to *run*, in reference to the flowing of volcanic matter.

The products of volcanic mountains often present very different appearances, and hence have received several names, as *volcanic slags*, *volcanic enamel*, *cellular lava*, *compact lava*, *pumice*, &c. But in general terms, all the liquified products of volcanoes are called *lava*, and for the purposes of elementary geology, this definition is perhaps sufficient.

The colors of lava are most commonly yellowish, or greenish gray sometimes running into sulphur yellow, and grayish black. Some are compact, while others are full of small pores, and others are fibrous with a silky lustre; but all the different kinds run into each other, so that it is often difficult to make distinctions between them.

DILUVIUM.

Diluvia, or *diluvial deposites*, are generally supposed to have been formed during the general deluge. They consist of sand, pebbles, and blocks, or fragments of various kinds of rocks, not generally existing in the districts where these deposites are found at the present day, and hence they must have been transported from a distance. In many instances, the diluvial rocks appear to have been moved from great distances, their dimensions and situations at the same time indicating a water power of much greater force, than any which has been described, except the Noachian deluge, and it is therefore considered reasonable to attribute these effects to that cause.—*See Deluge.*

ALLUVION.

Alluvia, or Alluvial deposites, are such accumulations of sand, mud, and soil, together with fragments of wood, as are constantly forming at the present day, by the currents of rivers and brooks, or by the rain which falls on hills and mountains. These are formed by causes now constantly operating, and we have shown that considerable changes have been wrought on the earth by such causes.

We have now given a short account of each formation, and species of rock which compose the great bulk of the earth. There are, however, several rocks described in more extended treatises on this subject which we have omitted, and which occasionally form considerable hills, or underlay certain districts of country. This deficiency, with respect to names, will be supplied by the following view of M. Boue's classification of rocks, corrected and extended by Dr. Ure, of Glasgow. This contains the names of all the known members of each class, and by it the student will be enabled to observe the synonymous terms, with the classification we have employed.

TABULAR VIEW OF ROCKS AND MINERAL STRATA.

Class I.—Primitive or Inferior Rocks.	*Concomitants.*
Order I.—*Gneiss.*	Granite, Hornblende rocks, Limestone, Quartz-rock, Gypsum.
Order II.—*Mica-Slate.*	Mica-slate, Porphyry.
Order III.—*Clay Slate.*	Talc-slate, Chlorite-slate, Gneiss, Whet-slate, Alum-slate,

	Dolomite, Gypsum.
Class II.—TRANSITION OR SUPERMEDIAL ROCKS.	
Order I.—*Graywacke.*	Conglomerate, Clay-slate, Flinty-slate, Alum-slate, Limestone, Dolomite.
Class III.—MEDIAL OR CARBONIFEROUS ROCKS.	
Order I.—*Old Red Sandstone.*	
II.—*Mountain Limestone.*	
III.—*Millstone grit.*	
IV.—*Coal Strata.*	Coal Sandstone, Slaty-clay, Bituminous Shale, Coal, Carbonate of Iron, Calcareous Marl, Compact Limestone.
Class IV.—SUBMEDIAL OR SECONDARY ROCKS.	
Order I.—*New Red Sandstone.*	
Order II.—*Magnesian Limestone.*	Bituminous Marl-slate. Copper Slate, with Flints, Breccia-like Gypsum.

Order III.—*Red Marl.*	Gypsum and Salt, Variegated sandstone.
Order IV.—*Shell Limestone, or second flat Limestone.*	In Germany called Muschelkalk, said to be wanting in England.
Order V.—*Third flat Limestone, or Jura Limestone.*	Argillaceous beds, Lias of England, Oolite, or calcareous Freestone, Marls.
Order VI.—*Iron Sand and Green Sand.*	Chlorite Chalk.
Order VII.—*Chalk.*	Chalk Marl, Chalk with flints.

Class V.—Superior or Tertiary Rocks.

Order I.—*London, Paris, and Isle of Wight basins.*	Plastic Clay, Clay-marl, Sand, lignite, and salt water shells.
Order II.—*First Tertiary Limestone.*	Blue London Clay, Chloritic Limestone.
Order III.—*First Local brackish water deposite.*	Marls, Gypsum.
Order IV.—*Second Tertiary Limestone.*	Marls, Burh-stones of Paris basin, and Isle of Wight.

Class VI.—Volcanic Products.

Order I.—*Basaltic Rocks.*	Basalt, Greenstone, Porphyry.
Order II.—*Lava.*	Lava, Pumice.

It will be observed in this classification, that the same formation or kind of rock sometimes occurs more than once, or is arranged under several different classes or orders. Thus limestone is sometimes primitive, at others, transition, secondary, or tertiary; and clay-slate and sandstone are sometimes associated with one formation, and sometimes with another. When, therefore, a rock, under the same name, is supposed, by its associations, to have been formed at different periods, it is classed severally with those of its own age. Thus limestone is of all ages, and consequently belongs to all the classes, except the volcanic. The same is more or less the case with sandstone and clay-slate, and several others.

COMPARATIVE AGES OF ROCKS.

We have already noticed, under the descriptions of the different formations, their relative ages, but a recapitulation is required in order to bring this subject distinctly before the reader.

It requires no arguments to show that the lowest formations must be the oldest, since these must have been deposited before those which lie above, or upon them. It is true that a mountain of granite, when shaken, or uplifted by an earthquake, may fall and spread its ruins on the plain below, but such an occurrence would readily be detected, since the situation of its fragments would show that this was not an original and undisturbed formation.

Granite and its associates, besides being placed lowest in the order of position, are, as we have already seen, entirely destitute of organic remains. It ought, however, to be noticed that Dr. Macculloch, in a single instance, in one of the Hebrides, observed gneiss overlaying a bed of limestone, which contained bivalve shells. But the extreme contortions of the gneiss, on that island, are sufficient to show that a bed, really superior in its general position, may appear to be inferior at some particular points

Fig. 21.

Thus let *a a a*, fig. 21, be the contorted substratum of gneiss, and *b*, *c*, *d*, *e*, a superior and incumbent bed of organic limestone, following its flexures. Now it is clear, that if these beds be visible only at the point *d*, the limestone will appear to be below the gneiss, though the error would readily be corrected by an examination at any other point.

Such apparent exceptions do not, however, affect the general fact, for nothing in geology is more clearly established, than that granite, and its associates, lie below all other rocks, and hence must be older than any of their super-strata.

The transition rocks come next to granite, with respect to position, and, consequently, with respect to antiquity. In these, organic remains begin to occur, as plants and shells.

Next to these are the lower, and then the upper secondary rocks. In these are found fossil relics in great quantities, as shells, fish, and some of the amphibious tribes.

Above the secondary come the tertiary strata, and in these formations, are found the bones of quadrupeds of extinct species.

Volcanic products are both of ancient and modern date.

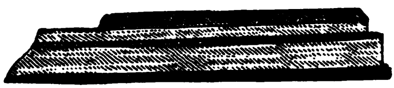
Diluvial deposites are supposed to be of no greater antiquity than the Noachian deluge, having been formed entirely by that catastrophe. In these, the remains of huge quadrupeds, as the elephant, mastodon, and rhinoceros, are found.

Alluvial products are the most recent in the order of strata; being, like volcanic products, constantly forming.

STRATA AND STRATIFICATION.

Most secondary, and several primitive rocks, are composed of layers, or portions, resting one above another, with seams between them. These portions, or layers, are called *strata*, and formations of this kind are called *stratified*. In general, such rocks are *fissile*, and may be divided into flat tables, or layers, in the direction of their strata. These rocks have apparently been formed by gradual depositions from water, accumulated one upon the other. Unstratified rocks show no signs of such gradual accumulation; they present no lines of stratification, nor are they fissile in one direction more than in another; such are granite, greenstone, and basalt.

Fig. 22.



Strata are said to be horizontal, when they coincide with the direction of the horizon, or have little or no inclination, as represented by fig. 22. It is very rare, however, that such strata are found, except among the most recent deposites, the secondary or tertiary strata, in nearly every instance being more or less inclined.

Dip. The inclination of strata from a horizontal position is called their *dip*, the amount of the dip being the quantity of the angle, which the line of inclination makes with that of the horizon. This is represented by fig. 23.

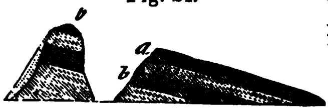
Fig. 23.

If the angle made by the meeting of the lines of the strata, *b b*, and the horizontal line *a*, be equal to 45° towards the east, then the strata are said to dip 45° in that direction.

Outcrop. When strata protrude above the surface, or are uncovered, as on the side of a hill, so as to be seen, they are said to *crop out*. The uncovered ends of the strata commonly rise above each other, like stairs, or, as Mr. Bakewell has it, like a number of slices of bread and butter, laid inclined on a plate. In fig. 23, the outcrop of strata is represented at *b b*. Outcrop is a matter of much importance to geologists and practical miners, since the upper, as well as the under, strata may be observed at these points; and thus, without excavations or borings, not only the dip can be ascertained, but also the different kinds of rock with which a country is underlaid.

Outlier. Strata are said to form *outliers*, when they constitute a portion of country detached from the main mass of the same bed of which they evidently once formed a part. Thus the bed *b*, fig. 24, on the top of the hill, is an outlier of the main stratum *a*, the intervening valley being scooped out, either by the general deluge, or some other means. The kind, and thickness, as well as the range of the intercepted strata, are sufficient to prove that they were once continuous.

Fig. 24.

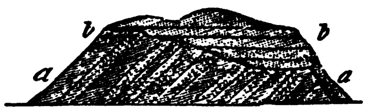


Escarpment. Strata are said to terminate in an escarpment, when they end abruptly, as at *a b*, fig. 24.

Mural precipice. Mural signifies *wall-like*, and rocks are said to form such precipices, when they present naked, and nearly perpendicular faces.

Conformable position. Strata are said to be *conformable*, when their general planes are parallel, whatever their dip may be. Fig. 25, *a a*, represents conformable strata, as shown by their parallel planes.

Fig. 25.



Unconformable Strata. When a series of upper strata, rest on a lower formation, without any conformity to the position of the latter, the upper series is called *unconformable*, as represented at *b b*, fig. 25.

Fault. This is such a dislocation of the strata, that not only their continuity is destroyed, but the series of beds on one or both sides of the fractures, are forced out of their original positions, so that it often happens in mining for coal, the workmen suddenly come to the apparent termination of the vein by a wall of rock.

Dyke. This is a wall of rock interposed between the two sides, or ends of a dislocation, and in consequence of which, the continuity of the beds or strata are interrupted.

If we suppose that the dyke was once fused matter, forced up from beneath, and that on one of its sides the strata were elevated, or on the other depressed by a subterranean convulsion, it would account for the phenomena both of the fault and the dyke.

Fig. 26.

Fig. 26 will make this understood. *a a*, represents the fault, and *b* the dyke. The coal strata *a*, terminates at the dyke on both sides; but on the one side it is raised, and on the other sunk down. When therefore the workmen search on the opposite side of the dyke, for the coal vein, they find instead of coal, perhaps sandstone or clay, and thus for a time, the work of the mine is entirely suspended, the coal being lost. In attempting to regain the vein, the first question to be determined is, whether it has been thrown up, or cast down on the other side of the dyke; and this in general, is readily decided by the position of the dyke, or its inclination with respect to the fault. For experience has shown, that if the dyke makes an acute angle with the upper surface of the coal vein, the strata are elevated on that side, while if the angle is obtuse, they are thrown down, as represented by fig. 26.

In some coal fields, the strata are raised or depressed on one side of the dyke, to the extent of four or five hundred feet.

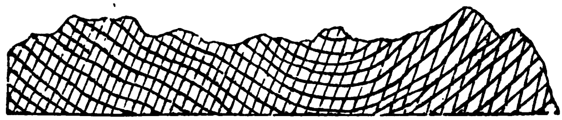
Dykes which intercept coal strata are most frequently composed of basalt, but sometimes of indurated clay. They are, in thickness, from a few inches to fifty or sixty feet, and in a few instances are three hundred feet thick. Dykes are seldom noticed except in mining districts, where they excite much interest in consequence of the disturbances they occasion to coal veins. Their extent therefore is generally quite uncertain, though in some instances they are known to traverse large sections of country.

Dykes being generally impervious to water, they obstruct its passage along the porous strata, and occasion it to rise towards the surface; hence it frequently happens that numerous springs make their appearance along the course of a dyke, which is entirely under ground, and by which alone its existence is indicated.

Slaty Structure. Professor Sedgwick has made some curious and important observations on the difference between the planes of stratification and those of cleavage, as applicable particularly to the roofing-slate of Wales.

In mica-slate, the cleavage is in the direction of the strata of deposition, whether the layers are curved or not, and the same is the case with common clay-slate, and in depositions of clay which are separable in layers. In beds of roof-slate the case is quite different, the cleavage being not in the direction of the strata, but in general, obliquely across them. The strata are seldom or never either horizontal or straight, but contorted, bent, or waved, and are often far from being parallel with each other.

Fig. 27.



Professor Sedgwick gives the diagram, fig. 27, in illustration of this subject, and remarks, "that the contortions of slate rocks are phenomena quite different from cleavage, and the curves presented by such formations are the true lines of disturbed strata." The contorted lines running lengthwise the diagram, are the true strata, while those crossing these in nearly a vertical direction, and preserving almost a geometrical parallelism, are the lines of cleavage. A region of more than thirty miles in length, and eight or ten in breadth, exhibits this structure on a magnificent scale. Many of the contorted strata are of a coarse mechanical structure; but subordinate to them are fine crystalline, chloritic slates. But the coarser beds and the finer, the twisted and the straight, have all been subjected to one change. Crystalline forces have re-arranged whole mountain masses of them, producing a beautiful crystalline cleavage, passing alike through all the strata; and through all this region, whatever may be the contortions, the planes of cleavage pass on, generally without deviation, running in parallel lines from one end to the other.

"Without considering the crystalline flakes along the planes of cleavage, which prove that crystalline action has modified the whole mass, we may affirm, that no retreat of parts, no contraction in dimensions, in passing to a solid slate, can explain such phenomena as these. They appear to me only resolvable on the supposition, that crystalline, or polar forces, acted on the whole mass simultaneously, in giving directions, and with adequate power."

COAL.

There is no subject, within the range of geology, of more importance than the natural history of coal, since the inhabitants of some countries are almost entirely dependent on its existence and quantity, for the comforts they enjoy during the cold season.

We have already described this mineral, and given some account of its manner of existence, when treating of rocks and formations generally. It remains here to give a more general and extended account of this important article, and to point out its indications, origin, associations, &c.

Form of Coal Beds. Nearly all coal formations are basin-shaped, or in that form, as before stated, which would arise from a deposition of strata in lakes, or ponds, of various depths. Mr. Bakewell compares the shape to that of a muscle shell. "The position of coal strata," says he, "in many coal fields, may be represented by a series of fresh water muscle shells, decreasing in size, laid within each other, but separated by a thin paste of clay. If one side of the shell be raised, it will represent the general rise of the strata in that direction, and if the whole series be dislocated by partial cracks, raising one part a little, and depressing the other, to represent faults in the coal, it will give a better idea of the coal field than any description can convey."

"We are here to suppose that each shell represents a stratum of coal, and the partitions of clay, the earthy strata by which they are separated. The outer or lower shell, represents the lowest bed of coal, which may be many miles in extent. Now if a much larger shell be filled with sand, and the lower shell pressed into it, we may consider the large shell to represent limestone, and the sand, grit stone; we shall have a model of the coal strata in many parts of England, and their situation over the metaliferous lime, with the beds of sandstone by which they are separated from it."—*Geology*, p. 117.

Searching for Coal. In most instances, the inclination, or bending of coal strata, is such that the veins rise nearly to the surface, and would be visible, were they not covered by the soil or gravel. When this is the case, the removal of the soil by rivulets, or the accidental slide of a side hill will uncover the strata, so that their dip and thickness can be determined. This is considered a very fortunate circumstance, because the boring for coal, without some such indications that it exists in greater or less quantities, even in coal districts, is a very uncertain means of its discovery. Sometimes borings to great depths have been made in the immediate vicinity of large coal fields, without producing any greater conviction of the existence of the mineral, than the surface before indicated.

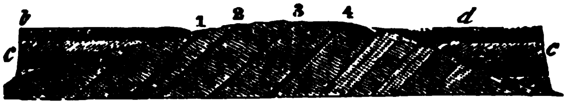
Fig. 28.

The cause of this will be seen by fig. 28, where suppose 1 is the coal vein, and 2 a stratum of sandstone, below which is limestone, and that the basin is filled to the surface with slate, clay, &c. Now, on boring at 2, it is evident that nothing but sandstone and limestone would be found, though it might be within a few feet of the coal vein, while had the examination happened to have been made at 1, coal would have been found within a few feet of the surface.

Where a coal stratum comes to the surface, it is generally in a decomposed state, and so mixed with the earth as to present no other appearance of coal than a darker color, when compared with the surrounding soil. Hence the real quality of the coal cannot be determined until it is taken from below the influence of the weather, and, in general, its quality improves as it sinks deeper into the earth.

In examinations for coal, the dip and direction of the strata in the vicinity, when known, should be carefully observed; for if the dip is *towards* the estate on which the trial is to be made, it is probable that the coal may extend under it; but if the dip is in the contrary direction, the search ought not to be undertaken, since experience has shown that it would be useless.

Fig. 29.



The reason will be understood by fig. 29, where 1 2 3 4, are a series of coal strata, dipping towards *b*. The unconformable strata *c c*, are sandstone, lying over the coal. Now, suppose the coal vein 4, makes an outcrop at that point, on the estate of A, adjoining the estate of B, which lies towards *b*, then it is apparent that A would find only a point of the vein 4 on his estate, and that it would be useless to search in the direction of *d* for coal, since the dip of 4 is sufficient to prove that none exists there, unless, indeed, another coal field should be found. Whereas, on the estate of B, though there might not exist an outcrop, still the dip of that on the estate of A would make it highly probable that B would find coal on his estate, though it might be too deep for working.

We have observed, in another place, that coal has seldom or never been found in hot climates. According to Mr. Bakewell, this mineral has rarely been discovered beyond the latitudes of 35° and 65°. It, however, exists in the province of Canton, in about the 30th degree of latitude. In this country, the great coal ranges appear to lie between the latitudes of 40° and 45°.

Indications of Coal. Although it is not certain that coal exists at any given place until it is actually found, still there are indications which might perhaps warrant the expense of a search, by boring in districts where coal has never been discovered. These indications are various, and to point them out requires much knowledge and experience on this subject.

In England, Mr. Farey states, that the coal districts incline to clay, and are generally of an inferior quality. When laid down to pastures, small daisies and insignificant weeds are more disposed to prevail than grass.

In these districts, water is generally procured at inconsiderable depths, and when the faults are numerous, springs are common, and range in a line with the fault, for the reason already explained.—*See Fault.*

The face of the country where coal exists, is generally undulating, the hills being rounded and not mural or precipitous, and the valleys gently sloping and not deep as they are in granite formations. Sometimes, however, coal is found in hills more than a thousand feet above the general level of the country.

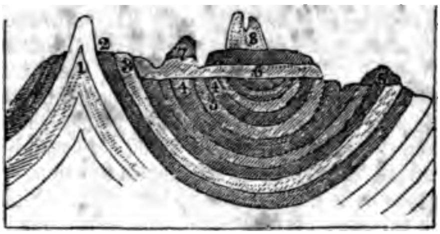
Strata which indicate Coal. In England and Wales, coal generally reposes on a series of beds called *millstone-grit* and *shale.* The millstone-grit is merely a coarse grained sandstone, consisting of quartzose particles of various sizes, agglutinated by an argillaceous cement. This differs from the sandstone that is found above and between the coal strata, chiefly in its greater induration.

The shale is a dark colored slaty rock, which differs little from the slate-clay beds found among coal.

In England, secondary limestone is often associated with coal. This is called *carboniferous* limestone, because it is generally found in coal or carboniferous districts. *Red marl* is also a common attendant on coal formations, and indeed, is so common, that few coal shafts are sunk without piercing through it. This is a kind of sandstone cemented with clay and colored with iron. Mr. Bakewell supposes that it has been formed by the decomposition or disintegration of trap, greenstone and granular quartz. Coal is also accompanied with thin strata of what the English call *iron-stone.* This is a dark brown or gray stone, of an earthy appearance, but of great specific gravity, being about three times the weight of an equal bulk of water. This stone is smelted for iron, and yields about thirty per cent. Another attendant on coal is that kind of limestone, in England, called *lias.* This name is said to be a corruption of the word, *layers,* probably because the strata of this rock are generally very regular and flat. The finer kinds of lias answer for lithographic stones. This rock alternates with *lias clay,* the whole formation sometimes being several hundred feet in thickness. This clay is highly impregnated with bitumen, and contains much sulphuret of iron, so that when once ignited it will continue to burn until the sulphur and bitumen are consumed. Several other minerals are found in coal beds, in greater or less quantities, in the English mines, but those enumerated are the most common.

The annexed diagram, fig. 30, showing the different strata as they occur in a coal field near Mamsbury, will illustrate the manner in which most of these minerals are placed with respect to each other.

Fig. 30.



The lowest stratum, or that on which the others are placed, as within a dish, and which also rises the highest, marked 1, is *Old red sandstone.* 2, *Carboniferous limestone.* 3, *Millstone-grit.* 4 4, *Coal seams.* 5, *Coarse sandstone.* 6 6, *Red marl, or new red sandstone.* 7, *Lias.* 8, *Oolite.*

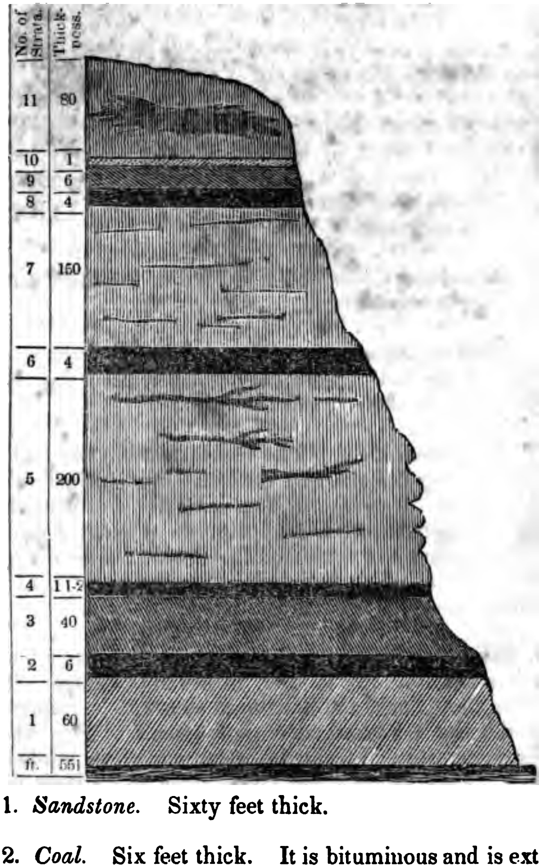
In this country, although several of the strata occurring with European coal are wanting, still it is found to be associated with minerals of the same general characters. In Virginia, the strata which cover the coal are sandstone and clay-slate, the latter often exhibiting vegetable impressions. The coal mines of Ohio, are situated among strata of limestone, sandstone and clay-slate.

The following section and description is from Dr. Hildreth's valuable communication on the coal deposites of the valley of the Ohio, contained in Silliman's Journal for Nov. 1835.

Dr. Hildreth's paper not only relates to the Geology, but also to the Topography, and Geography of the Ohio, Valley. It is illustrated with a map, several views, and many wood cuts delineating organic remains, and is among the most valuable and interesting communications on these *subjects* ever made to the American public.

Section of the Coal strata at the Salines on Kenawha River, Ohio.

The strata beginning at the deepest are as follow:



1. *Sandstone.* Sixty feet thick.

2. *Coal.* Six feet thick. It is bituminous and is extensively worked for several hundred feet under the hills.

3. *Bituminous Shale,* and slaty shale, forty feet thick. This, both slate and shale, is filled with extinct species of plants. Every layer not more than the fourth, or the eighth of an inch thick, when separated, displays fresh

impressions of a variety of species, delineated on the face of the slate with the most exquisite beauty and perfection. Four or five species of the Palm tree, as many of Calamites, and several Equisetae, are among the number.

4. A thin bed of *coal*, twenty inches in thickness, resting on the shale and clay-slate. This is not worked.

5. *Argillaceous* sandstone rock, the upper stratified in thin beds, the lower in beds of fifteen or twenty feet in thickness. This bed is about 200 feet thick, and splits easily into building stones, for which it is much employed. It is a vast magazine of fossil plants.

6. *Bituminous Coal.* This bed is four feet thick, and is extensively worked.

7. *Silicious Sandstone.* The grains are coarse, and sharp, and the bed reposes on the coal without any intervening slate, or shale. 150 feet thick.

8. *Bituminous Coal.* The structure of this bed is slaty, and in burning it melts, and runs together, obstructing the current of air necessary to combustion, a fact noticed as being common to all the upper beds of coal deposites. This bed is four feet thick, and the slate or shale on which it rests contains many impressions of plants, chiefly of the arundinaceous and culmiferous tribes.

9. *Silicious Slate,* or lydian stone; color nearly black, and in strata from two to eight inches in thickness. The bed is six feet thick, and is so hard as not to be impressed with the best tempered steel instruments. The Aborigines manufactured this kind of stone into arrow heads and knives. This deposite has been traced more than forty miles.

10. *Argillaceous iron ore,* in nodules from three to six inches in diameter, imbedded in argillaceous, yellowish marl. Eight inches thick.

11. *Silicious sandstone;* color yellowish, grain coarse, with feeble cohesion. At this place this bed is eighty feet thick, but in other places it has a thickness of 150 feet. It

contains a vast number of fossil trees. The wood has been replaced with silicious matter tinged with iron. Sometimes whole trees, with their roots and branches, have been found.

Very few fossil shells, or animal remains of any kind, have been found in the Kenawha Valley.

It is intended that our descriptions and remarks, thus far, should apply entirely to the several kinds of coal called *bituminous*, and which burn with more or less blaze. These kinds, known under the names, *Cannel coal*, *Slaty coal*, *Coarse coal*, &c., are found only among secondary rocks, and it would be a useless expenditure of time and money, to search for them in any other situations. Dr. Macculloch thinks that bituminous coal does not exist below the old red sandstone formations.

Anthracite. This name, which is derived from the Greek, signifies, merely, carbon or coal. It is called, in England, *stone coal*, and in Scotland, *blind coal*. In this country, where there are many extensive localities, it is distinguished by the names of the places whence it comes, as, *Lehigh coal*, *Lackawana coal*, *Peach Orchard coal*, &c.

Anthracite has been found in small quantities only, in any part of Europe, but in this country it appears to exist in great abundance, and within the last ten years, has come into such general use, as an article of fuel, as in a good degree to supersede the use of wood for the warming of dwellings, in most of the sea-coast towns of the Northern States. These supplies come chiefly from Pennsylvania and New York, though this coal exists also in Massachusetts and Rhode Island.

Anthracite is found among primitive and transition rocks, as mica-slate, clay-slate, and graywacke.

This mineral is distinguished from bituminous coal by its greater lustre and weight; by its hardness and conchoidal fracture, and by its burning without smoke, or blaze, or bituminous odor.

ORIGIN OF COAL.

It is now generally believed, by naturalists, that coal has originated from vegetables, though there are many different opinions with respect to the modes in which the vast quantities of woody matter, required for this purpose, came together, and also with respect to the chemical changes which it underwent during its conversion into coal, as well as the nature of the agent by which this was effected.

That coal originated from wood, appears to be proved by the fact that at the present day, parts of trees are found in a state of partial conversion into that substance. This is called *wood coal*, or *lignite*, and in some countries, is not an uncommon substance.

Near Cologne, in Italy, exists a great depository of this fossil, which extends many leagues, and is fifty feet thick. Its covering is a bed of gravel about twenty feet thick. Here trunks of trees, partially converted into coal, are common, and many of them are deprived of their branches, which would seem to indicate that they had been transported from a distance. Nuts, which are indigenous in Hindoostan and China, are found among this lignite.

" In wood coal," says Mr. Bakewell, " we may almost seize nature in the fact of making coal before the process is complete. These formations are of a far more recent date than that of common coal, though their origin must be referred to a former condition of the globe, when the vegetable productions of tropical climates flourished in northern latitudes. The vegetable origin of common mineral coal, appears to be established by its associations with strata, abounding in vegetable impressions—by its close similarity to wood coal, and lastly, by the decisive fact, that some mineral coal, in the Dudley coal field, is entirely composed of mineralized plants."

But though the vegetable origin of coal may be satisfactorily established, there is considerable difficulty in conceiving by what process, so many beds and seams of coal have been regularly arranged over each other, in the same place, and separated by strata of sandstone, shale, and indurated clay. It will perhaps tend to simplify this inquiry, if we examine a coal field of very limited extent, such as those which occur in small coal basins, called *swilleys*, and which are not more than one mile in length and breadth. It seems evident that these basins have once been small lakes or marshes, and that the strata have been deposited on the bottoms and sides, taking the con cave form, which such depositions, under such circum stances, must assume; and it is deserving of notice, that the stratum of coal, which in one of these basins, is a yard thick in the lowest part, gradually diminishes as it approaches the edges, and then entirely vanishes. This fact proves that the present basin-shaped position of the strata, was their original one; and that the basin, at the period when the coal was deposited, was a detached lake or marsh, and not a part of the bed of the sea.—*Geology*, p. 123.

It would seem from the above, as well as from other facts stated by geologists, that coal strata were formed in accumulations of water; but whether this was salt or fresh, it is difficult to determine. The shells found in some coal beds, according to the opinion of Mr. Conybeare, are those of salt water; but, on the other hand, the vegetable remains found in the same strata are clearly those of the land and not of the sea. But the difficulty of distinguishing salt from fresh water shells, where the species are extinct, is well known. And it is also true, that some shell-fish belonging to the ocean may gradually be inured to brackish water, and, finally, to that which is entirely fresh, and this, too, without any material change in the form or thickness of their shells. Hence, any decision of this kind, founded on the appearance of a few shells merely, must always be extremely doubtful.

It would appear, from the account of Dr. Hildreth of Marietta, Ohio, that beds of coal on the Muskingum river, in that state, have either been formed in the ocean, or that since their formation they have been submerged by salt water. "The lime rocks here," says he, "abound in fossil marine shells of the genera Productus, Terebratulæ, and Spirifira, with Ammonites and chambered shells, indicating that some of the coal deposites have been deeply submerged under the salt water since their formation; or that the vegetable materials, composing the coal, had once floated in an ocean, and were precipitated by an accumulation of calcareous, argillaceous, and sedimentary materials, collected on and about them while floating."

"Marine fossils," continues the author, "are found both above and below the coal, and sometimes deposites containing fresh water shells are intermixed, although they are not so common as they are nearer the Ohio river. Some of these fresh water fossils bear a striking resemblance to living species now found in our rivers.

"Through nearly all the coal region, we find many proofs of the predominance both of fresh and salt water. West of the coal deposites in Ohio, the fossil shells are altogether marine, at least so far I have seen them, and many of them belong to the supercretaceous, or tertiary genera, and many are similar to those found in the same formations in the southern States."—*Silliman's Jour. Nov.* 1835, p. 29.

The only analogy which the present state of things offers to the manner in which coal was formed, is the filling up of lakes and estuaries with vegetable matter. In these situations we sometimes find series of strata, composed of peat and submerged wood, alternating with those of sand, clay, and gravel; and, therefore, presenting the model of a coal field. Of the quantity of vegetable matter required to form a stratum of coal, we know nothing, but there is reason to believe that the thickness of these strata bear but a very small proportion to those of the plants of which they were formed.

It is not difficult to conceive, however, that the earth might have produced a quantity of vegetation, even within the circuit of a few miles, sufficient to form a thick bed of coal, though the thickness of this might bear only a fractional proportion to that of the wood. Those who have seen the pine forests of our western country, can, perhaps, have some conception of the vast pile which a single square mile of these trees would form, if thrown together. Now, if hundreds of square miles of such timber were accumulated, we might suppose that there would be a quantity sufficient to form a single bed of a large coal formation.

The quantity of drift wood which descends the Mississippi, in the course of a few years, might be supposed to furnish ample matter for such a coal bed. According to the estimate of Mr. Bringier, the quantity of timber which drifted into the Achafalaya, an arm of the Mississippi, during an overflow in 1812, amounted to 8000 cubic feet per minute. The same writer states that the raft thus collected at the mouth of the Red River, is sixty miles long, and, in some parts, fifteen miles wide. On this, in some places, cedars are collected by themselves, and in others, pines.—*Silliman's Journal*, vol. iii. p. 18.

Now, in case the bed of this stream should, at some future time, be changed, so as to leave this immense raft covered with the earth, generations to come, might here discover one of the most extensive coal fields yet known.

Captain Basil Hall states, that on a tongue of land, nearly opposite to the mouth of the Mississippi, and which has extended many leagues since the building of New Orleans, large rafts of drift wood are deposited every year. These rafts are matted together into a net work, many yards in thickness, and cover several hundred square leagues of surface.—*Travels*, vol. iii. p. 338.

These rafts afterwards become covered with mud from the river, and sink down to the bottom; and on this, the next year is deposited another layer of trees, thus forming alternate strata of wood and soil.

What analogy exists between the facts here stated, and the circumstances which took place at the formation of coal beds, it is impossible to determine. But with respect to the manner in which vast quantities of woody matter may be accumulated by the operation of natural causes, there is certainly little difficulty; and perhaps it is as easy to believe that these accumulations took place in lakes, or ponds, as at the mouths of rivers; nor is it improbable that coal might have been formed in both situations.

There is no doubt but all regular coal formations were deposited before the general deluge, or at that period when the temperature of the earth was much higher than at present; and therefore, when all plants, not only attained a greater size, but grew much more rapidly than they do now in temperate climates. Hence, if we suppose that wintry torrents, or occasional inundations, denuded the earth of her vegetation to a great extent, and swept it into lakes or estuaries, there would be little difficulty in imagining, that under such a climate, the earth would soon be again prepared with her vegetation for a similar sweep, and thus one stratum of coal after another would be formed. During the intervals of these inundations, the operation of ordinary causes as the flowing of rivers into these lakes, would bring down from the mountains the materials which have formed the clay and sandstone, now interposed between the beds of coal, in a manner similar to what is now taking place at the mouth of the Mississippi.

With respect to the inundations which caused the ancient forests to descend from the hills to the valleys, and to accumulate in lakes and estuaries, there is little difficulty, since the same happens more or less at the present day; and especially since geologists agree, that judging from appearances, natural causes were infinitely more powerful in their effects on the primeval earth, than they have been since.

Perhaps this circumstance may be considered a sign of that over-ruling Beneficence, which has ever been displayed towards man; for then, if he existed at all, it must have been only on a small portion of the globe.

That natural causes anciently operated with much greater power than at present, is shown by the changes which earthquakes produced on the globe, before the historical era. The dislocations of strata, and the elevation of mountains which were effected by this cause in ancient times, have analogies only in miniature, at the present day. Nor is it unreasonable to suppose, that corresponding effects were produced by water, during similar epochs.

It is, therefore, to such ancient torrents that we must attribute these effects, and which, with awful devastation, undermined the sides of hills, and floated the vegetation into lakes and ponds; or deposited it at the mouths of rivers, there to undergo, in the lapse of time, those chemical changes, by which wood is converted into coal; and thus to supply present and future ages with one of the absolute necessities of life.

That both earthquakes which elevated and dislocated strata, and inundations of great power, continued in operation after coal was formed, is evident by their effects, which still exist. For, in many instances the strata of coal fields are not only broken into faults, in the manner already described, but they also, near the surface, show the violent effects of water, a part of some beds being entirely removed.

These circumstances are ascertained by the exact correspondence of the strata, on both sides of valleys; showing that they were once continuous, and that the hills have been formed by the removal of the strata between them.

Sometimes strata are so separated, that the direction in which they ranged, when entire, are completely changed; the appearance being such as would be produced by a violent upheaving, and consequent fracture of the whole formation.

Fig. 32. WO

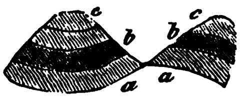


Fig. 32, represents an instance which occurs at the Ashton coal mine, in England, and where, after the dislocation in consequence of a subterranean force, a large portion of the strata was removed by a torrent of water. The strata on each side of the valley, exactly correspond in kind and thickness, though widely separated. *a a*, coal veins; *b b*, millstone grit; *c c*, limestone.

Thus is it proved, that these changes took place after the formation of coal fields.

American Coal Fields. With respect to the coal fields in our own country, and especially of those beyond the Alleghany mountains, the following information is taken from a report made by J. L. Packer, Esq. before the Senate of Pennsylvania, in 1834.

The great secondary deposite, extending as is generally believed, from the Hudson to the Mississippi, and to the Rocky mountains, is in Pennsylvania, limited by the Alleghany mountains, which appear to form the barrier, or dividing line between the anthracite and bituminous coal beds, or between the transition and secondary formations.

The bituminous coal field is therefore confined to the west side of the Alleghany, and is supposed to extend to the centre of the mountain. These coal beds vary from one foot to twelve feet in thickness, but rarely exceed six feet. They lie in nearly horizontal strata, there being merely sufficient dip to free the mines from water. Some mines contain three or four beds with alternate layers of earth and slate between them. Faults are seldom met with, and in this they differ from the anthracite, and go far to confirm the opinion, that all this vast extent of secondary rocks, was once the bottom of a vast lake or sea, the surface of which suffered little change from the discharge of its waters, which therefore must have run off gradually. This great secondary region has been drained by the Mississippi, the St. Lawrence, the Susquehannah and the Hudson.

It is a curious and interesting geographical fact, that near the northern termination of this coal field, viz. in Potter county, Pennsylvania, and within an area of about five miles, take their rise the head waters of the Alleghany, the Susquehannah, the Genesee, the Chesapeake and the St. Lawrence rivers. With the exception of the Susquehannah and its tributaries, discharging into the Potomac, all the streams arising in the coal field west of the Alleghanies flow into lakes, or into the Ohio river, consequently the elevation of the ground is gradually depressed in that direction, and, as is supposed, it becomes too low to contain coal.

The northern boundary of the coal region appears to be from the head waters of Towanda creek, in Bradford county, across the counties of Potter, McKean, Warren, and Venango, to the Ohio line.

A report on this region has lately been made by R. C. Taylor, Esq., a practical engineer and geologist, for the Blossburgh rail-road company, in which it is shown that the coal runs out, as the streams decline towards the north. The dip of the coal strata towards the west, is such as to require towards the east an elevation of upwards of five thousand feet, in order to include the coal measures at the state line between New York and Pennsylvania, whereas the hills there are probably less than six hundred feet in altitude.

This calculation, says Mr. Taylor, is made for the purpose of showing the futility of the expectation of tracing these coal fields in a northerly direction, beyond the limits at which they are discoverable.

This coal field being bounded on the south by the Alleghany mountain, extends into Virginia, and underlies more or less all the western counties of Pennsylvania, with the exception of Erie, in which it has not been discovered. The counties of Bradford, Lycoming, Tioga, Potter, McKean, Warren, Crawford, Bedford, and Centre, lie partly in, and partly out of the coal field. The counties of Alleghany, Armstrong, Beaver, Butler, Cambria, Clearfield, Fayette, Green, Indiana, Jefferson, Mercer, Somerset, Venango, Washington, and Westmoreland, are wholly within its range, and embrace together an area of twenty-one thousand square miles, or thirteen million, four hundred and forty thousand acres.

Coal is mined to a greater or less extent, in all the above counties, at the expense of one or two cents the bushel, and is thus brought to every man's door.

That the abundance and cheapness of coal has given birth to the vast, and widely extended manufacturing establishments of the west, there can be no doubt. Pittsburgh and its environs contain ninety steam engines for the various manufactures of iron, steel, glass, cotton, salt, brass, white lead, flour, oil, leather, &c. These engines consume annually 2,065,306 bushels of coal. The city of Pittsburgh and its suburbs, Alleghany town. Birmingham, &c., contain a population of 30,000 souls. The coal consumed for every purpose in and about Pittsburgh, is estimated at 7,665,000 bushels, or 255,500 tons; which, at four cents a bushel, the price now paid there, amounts to the sum of 306,512 dollars.

Besides the coal used in the various manufactures of Pittsburgh, vast quantities are consumed in the western counties of the State, in the manufacture of common salt. In these counties, there are already about ninety establishments for this purpose, and which produce yearly about 1,000,000 bushels of salt, and consume 5,000,000 bushels of coal.

It is found that the bituminous coal of Pennsylvania produces coke equal to that of Great Britain, and is employed to a considerable extent by the manufacturers of iron.

See Silliman's Journal, No. 59. This number is occupied by an account of the geology and mineral resources of the valley of the Ohio, which ought to be read by every American.

PEAT.

Although peat is a substance entirely distinct from coal, yet there exists considerable analogy between them. They are both of vegetable origin; both are formed by natural processes; their colors are similar; and when perfectly formed, they neither of them present the least traces of their origin; and, lastly, they are both dug out of the earth and employed for fuel.

There is reason to believe that peat moors will ultimately become coal beds. In all instances, peat appears to have been formed since the present order of things on the earth, or since the deluge; while it seems to be equally true, that coal was formed before that epoch.

Dr. Macculloch has shown that there is a connected gradation from forest peat, that is, submerged wood, through lignite, to perfect coal. "Lignite," says he, "presents no difficulties, being derived from submerged wood, or forest peat. I have shown that the deposites of this substance [lignite] are of a far higher antiquity than any peat, and thus the degrees of bituminization may be accounted for, though there may be many other causes also still unknown to us."

"If the contrast between peat and coal is far greater, [than between peat and lignite,] the resemblances are too striking to leave a doubt of the origin of the latter, from beds of that substance. I have shown that all the geological circumstances are similar, or identical in both; the alluvial bed of one corresponding to the rocky strata of the other, as do the deposites of organic substances; while the insulated condition of each class is also a striking point of resemblance. The mechanical structures of peat and coal often present sufficient analogies; the resemblance of forest peat to the latter, being often absolute in all but the mineral character; as in both do similar organic remains occur, and in a similar manner, while in both, also, they are sometimes wanting."—*Geology*, vol. ii. p. 357.

The same writer has shown that wood may be converted into a substance having all the chemical properties of peat; then of lignite; and, lastly, of coal. The process consists in subjecting the wood to heat and moisture in a close vessel, so that none of the gases may escape. He does not, however, suppose that coal has been subjected to a high temperature during the progress of its formation, but, if we understand him, (for of all late writers he is the most obscure,) he believes that the pressure of the incumbent strata, together with fermentation, and above all, *time*, has converted wood into coal.

It has been supposed that peat had the property of preserving animal matter from decay, and the following account, written by Dr. Balguy, and published in the Lon. Phil. Trans. for 1734, seems to verify such an opinion.

"On the 14th of Jan. 1675, as a farmer and his maid servant were crossing the peat moors, near Castleton, in Derbyshire, they were overtaken by a great fall of snow, and both perished; their bodies were not found until the 3d of May, in the same year, and were then in such a state, that the coroner ordered them to be buried on the spot in the peat. Here they lay twenty-eight years and nine months when the curiosity of some countrymen, (probably having heard that peat would preserve dead bodies,) induced them to open these graves. The bodies appeared quite fresh, the skin was fair, though somewhat darker than natural, and the flesh as soft as that of persons newly dead. These bodies were afterwards frequently exposed as curiosities, until the year 1716, forty-one years after their deaths, when they were buried by order of the farmer's descendants. At that time, Dr. Bourne, of Chesterfield, who examined these bodies, says that the man was perfect; his beard was strong, his hair short, and his skin hard, and of a tanned leather color, like the liquor in which he had lain. The body of the woman was injured, having been more frequently exposed, but the hair was like that of a living person.

In the beginning of the last century, the perfect body of a man dressed in the ancient Saxon costume, was discovered in a peat bed at Hatfield chase, in Yorkshire, but it soon perished on exposure to the air.—*Bakewell's Geol.*

In 1747, the body of a woman was found six feet deep, in a peat moor in Lincolnshire. The antique sandals on her feet afforded evidence of her having been buried there for many ages, and yet her hair, nails, and skin, are described as having shown hardly any marks of decay.

On the estate of the earl of Moira, in Ireland, a human body was found a foot deep in gravel, covered with eleven feet of moss. The body was completely clothed in garments of hair. The great length of time it had been interred, may be inferred from this circumstance, for it is known, that before the use of wool, the inhabitants of Britain made their clothing of hair, and yet this body was fresh and unimpaired.

At the battle of Solway, in the time of Henry VIII., (1542,) when the Scotch army was routed, an unfortunate troop of horse were driven into the Solway morass, and sinking down, the surface closed upon them. A tradition of this catastrophe had always been kept alive by the people of the neighborhood, and the place where it was supposed to have happened, designated. This tradition has now been authenticated, for a man and horse, in complete armor, such as was worn in Henry's time, has been found by the peat diggers, in the place where it was believed the accident occurred. The skeleton of both man and horse was well preserved, and the different parts of the armor readily distinguished.

These cases are from various authorities, but are well authenticated.

Cause of the antisceptic property of Peat. This property has been attributed to the carbonic and gallic acids which are set free by the decaying of wood, and also to the gums and resins which various plants contain. Others have attributed this effect to the tannin which the peat contains. It is most probable, however, that this property is owing to the formation of pyroligenous acid, during the decomposition of the vegetables. It is true that no known process, except that of the destructive distillation of the wood, can form this acid by art, still it may be conjectured, that the natural destruction of the same organic substances may produce the same effect.

ORIGIN AND PHENOMENA OF TRAP ROCKS.

It has already been stated, that the term *trap*, includes a family of rocks of igneous origin, and that these are basalt, porphyry, green-stone, and their associates.

Under what conditions the trap rocks were formed, it is impossible to determine, there being no examples of such formations at the present day. We know that fused matter, as it is thrown out of volcanoes, differs in most respects from any of the varieties of trap; nor do the ancient lavas vary materially from those of the present day, a proof that age does not convert lava into trap. The form under which trap rocks exist, also seems to show, that they could not have been produced under similar circumstances with the volcanic products of the present day.

Some geologists have supposed that trap was thrown up under the sea, and that the pressure of the water has been instrumental in causing the difference between it and lava. But were this the case, it might be expected that marine remains, as shells, would be common among the fissures of these rocks. If it is supposed that these have been converted into quicklime and washed away, still such remains ought to exist on the strata over which these rocks are found.

It is true that such cases do exist, but they are far from being universal, or even common.

If these rocks were thrown up into the open air in the form of lava, and after the elevation of the land from the sea, then we might inquire how the difference between products having the same origin is to be accounted for, and why trap has taken the form of precipitous mountains, instead of being spread in comparatively thin sheets on the surface, as lava is at the present day. It appears therefore, that these rocks were formed under circumstances which it is difficult, or impossible satisfactorily to explain, and on which this is not the place to speculate.

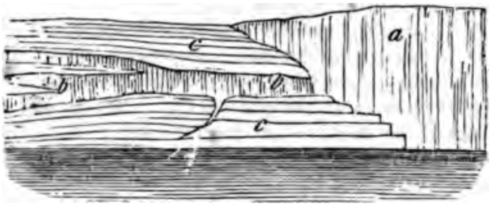
These rocks appear to be of all ages, between that of granite, and those of secondary stratified formations, containing organic remains. This is proved from the circumstance that trap is found above all the others, and when it occurs below them, the phenomena prove that the trappean matter has been forced between their strata from beneath.—(*See Fig.* 33.)

The igneous origin of trap, especially of basalt and greenstone, is most directly proved by the fact, often observed, that where they come into contact with the original strata in their passage from beneath, the effects of heat are always apparent on these strata.

When a dyke of basalt intersects a stratum of coal, the coal, to the distance of several feet, or, sometimes even yards, is deprived of its bitumen, or converted into *coke.* Dr. Macculloch observed that the proximity of trap to shale, (a kind of slate,) has the effect to convert it into a substance resembling basalt. But it is unnecessary to cite further examples, since it may be stated in general terms, that the effect of a basaltic dyke on the contiguous strata, is precisely that which would have been produced, had the matter of the dyke been at a red, or even at a white heat, at the time of its protrusion.

But there are other circumstances which show that basaltic dykes were formed in a fluid state, for when these penetrate stratified formations, the matter of which they are composed, sometimes insinuates itself between the strata from beneath, in a manner which would be impossible, had it not been in that state. Dr. Macculloch, in his account of the Western Isles, gives a figure, in illustration of such an instance, which is subjoined.

Fig. 33.



The vertical lines *a*, fig. 33, represent the basalt partly incumbent in the unconformable position, on the horizontal strata *c c*. At *b b*, the basalt has forced up the sandstone, and passed between its strata, two of which it has entirely separated from their fellows, forming between them sheets of its own matter.

Dykes of basalt form angles with the horizon of every quantity. Sometimes they are nearly or quite perpendicular to the horizontal strata through which they pass. In some instances a large vein is pierced by a smaller one, which passing through its middle, divides it into two parts. The adjoining cut from Dr. Ure, represents such an instance.

Fig. 34.

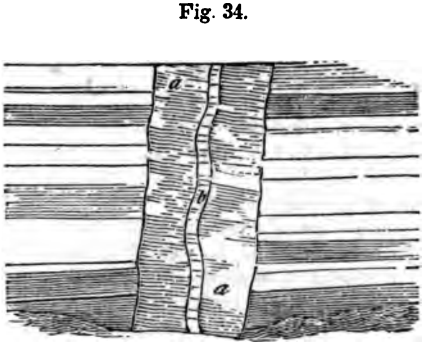
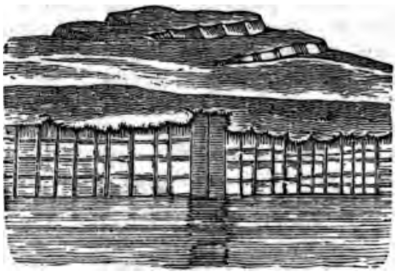


Fig. 34, *a a*, represents the great basaltic dyke, passing through calcareous sandstone, and *b*, a small vein of the same matter, by which it is pierced through the line of its axis. The latter is singularly undulated, somewhat like the zig-zag line of an electric shock passing through the atmosphere.

Although, in most instances, the trap veins pass from below, towards the surface, still there are instances where they descend from the surface into fissures beneath. This is among the more rare and remarkable phenomena which this interesting rock exhibits.

This example occurs in the island of Sky, and is described by Dr. Macculloch. The basaltic veins traverse strata of sandstone, in a vertical direction, and parallel to each other. Fig. 35.

Fig. 35.



They appear to descend from the mass on the surface, and are so numerous, in some places, as nearly to equal, taken collectively, the mass of rock through which they pass. Sometimes six or eight veins occur within the space of 150 feet, and their aggregate magnitude is apparently sixty or seventy feet. Their average breadth is about ten feet, though they vary from five to twenty feet.

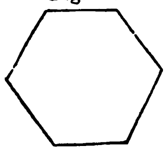
It is certainly very difficult to account for the manner in which nature performed this work. Were these veins only an inch or two thick, we might suppose that the melted trap ascended by the large middle vein, seen in the drawing, and having fissured the sandstone by its great heat, descended again by the apertures thus produced; but the fissures are much too large for such a supposition.

It is supposed that every basaltic dyke terminates in a mass of basalt below the surface, and, therefore, that basaltic rocks, resting on the surface, are connected by the dyke or fissure through which they were thrown up, with that part of the mass which still remains beneath the earth. So that these dykes are necks passing through the crust of the earth and connecting the two masses. Where dykes do not reach the surface, of course they are only connected with the lower masses.

Columnar Basalt. All the members of the trap family occasionally assume the form of columns, more or less perfect, but, in this respect, basalt excels the others.

These columns are formed by a natural division of the whole mass of basalt in a vertical direction. They vary in the number of their angles, from three to eleven or twelve, the medium polygons having from five to seven faces. These are often perfectly regular, the angles being sharp and well defined, and the faces plain and smooth, as represented by the annexed cut, fig. 36.

Fig. 36.



In most cases, when standing in their original positions, their sides are in contact, or so little separated as barely to admit the infiltration of carbonate of lime; a striking difference, as observed by Dr. Macculloch, between them and the irregular prisms, which result from the cracking of dried clay. and showing that the nature of the process by which these divisions are made, (whether crystalline or not,) are entirely different from each other.

The columns are sometimes continuous, at others jointed, either obliquely or at right angles; occasionally, also, they are fissured without the appearance of regular joints.

The appearance of a six-sided basaltic column, regularly jointed, that is, consisting of short prisms laid on each other, is represented by fig. 37. It is not common, however, that the prisms are as regular, with respect to length, as here represented, the joints being more commonly repeated at intervals, varying from a few inches to several feet.

Fig. 37.

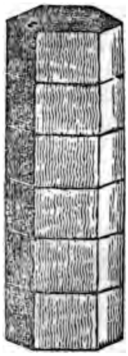
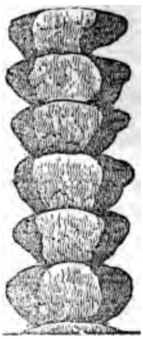


Fig. 38.



In their lengths, these columns also differ exceedingly. In the island of Sky are some which are 400 feet long, while others are only an inch in length. In diameter some are several feet, while others are less than an inch.

In exposed situations the prismatic blocks represented by fig. 37, lose their angles by the action of the weather, and become globular, but still retain their columnar position as shown by fig. 38.

It must not be understood that basaltic columns preserve their vertical positions, as usually represented by the drawings of Staffa and the Giant's Causeway, these being rare instances, both with respect to position and height. These columns are placed in every manner, from the horizontal to the vertical angle, though attracting most attention in these latter cases, from their resemblance to the efforts of architecture.

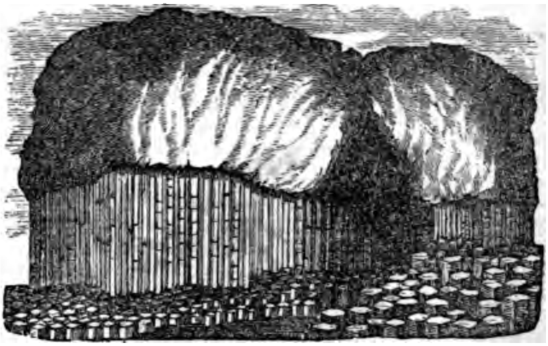
Trap rocks often form mountains of considerable height and sometimes spread over large districts of country. The island of Sky, on the western coast of Ireland, is one continuous mass of erupted rock, fifty miles long and twenty broad. With respect to the elevation of trap mountains, the following are examples. Tinto, in the district of Clyde, is 2036 feet high. Benmore, in the island of Mull, 3097. Salisbury Craig, 550, and Arthur's Seat, 800 feet; the two last near Edinburgh.

On this side of the Atlantic, Mount Holyoke in Massachusetts is 830 feet above the Connecticut, and 900 feet above the level of the sea. Mount Tom, on the opposite side of the river is still more elevated, being nearly 1000 feet high.

In the valley of the Connecticut, the mural side of the greenstone formations, is generally, and perhaps always towards the west, in which direction the precipices are often nearly perpendicular; while towards the east, the ascent is commonly quite gradual. Whether this fact has been observed of the greenstone of other countries, we do not know.

Who can conceive of the mighty power which forced these enormous masses from the bowels of the earth; or the awful scenery which was exhibited, when they were poured forth in the form of red hot lava? for there is no doubt but this was the manner of their production.

Fig. 39.



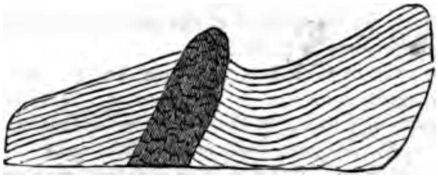
In most instances, basaltic and greenstone mountains present the form of rounded outlines, with occasional precipices on one or more of their sides.

The configuration of the basaltic columns of Staffa, represented by fig. 39, is peculiarly striking on this account. A part of the mountain has fallen down, in the form of pillars of various dimensions, leaving the others standing in fair view, and preserving a high mural face of great elevation, composed entirely of columnar pieces, touching each other.

The rounded form of the massive cap, which surmounts these pillars, presents the outline common to basaltic hills.

Protrusion of Greenstone. Although greenstone strictly belongs to the trap family, and passes by insensible degrees into basalt, still there have been detected but few instances, where it has protruded through superincumbent rocks so as to exhibit the fact to the eye of the geologist. The diagram fig. 40, from Prof. Hitchcock's Geology of Massachusetts, shows such a case.

Fig. 40.



"The protrusion," says Prof. H., "of the unstratified rocks through the stratified ones, by internal igneous agency, now admitted by most geologists, has led observers to examine carefully for evidences of mechanical disturbance, near the line of contact. They have, I believe, found less proof of such disturbance by the intrusion of greenstone, than in the case of the older rocks, as sienite and granite. Every such case, therefore, deserves to be noticed. If I mistake not, the following sketch of a vein of greenstone in argillaceous slate, is an example of this sort. The dyke is about ten feet thick, and the general dip of the layers of slate in the quarry, is about 30° southeast. But as shown in the figure, near the greenstone it is considerably curved upwards in the contrary direction. The quarry, where the example occurs, is about half a mile north of the powder house in Charlestown."

MINERAL VEINS.

Metallic veins appear originally to have been fissures, often passing through different beds of rock, and which were subsequently filled with metallic ores. These veins must therefore be considered as subsequent formations to the rocks through which they pass. When, however, a vein is found in only one bed of rock, the vein may have been formed and filled at the time when the rock was consolidated.

When mineral veins occur in considerable numbers in any tract of country, they maintain a general parallelism, as if all the fissures to which they owe their origin, had been formed at the same time, by some common cause.

The absolute antiquity of veins cannot be conjectured, but where one vein intersects another, as is often the case, the dislocation of the strata, through which the oldest vein passes, by the contact of the new one, is sufficient to show a difference in their ages.

Veins exist in primitive, transition, and secondary rocks, but are most common in the former. The substances most commonly found in them, are the *metals*, *quartz*, *calcareous spar*, *barytes*, and *Derbyshire spar*. It hardly need be remarked, that the chief object in pursuing veins, is the metals which they contain.

With respect to the depth of metallic veins, nothing but conjecture can be offered. The miners believe that they reach quite through the earth, but this opinion has no other foundation than that they never find their termination. Indeed, it is believed, that no instance has been recorded, where the end of a metallic vein has been found. They, however, often grow too poor to pay the expense of working; and the difficulty of clearing deep mines of the water, is a frequent reason why they are relinquished when they would pay a good profit, were they near the surface. Veins are seldom rich near the surface; but increase in value at a medium depth, and grow poor again at a greater.

Metallic veins often change their metals at different depths. In France, there are veins which contain iron above, then silver, and below the silver, copper; and one of the Cornwall mines contains zinc, in the upper part of the veins, which becomes rich in copper at a greater depth. Veins often change their dimensions also, being narrow in some parts, and wide in others. Thus the Dalcoath mine of Cornwall, varies from forty feet, to six inches in width.

It is a curious circumstance, that where a vein is intersected by a dyke, that the former often divides into two branches, which unite again before reaching the latter, and after having passed it, separates into several ramifications.

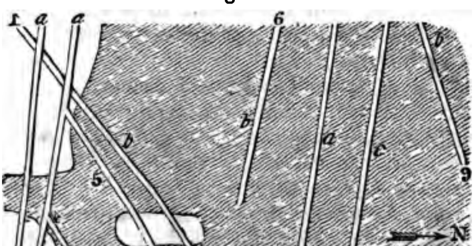
Thus, fig. 41, *b b*, is the dyke, and *a a*, the metallic vein, divided at *a*, but united again before reaching the dyke, after passing which, it again separates into several parts. The dyke has occasioned a fault, by which the two ends of the vein are widely separated. The lower branches are not supposed to terminate as represented in the cut, but to unite again and proceed downwards. *c c*, shows how veins sometimes change their dimensions, being narrow in some parts and wide in others.

Fig. 41.

Sometimes veins containing different metals cross each other, and as above stated, pass from one kind of rock into another. Examples of both, are contained in the tin Croft mine in Cornwall.

In this mine are five copper veins, three of tin and one mixed, all within about a furlong of space, from north to south. Two of the tin veins proceed in a straight line, the other alters its course repeatedly, in a gradual approach to the perpendicular, and is intersected by two of the copper veins. The rocks through which these veins pass, are slate and granite.

Fig. 42.



The annexed cut, fig. 42, from Mr. Phillips' paper, on this mine, will make the direction of these veins understood. *a a*, copper veins; *b*, tin veins; *c*, copper and tin intermixed. The dark shade is slate, and the white parts granite. The vein number 3, passes between slate and granite, one of these rocks being found on the north side, and the other on the south. Detached masses of granite and slate are found in this vein, and also in number 2. In this mine it was frequently the case, that where the vein was passing through slate, it contained fragments of granite, and when passing through granite, it contained pieces of slate.

THEORY OF VEINS.

No subject belonging to geology, has been contested more warmly, than the theory of metallic veins. These may be considered analagous to dykes, which are veins of stone penetrating strata differing from themselves in kind, and it is hardly disputed at present, that dykes have not owed their origin to melted matter injected from below. In like manner many of the earlier geologists, and among them Dr. Hutton, supposed that the metals were forced into their veins in a fused state, the expansive force of the heat, producing the fissures. This is called the *igneous theory* of mineral veins.

Opposed to this doctrine is that of Werner, and his followers, who believed that the fissures of dykes and veins were produced by the shrinking of the rocks in which they are contained, and that the metallic veins were afterwards filled with the metals in a state of solution, poured in from the surface of the earth. This is called the *aqueous theory*.

From the facts we have stated concerning veins, and what will be stated directly, the reader will see, that this latter theory contradicts at once, the principal phenomena by which they are attended. For even were it shown that the metals were soluble in water, which, however, cannot be true, still the supposition that the fissures were filled from above, could not be maintained, for the following reasons. First. The ores of most veins are unmixed, but where a vein contains several metals, one kind is above, or below the other. Were the metals poured in from the surface, no reason can be assigned why the several solutions should not have fallen in together; or why one should have filled the lower part of the vein and the other the upper. Second. When a vein passes through a different kind of rock, as from sandstone through limestone, the quality of the ore is changed, and it becomes richer or poorer. This is a general fact well known to miners. Now, it is plain, that were these veins filled by solutions poured in, the kind of rock could not possibly influence the quality of the metal. Third. When a fault changes the strata through which a vein passes, by lifting that on the one side, or throwing down that on the other, so as, for instance, to place sandstone on one side of the vein, and limestone on the other side, the vein is never so rich in ore, as it is when both sides are of the same kind of rock. This fact is also plainly incompatible with the aqueous theory. Fourth. Were the metals poured in from above, we should expect that all the narrow parts of the veins would soon be filled with earth mixed with the solutions, and, therefore, that they would reach only to a short distance below the surface, whereas the termination of a vein, as already stated, has never been discovered. Many other objections might be stated; but these are sufficient to show that the aqueous theory is incompatible with the known phenomena which metallic veins present.

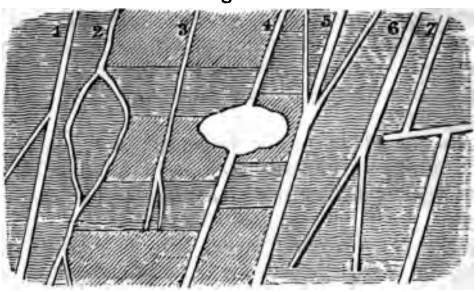
If now we advert to the igneous theory, we shall find fewer absurdities, because much must here be left to con jecture; but the difficulties are little less than those of the aqueous.

The objections already made, may be applied, without modification to this theory; for if the metals were injected in a state of fusion from below, as we must now suppose, how would any change in the kind or position of the strata, change their quantities? and how can we account for the fact, that veins in the same vicinity contain different kinds of metal, perfectly distinct, as tin and copper, in the Cornwall mine? Besides these objections, the heat of the fused metal would have produced obvious effects on the walls of the veins, as is the case with basaltic dykes. The adoption of either of these theories is therefore only a choice of dilemmas, as they both fail entirely to account for the phenomena observed.

But the difficulty concerning metallic veins, does not end here; for were it shown in the most satisfactory manner, how the metals might have been soluble in water, and in what way they might have been introduced from the surface into the fissures; or, on the contrary, could it be made to appear that all the phenomena which veins present, were compatible with the igneous theory, still the great difficulty would remain unanswered, viz., whence did *the metals come, before they were melted by the heat below, or dissolved by the fluid above?*

This, after all the arguments that have been employed on both sides, is the principal question; and the reasonable answer is obvious. The metals were created by Him who made the other parts of the earth; but whether they were formed at the same time, and in the veins as we see them, or whether the veins were fissures, afterwards filled with the metals; and, if so, whether they came from below, being dissolved by heat, or from above, in solution with some fluid, are questions which man, with all his curiosity, seems destined never to answer.

Fig. 43.



The adjoining cut represents the most common varieties of metallic veins. It is from Sir W. T. Brande's "Outlines of Geology," and is placed here to gratify the curiosity of the reader, on this mysterious subject.

With respect to the direction of different metallic veins, we have already observed, that in the same neighborhood, they commonly run parallel with each other, and are often nearly, or quite vertical, or perpendicular to the line of the horizon. But the inclination of different series of veins is found at every angle, from the perpendicular to the horizontal; and the manner in which they run among the strata is also exceedingly various. In most instances, the line of the vein is across that of the strata, but sometimes they run parallel with each other, and the veins spread out between the strata, as represented at No. 4. Sometimes, also, a vein, whose general direction is across the strata, will take a short turn between them, and then proceed on as before, as represented at 7. The branches of the veins do not terminate as they seem to do in the figure, but commonly join themselves together again, as seen at 2.

It must not be understood that metallic veins consist of metals, or their ores alone; on the contrary, they are mixed with greater or less proportions of stony matter. Sometimes the ore is diffused through the vein, in some manner as it would be, had the stone been porous, and dipped into a solution of the metal. In other instances, the metal lies in concretions, or crystals, entirely surrounded by the stone. An instance of this is common in the sulphuret of iron, the crystals of which appear as though they had been perfectly formed, and then dropped into the stone when in a soft state. Indeed, so mysterious are the phenomena which metallic veins exhibit, as in the present state of knowledge, to defy all hypothesis.

MINES AND MINERS.

The means of arriving at a vein, or working a mine, varied according to the nature of the rock or country which it traverses, and are dependent upon a great variety of adventitious circumstances, frequently connected with those under which the vein was discovered; which discovery is often accidental, as during the making of roads, cutting of ditches, or draining land; or sometimes it is arrived at, by the discovery of fragments, or pebbles of ore in the bed of rivers, or in alluvial soils through which streams formerly appear to have passed. Thus the ancient mode of *shoding*, or searching for tin, consisted in tracing certain stones containing that metal, to the vein whence they came. Sometimes the course of a vein may be learned by the nature of the fragments and stones upon the surface, and, more especially, when it is of iron, by their ocherous tints. A knowledge too, of the substances which, in different countries, usually accompany the ore of a metal, forming what is called the *ganue*, or matrix, is often of much importance in these inquiries.

Sometimes the springs in the vicinity of metallic veins are so tainted, as to lead to their discovery. Of this, a singular instance occurred some years ago at Dolgetty, where the peat in the neighborhood of the vein, was so impregnated by sulphate of copper, as to leave some of the metal in its ashes when burned. When this was ascertained, the injured vegetation guided to the vein. By the retention, therefore, of these contaminated waters, in the soil near the vein, it may become unfit for vegetation, and thus the sterility of certain patches of ground, may indicate the existence of metallic substances in the district.

(Mr. Brande, who writes the above account, has not stated what species of copper was discovered. It was, however, undoubtedly a sulphuret, and from the decomposition of which, the sulphuric acid was produced, which uniting with the oxide of the metal, formed sulphate of copper. In the Anglesea copper-mine, considerable quantities of the metal are obtained from the natural solution of the sulphate in water. This is done by throwing in pieces of waste iron, on which the copper is precipitated.)

"There are no class of persons," continues Mr. Brande, "more curiously superstitious than miners; and hence a variety of omens, connected with the interference of agents from the spiritual world, are among the items of their creed. Sometimes while under ground, they fancy they hear another pick at work, announcing the presence of a little man, or *pixey-knocker*, in some neighboring cavern, and the consequent vicinity of a good course of ore. Sometimes the divining rod is resorted to, as a means of finding the ore; and sometimes it is said that flames of light, dancing about a mining district, have suddenly perched upon the looked for vein; a circumstance not improbable, and perhaps referable to the power of the vein to conduct electricity."

The habits, however, of the miner, are those of industry and perseverance, which sometimes tempt him to exploits that excite astonishment at his venturous hardihood "The very idea of a descent beneath the surface of the earth, has something in it of the terrible," says Mr. Phillips, "and at which those shudder who are unacquainted with practical mining; but such is the force of habit, that any other employment rarely tempts him to forsake his own. The occasional perils of his occupation are scarcely noticed, or if noticed, are soon forgotten. He walks, often in the middle of the night, and in all weathers, two, or three, or more miles, to the mine, undresses, and puts on his underground clothes, and with his tools, slung over his shoulder, descends to a depth of 1000 or 1200 feet, assisted by the light of a small candle, and works in the bottom of the mine six or eight hours, amidst the noise of the working of the pumps, with as much alacrity and with as little sense of danger, as he would feel amidst his ordinary occupations above ground. We should be inclined to feel pity for the wretch, who, as an atonement for his crimes, should be compelled to undergo what the Cornish miner voluntarily undertakes for a small pittance, and that even of an uncertain amount."—*W. Phillip's Geol. Trans.*

One of the mines in the parish of St. Just, is wrought nearly 500 feet under the sea, beyond low-water mark; and the sea, in some places, is only about eighteen feet over the back of his workings; insomuch that the miners underneath hear the break, flux, ebb, and re-flux of every wave; which, upon the beach overhead, may be said to have the run of the Atlantic ocean for many hundred leagues, and consequently are amazingly powerful and boisterous. They also hear the rumbling noise of every nodule, and fragment of a rock, which are continually rolling upon the submarine stratum; which altogether make a kind of thundering roar, which would surprise and terrify the stranger. Add to this, that several parts of the land which were richer than others, have been indiscreetly hulked, and worked within four feet of the sea, whereby, in violent stormy weather, the noise overhead has been so tremendous, that the workmen have many times deserted their labor, under the greatest fear, lest the sea should break in upon them.—*Pryce's Mineralogia Cornubiensis.*

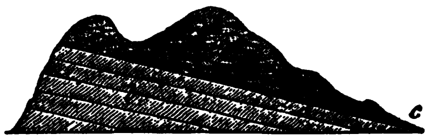
In former times, when a vein of metal was discovered, it was worked to a certain depth, and then often abandoned, in consequence of the insufficiency of the pumps to carry off the water, or the expense incurred in their erection and working. In certain situations, however, it was found that this water run off at lower levels, and that in most instances it might be carried away by an underground tunnel, commencing at the foot of the hill, penetrating to the vein, and thus forming a communication with the working of the mine, and a neighboring valley. These tunnels are now called *adits*, and when it is resolved to try a vein, one of these underground passages, about six feet high, and two and a half wide, is begun at the bottom of the neighboring valley, and driven up to the vein for the purpose of carrying off the water; or if a mine has an engine to raise the water from a greater depth than that of the entrance of the adit, the engine then, instead of having to lift the water to the surface, throws it off, with diminished labor, at the adit. In general, adits are nearly horizontal, for although a declivity would accelerate the drainage, it would enter the mine at a less depth. The importance of draining mines by adits has led to some gigantic undertakings of this kind. The great Cornish adit, commences in a valley above Carnon, near the sea, and branches off in its course in several directions to about fifty mines. Most of the mines are far below the level of the adit, the water being raised into it by means of steam engines. The entire length of this adit, with its various branches, is about thirty miles. But the greatest length of any one branch from its mouth to the mine, is that of Cardrew Mine, which is about five and a half miles. The greatest depth of any part of this adit is at Wheel Hope, where it is about 400 feet deep. It empties itself into Falmouth harbor. Several great works of the same kind exist in different parts of Great Britain. The adit belonging to the Duke of Bridgewater's coal mines, is nearly thirty miles long, and navigable for small boats.

Where an adit is of any considerable length, it is obvious that the air would become stagnant in it, so that the workmen would be unable to proceed. To prevent this, and also to enable them to remove the produce of the excavation without transporting it to great distances, perpendicular openings, called *shafts*, are made at various intervals. From these shafts, *levels*, or *galleries*, are driven in different directions, either for exploring for new veins, or for removing the contents of those already known.—*See Brande's Geology.*

PHENOMENA OF SPRINGS AND WELLS.

The origin of common springs is easily understood The water which falls on the surface of the earth, penetrates its substance, until meeting with a stratum of clay or the surface of a continuous rock, which hinders its descent, it accumulates, and taking the direction given by these impediments, continues its course, until meeting with an aperture, gushes out in the form of a spring.

Fig. 44.



Suppose *a*, fig. 44, to be a gravel hill, and *b*, strata of clay or rock, impervious to water. The fluid percolating through the gravel would reach the impervious strata, along which it would run until it found an outlet at *c*, at the foot of the hill, where a spring would be formed. As water in the earth observes the law of gravity, springs are most commonly found lower than their sources. When however the fluid is intercepted by a dyke, which rises as high as its source, the hydrostatic law of tending to a level, will carry it as high as its source; though this in fact is probably not a common circumstance, since the pressure of the water generally will find an outlet before it rises to such a height.

The people of Artois in France, for a long time, have been in the practice of boring into the earth, until they find a sheet or vein of water which rises to the surface. These are called *Artesian* wells, because the method was first invented, or employed in Artois.

This method has for many years been practised in other parts of Europe, and more recently in this country. The size of the boring is usually three or four inches in diameter, and to prevent its sides from falling in when it passes through a stratum of sand, there is introduced a jointed tube, which in Artois, is made of wood, but in other countries of copper, or other metal. It often happens that after passing through hundreds of feet, without success, a vein of water is pierced, which immediately ascends to the surface, and flows over the end of the tube. The first rush of the water is sometimes so violent as to throw it many feet above the surface, where for a time it plays like an artificial fountain, and then continues to run in a steady stream, or perhaps sinks away below the sur face to the great disappointment of the operator. This violent gush of the water appears to be owing to the pressure of air or gas on its surface, before it was pierced by the auger. Dr. Hildreth states that in boring for salt in Ohio, the gas rushed out with such force as to throw the auger and poles into the top of a tree.

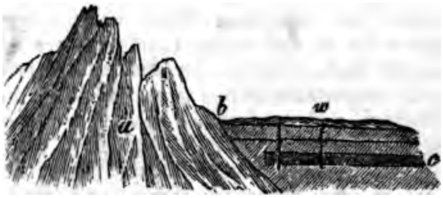
In some instances large quantities of water have been discharged from great depths in this manner. In 1824, a well was dug at Fulham, near the English Thames, to the depth of 317 feet, the deepest part of which passed through sixty-seven feet of chalk. On piercing through the chalk the water immediately rose to the surface, and discharged itself at the rate of fifty gallons per minute.

Sometimes borings for Artesian wells are entirely without success. Thus, at Toulouse, in France, the excavation was carried to the immense depth of 1260 feet, and abandoned without finding water. In most places, indeed, there is no doubt but success must depend on chance, since neither skill nor experience in ordinary circumstances, can ascertain beforehand the direction of a water vein. It appears, however, that in certain situations, water bearing strata underlay considerable extents of country, as will appear by the following account.

In the country about Modena, in Italy, to find water, they dig through several kinds of soil, until they come to a stratum of hard calcareous clay, which resembles chalk. Here they begin their mason work, and build the wall at their leisure, carrying it up to the surface, without the least sign of water. But experience has taught the workmen not to expect it until they pierce this stratum, when it never fails to reward their labors. When the well is finished they bore through this hard stratum with a long auger, but take care to leave the well before they draw it out again; which when they have done, the water springs up into the well, and in a short time rises to the brim, or in some instances overflows into the neighboring valley.

The source of these wells is supposed to be in the Appenine mountains, which lie not a great distance from Modena, and to which the impervious stratum does not reach. The water from the mountains, therefore sinks below this stratum, at a distance from these wells, and is thus prevented from rising to the surface until this is pierced.

Fig. 45.



Suppose *a*, fig. 45, to represent the Appenines, sloping down towards Modena, and passing under the secondary strata at *b*. Suppose that the impervious strata *c*, does not reach the side of the mountain, and that the strata, both above and below it, admit the water through them; then the fluid would not rise in any quantity above this stratum, except about its edges; but the pressure being constant on its lower side, because the source is elevated, the moment this is pierced the water flows above it, as at *w*, which represents a well.

In many instances, wells overflow their brims, and continue to discharge water, in the manner of springs. These may be springs deeply situated, which happen to be struck by the well, or they may be dishes of water, confined by dykes, or by impervious strata, inclining towards each other.

Fig. 46.

The annexed cut, fig. 46, represents inclined strata covered with alluvial deposites. The water descending along the strata, would be lost in the adjoining valley, was it not intercepted by the dyke, *d*, which serves as an impervious dam. The water, therefore, rises and forms springs along the inside of the dyke. Now, if a well be sunk at *w*, the water will rise to the surface of the ground, and if the inclined rocks be considerably higher than the well, it will overflow. If the strata form a dish, one side of which is considerably higher than the other, the same effect will be produced.

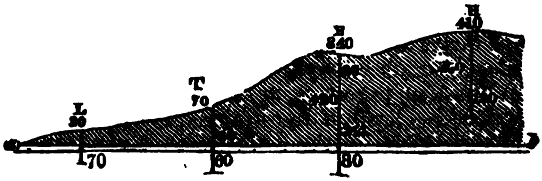
London and its vicinity stand over a formation, of rather a peculiar kind, called *London clay*. Its direction is nearly horizontal, and its thickness from 100 to 500 feet. It is covered with alluvial deposites of various thickness; so that although the surface of the clay may be horizontal, till the depths of the wells are various, according to the thickness of the alluvium. Until within a few years, most of the wells in and about London, were sunk no deeper than the surface of this clay, and its impervious nature is of vast importance to that great city, since the water is thus retained, and a plentiful supply is always furnished by means of shallow wells. But this water, though limpid, is hard and impure. That, however, which is drawn from below the clay, is perfectly soft and transparent; and hence all the pumps about London, which furnish such water, are of great depth, piercing the sand below the clay.

This water, says Mr. Conybeare, frequently rises so instantaneously, on passing through the clay, as not to suffer the well digger to escape, without rising above his head. It appears to rise in different places to different heights. Thus, at Liptrap's distillery, near the Thames, it rises no higher than the level of that river; but at Tottenham, four miles north of London, it rises sixty feet above that level; while at Epping, fifteen miles north of London, the water rises to within twenty-six feet of the summit of the well, which is 340 feet above the level of the Thames, and therefore 314 feet above that level. This well is 420 feet deep, of which 200 feet were sunk through by digging, and 220 bored with an auger, four inches in diameter. After boring to this depth, no water being found, the project was relinquished, and the well was covered over; but at the end of five months it was found that the water had risen to within twenty-six feet of the surface, and has so continued ever since. The sinking of this well was therefore 340 feet above the level of the Thames, and eighty feet below it.

Another well, two miles from this, at Hunter's Hall, is 350 feet deep, but its summit is seventy higher than that at Epping, and 410 feet above the level of the Thames. The water in this well stands 130 feet above its bottom, which is sixty feet above the level of the Thames; the actual elevation of this water, therefore, is not so great as that at Epping, by fifty-four feet.

These facts will be better understood by fig. 47, where H marks Hunter's Hall; E Epping; T Tottenham; L Liptrap's well, at Mile End. *a b*, is the level of the sea, as indicated by that of the Thames. It will be observed that all the wells reach below the level of the Thames, except

Fig. 47.



that at Hunters' Hall. The numbers will be chiefly understood by the explanations already given. Thus the water in the well at Hunters' Hall, stands 130 feet from its bottom, the well is 350 feet, and its mouth 410 above the level of the Thames. That at Epping, is 420 feet deep, its summit is 340 feet above the Thames, and its bottom, 80 feet below it; the water is 314 feet deep, and it rises to within 26 feet of the top. The well at Tottenham is 130 feet deep; its top is 70 feet above the Thames, and its bottom 60 feet below it, and the water rises 60 feet above the sea.

All these wells being sunk below the London clay, and deriving their water from the same source, it might be expected that agreeably to the general law of hydrostatics that their surfaces would have a common level. The London clay, as we have stated, is nearly on a horizontal level; the depth of the well at Hunters' Hall, however shows a slight rising of the strata there, but still the water in that well does not rise so high by 54 feet, as that in the well at Epping.

Now did the water which supplies these wells, exist in a great reservoir, so that a full and instantaneous communication could take place between the different points pierced by the wells, then the water in them all would stand at the same hydrostatic level; whereas in fact, no such case exists. The strata on the contrary, which bear the water, though more or less porous, are still too close to allow the fluid to pass with rapidity; hence such strata may be considered as acting on the water in the same manner as a series of imperfect dams. Now although the water in the present case has the same general source, being that which falls on the highlands, beyond the confines of the London clay formation, and percolating so as to rise under it, yet from the want of free communication, it will not everywhere rise to the same height when the clay is pierced, but the well will only drain that which presses with the greatest force in its immediate vicinity, without affecting that which is at a distance. If there is a free and extensive drain in any part of such a formation, then it is obvious that the water in that vicinity will rise no higher than the level of the drain. Thus the water in the well marked L on the cut, rises no higher than the Thames, bacause that river cuts through the London clay, and serves as a drain to the same water bearing stratum which supplies the other wells.

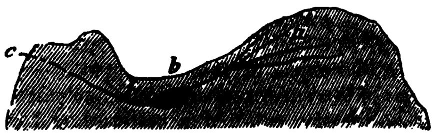
Wells situated in level countries, and in alluvial formations, generally require to be sunk only thirty or forty feet, and sometimes no more than twenty before water is found. These are not commonly supplied by springs, but merely by the draining of the water which exists within the circuit of a few yards, into a cavity. During severe droughts, many such wells fail, which shows that they are supplied only by the rain which percolates from the surface, and not by deeply seated springs.

But there are some extraordinary phenomena connected with springs which require a different explanation, if indeed they can be explained at all.

There is little difficulty with respect to those springs which rise in salt marshes, or which gush from the fissures of rocks under the sea. The sources of these are in the distant hills; or in the strata of the vicinity, situated higher than their outlets; and the presence of the sea or marsh it is plain, could not affect them, since the water from these do not penetrate their sources. This principle will also account for such springs as rise on small islands at little distances from the sea shore, where they could not have been collected from the rain falling there.

There are however springs which arise near the tops of hills, and which are so situated as to make it apparent that their sources could not exist in the same hills, nor in those in the immediate vicinity. The water with which such are supplied, must therefore, come from the higher hills or mountains, at a distance, and passing the intervening valley, rise by hydrostatic force to these outlets. Many rocks are so full of fissures, as to present no difficulty in supposing that considerable rivulets might run among them, at great depths below the surface. Rocks also frequently contain large cavities, so that some rivers sink down into them and disappear for miles, when they again issue from their hiding places, and continue their courses. In limestone districts it is well known that large cavities are of common occurrence. Perhaps, therefore, the manner in which water is conveyed to the springs, situated as above described, may be as follows. Water, from hills at a distance, and more elevated than the springs, descend through fissures, to a cavity in the valley, which cavity communicates with another fissure running to the spring. In this manner the hydrostatic pressure from the highest hill, would overcome that from the lower one, and the water would be perpetually transferred from one to the other.

Fig. 48.



The annexed cut, fig. 48, will make this obvious. The rills *a*, are supposed to unite and fall into the cavity below *b*, from which, the greater pressure from *a*, forces the water up the hill, through a fissure, to *c*, where the spring issues.

That water runs in considerable streams under the earth and among the fissures of rocks, is proved by its issuing in springs, sometimes in large quantities. Dr. Macculloch states, that a spring in Staffordshire, is computed to discharge more water annually, than all the falls in the surrounding country; and the same, even to a greater degree, is true of that of the Sorgne, in France.

A writer in Featherstonhaugh's Journal, for August, 1831, p. 65, refers to a great body of water which issues from the ground, ten miles from Harrisburgh, Virginia, and which is known under the name of "Big Spring." He says, "it should rather be called a river, so large is the body of water which rises suddenly from the foot of a limestone hill, and continues in a stream some yards in breadth, and half a foot deep, with force sufficient to turn two large mills immediately below."

There is a spring at Kingston, R. I., which arises from primitive rocks, and discharges such a quantity of water that a grist mill has been driven by it for a great number of years, and more recently, a large cotton factory has been erected below the corn mill, which depended entirely on the water of this spring to turn its whole machinery.

From these, and such like facts, there can be but little doubt, that small streams are constantly running under ground among the crevices of the rocks, and that such springs are formed by a union of many of these tributaries, in a similar manner to which larger streams are formed on the surface of the earth, by the union of several smaller ones.

CHANGE OF CLIMATE.

It will be the object of this section to show, that the temperature of the earth's surface, at some period anterior to the era of history, suffered a material, and probably a sudden change, and that in consequence, the climates of different countries have become colder than they were at some remote period.

This is a subject of great interest in geology, and although the idea of a universal change of climate was once strongly controverted, most writers, at the present day, consider that there is sufficient evidence, that the temperature of the earth's surface is much lower than formerly.

"That the climate of the northern hemisphere has undergone an important change," says Mr. Lyell, "and that its mean annual temperature must once have resembled that now experienced within the tropics, was the opinion of some of the naturalists who first investigated the contents of ancient strata. Their conjecture became more probable, when the shells and corals of the secondary rocks were more carefully examined, for these organic remains were found to be intimately connected, by generic affinity, with species now living in warmer latitudes. At a later period, many reptiles, such as turtles, tortoises, and large saurian (lizard-like) animals, were discovered in the European strata, in great abundance, and they supplied new and powerful arguments from analogy, in support of the doctrine, that the heat of the climate had been great when our secondary formations were deposited. Lastly, when the botanist turned his attention to the specific determination of fossil plants, the evidence acquired the fullest confirmation; for the flora of a country is peculiarly influenced by its temperature; and the ancient vegetation of the earth might more readily than the forms of animals, have afforded conflicting proofs, had the popular theory been without foundation.

"It is not merely reasoning from analogy, that we are led to infer a diminution of temperature, in the climate of Europe; there are direct proofs in confirmation of the same doctrine, in the only countries hitherto investigated by expert geologists, where we could expect to meet with direct proofs. It is not in England, or Northern France, but around the borders of the Mediterranean, from the South of Spain to Calabria, and in the islands of the Mediterranean, that we must look for conclusive evidence on this question; for it is not in strata, where the organic remains belong to extinct species, but where living species abound in a fossil state, that the theory of climate can be subjected to the experimentum crucis. In Sicily, Ischia, and Calabria, where the fossil testacea, of the more recent strata, belong almost entirely to species now known to inhabit the Mediterranean, the conchologist remarks, that individuals in the inland deposites, exceed in their average size the living analogues."—*Lyell's Geology*, vol. i. p. 92.

The shells thus existing in strata, and in the fossil state, differ in no respects from those now found in the adjoining sea, except in size; the ancient ones being much larger than those now living. Hence the conclusion, that because these animals do not attain the size the same species did anciently, the climate has deteriorated.

It has also been ascertained that some species of shells found in the fossil state, in Italy, are now living in the Indian Ocean, and that these correspond in size; whereas the same species existing at present in the Mediterranean, are comparatively dwarfs in size, having been stinted in their growth, for want of the heat which now exists in the Indian Ocean.

These circumstances go far to show, that the climate of Italy is not so hot as formerly, for it is well known, that these shells attain a size in some proportion to the heat of the climate in which they are found.

Another and perhaps stronger proof, is drawn from the vegetable remains, which are found in various strata, especially in those of coal. M. Adolphe Brogniart, in his "Treatise on the classification and distribution of fossil plants," has come to the following, among other conclusions on this subject. First. "That in the strata of coal and anthracite, the vegetables preserved are nearly all cryptogamous, or monocotyledonous* plants, as ferns,† equisetums,‡ and lycopodiums,§ &c., and that some of these tribes which no longer exist, except as fossils, grew to an immense size in Europe."

(Some of the Equisetums were ten or twenty feet high, and from six to twelve inches in diameter. These tribes in our climate at the present day, grow from one to three feet in height, and are ordinarily about the size of a pipe-stem. A specimen of this tribe from the borders of Canada, now before us, is more than two inches in diameter, a proof that the climate of North America, as well as that of Europe has changed. Plants of the fern kind, in some parts of Europe, attained the height of forty or fifty feet; and the aborescent club-mosses were sixty or seventy feet high. No plants of these tribes, at the present day, ever attain one fourth of these sizes.)

Second. "That in the higher strata, a great variety of fossil vegetables exist, which, for the most part, appear to belong to similar tribes of plants, if not in species, at least in genera, to vegetables which still inhabit the hottest regions of the earth; nor is it probable that they have been transported to the places where they are found in Europe, from such climates, since their most delicate parts are uninjured." It is therefore, reasonable to suppose, that since the growth of these vegetables, the climate of Europe has suffered a great change.

The Count Sternberg, author of a splendid work, the "Botanical and Geological Flora," of the Ancient world,

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* Plants with one Cotyledon, as wheat, Indian corn, and the grasses.

† Polypodies and Brakes.

‡ Horsetails. The scouring rush is a species.

§ Ground-pine or Club-mosses. The ground-pine, employed in dressing churches for Christmas, is an example.

"concludes, that the vegetation of which bituminous coal," has been formed, consisted of several species of large trees, of which he has in his collection trunks eighteen inches in diameter. These trees seem all to have belonged to the monocotyledonous or polycotyledonous* families. They were palms, bamboos, &c., plants which at the present day are found only in hot climates.

"If," says Dr. Ure, "we examine the fossilized fruits found in the upper (coal) strata, we shall see that several of them evidently belonged to the same family of palms; but one of the most extraordinary facts connected with this subject is, that none of these fruits appear to have grown on the palms with fan-shaped leaves; but on the contrary, that all the fruits that have been delineated by authors, seem referable to the genera with pinnate, (feather-formed) leaves."

There is no doubt, however, that palms, with fan-shaped leaves, (fan-palms,) once covered Europe with their lofty vegetation, since petrified specimens of these plants exist in great abundance. The opinion formerly entertained, that these trees had been transported to Europe from warmer climates, appears in the present state of knowledge, to be without the least foundation, since not only trees with entire branches have been found, but also roots in the places where they grew. In some coal mines, have been discovered the trunks of large trees standing in their original vertical positions, around which several strata of rock and coal have been deposited, which fact is clearly incompatible with the hypothesis of transportation.

The existence of the bones of animals of enormous dimensions, though of extinct species, afford by analogy, an indication of the tropical heat of Europe, at some remote period.

The great *megalosaurus*, (great lizard,) and the still more gigantic *iguanadon* (iguana-toothed,) says Mr. Mantell, to which the groves of palms and arborescent ferns, would be mere beds of reeds, must have been of such prodigious magnitude, that the existing animal creation presents us with no fit objects of comparison. Imagine an

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* Seeds consisting of more than two seed lobes. Very few plants of this character are known at the present day.

animal of the lizard tribe, three or four times as large as the largest crocodile, having jaws equal in size to those of the rhinoceros, and a head crested with horns. Such must have been the iguanadon.

This huge animal is supposed, from the dimensions of some of his bones, to have been about seventy feet in length, with a body as thick as that of an elephant. Its skeleton was found in Sussex, England.

The bones of the megalosaurus, also found in England, indicate an animal of the lizard kind, about forty feet long, and when standing, eight feet high.

It is true that these animals no longer exist, and therefore only indicate a change of climate, by the analogy, that animals of similar tribes, and of great size, are found exclusively in tropical climates at the present day. But there is not wanting other evidence of such a change, and perhaps as direct as the nature of such a case will allow, in the fact clearly proved by Dr. Buckland, that animals once inhabited Europe, the genera of which are known to live only in tropical climates. The following are the circumstances:

A cave was discovered by some workmen at Kirkdale, in Yorkshire, in 1821. Its mouth was at first nearly covered by rubbish, but on removing this, and exploring the interior, there was found a cavern 240 feet in length, fourteen feet high, and from three to seven feet wide. The rock being of limestone, its roof was covered with hanging stalactites,* and its floor in many places incrusted with stalagmite.† The floor was covered with a coat of soft mud, or loam, about a foot thick, and in this were found the bones of various animals. These were in a high state of preservation, they were broken, but none appeared as though they had been worn by the action of water,

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* *Stalactites* are formed by the percolation of water through limestone rocks, by which calcareous particles are dissolved, and subsequently left by the evaporation of the water, on the roof of the cavern. They hang like icicles, and gradually increase by the deposition of stony particles, in concentric circles.

† *Stalagmite* is formed by the water which falls from the stalactites to the floor of the cavern, where by evaporation, it deposites its calcareous matter. Sometimes the stalactite and the stalagmite meet each other, and joining, form pillars, extending from the floor to the roof of the cavern.

or sand, which most probably would have been the case, had they drifted there in the naked state.

The genera of animals to which the Kirkdale bones belong amounted to twenty-three in number; viz., Hyena, Tiger, Bear, Wolf, Fox, Weasel, Ox, Elephant, Rhinoceros, Hippopotamus, Horse, Deer three species, Hare, Rabbit, Water-rat, Mouse, Raven, Pigeon, Lark, Duck, and Partridge.

A great proportion of these animals belonged to species now supposed to be extinct, though the genera of them all are still living.

On examination of all the circumstances, Professor Buckland concludes that this cave was the den of hyenas, and that the multitude of bones thus discovered, were carried into this place by these animals, and therefore that the hyena, an animal now inhabiting the hottest climates, once lived in England.

These bones were, without exception, broken or gnawed, so that, among the vast numbers the cave contained, there could hardly be found all the pieces for a single limb, much less for an entire skeleton. The great number of hyenas which had died in this cave, or whose skulls had been carried there, was proved by the number of the canine teeth of this animal, which it contained.

Professor Buckland states that one collector obtained more than 300 of these teeth, and as each individual has only four of this kind, these must have belonged to at least seventy-five of these animals. But from the number of such teeth found, besides the 300, and other circumstances, it was judged that not less than from 200 to 300 hyenas had perished in this cave. Hence, it is concluded, that the cave had been for a long series of years a den of hyenas, and that these bones were carried there as their food.

This supposition is supported by the well known habits and appetites of these animals at the present day; their habitations being the deep recesses of the rocks, and their food the carcasses and bones of animals already dead, and decayed.

The immense power of the jaw, which these animals possess, enables them to break and masticate bones in a manner which no other animal can do. When they attack a dog, it is said they begin by biting off his leg at a "single snap;" and Prof. Buckland, after a part of his work was written, had the satisfaction of seeing a Cape Hyena, in confinement, crush the thigh bone of an ox, in a manner which convinced him that the bones in the cave had undergone a similar operation. The animal bit off all the upper part of the bone, which he swallowed in the shape of fragments, licking out the marrow from the cavity. The lower part, being exceedingly hard, he did not eat; and with this Prof. Buckland compared the fragments of similar bones found in the cave. His words are, "I preserved all the fragments and gnawed parts of this bone, for the sake of comparison, by the side of those I have from the ante-diluvian den in Yorkshire: there is absolutely no difference between them, except in point of age."

This experiment was followed by presenting the ferocious animal with other bones. "I gave him, successively," says he, "three shin bones of a sheep, he snapped them asunder in a moment, dividing each into two parts, all of which he swallowed entire, and without the smallest mastication. On the keeper putting a spar of wood, two inches in diameter, into his den, he crushed it in pieces, as if it had been touch-wood, and in a minute the whole was reduced to a mass of splinters. The power of his jaws far exceeded any animal force of the kind I ever saw exerted, and reminded me of nothing so much as a miner's crushing mill, or the scissors with which they cut off bars of iron and copper, in the metal foundries."—*Reliquiæ Diluvianæ*, p. 37.

It is not to be supposed that the carcasses of the Elephant, Rhinoceros, and Hippopotamus, were carried into this cave in an entire state; for neither the strength of the Hyena, nor the size of the aperture would favor such an opinion. The state of the bones, on the contrary, would seem to indicate that they were dragged in, one at a time, from the carcasses of such animals as were found dead in the neighborhood, as food for these ferocious beasts.

On the hypothesis that these animals had entered the Kirkdale cavern, when living, and of their own accord, it may at once be objected, that unless the size of the aperture was much larger formerly than when discovered, this would have been impossible; besides, the elephant, horse, hippopotamus, and most of the other animals whose bones the cave contained, never voluntarily go into such places.

The idea has also been suggested, that these animals might have taken shelter in this place in order to avoid some catastrophe, perhaps the deluge. But this opinion is fully as improbable as the other, for in addition to the fact, that most of these animals have never been known to enter caves, on any occasion—no circumstances can be imagined, which would have forced the deer and the tiger, the horse and the wolf, the fox and the rabbit, together with the hyena and elephant, to take shelter in the same place, at the same time. But what makes all this improbable, and indeed impossible, is, that not a single entire skeleton was found in the cave; clearly proving that the bones, only, of these animals were carried there.

All these facts and circumstances prove, in as satisfactory a manner as can be desired, that England was once inhabited by elephants, hyenas, tigers, and other animals belonging only to hot climates; for that these bones could have been drifted from a foreign climate into this cave, is more improbable than any hypothesis we have mentioned; for the bones alone would have sunk in the water; and had they been covered with flesh, the larger animals not only could not have entered, but if so, their entire skeletons would have still remained.

It is therefore reasonable to conclude, that these animals lived and died in the country where their bones are found; nor is there any one circumstance which can be employed as an argument against such a belief, except the coldness of the climate at the present day.

The only climates in which the elephant, the rhinoceros, the hippopotamus and hyena are now found, are among the hottest on the earth; and it is said, the only country which all these four animals inhabit together, is Southern Africa. In the neighborhood of the Cape of Good Hope, these four animals live and die together, as they formerly did in England.

"To the question," says Prof. Buckland, "which here so naturally presents itself, as to what might have been the climate of the northern hemisphere when peopled with genera of animals, which are now confined to the warmer regions of the earth, it is not essential to the point before me to find a solution; my object is to establish the fact, that these animals lived and died in the regions where their remains are found, and were not drifted thither by the diluvial waters from other latitudes. The state of the climate in which these extinct species may have lived, antecedently to the great inundation by which they were extirpated, is a distinct matter of inquiry, and on which the highest authorities are not agreed."

Cuvier is of the opinion, that many of the extinct fossil animals were of a different species from those now in existence, and therefore the inference may be drawn, that some species of the same genera might have been fitted for a cold, while others could live only in a warm climate.

Thus the fox is found, both in the coldest, and the hottest regions; and the Newfoundland dog is so protected by his coat, as to endure the cold of an arctic winter, while the naked African species would perish in a moderate climate.

On the other hand, it may be contended that the remains of many animals are found in strata in cold regions, which are not liable to any such variations, and which from their nature, or structure, are known to live only in hot climates; such are the crocodiles and some species of the tortoise.

But the want of vegetation in cold climates, is an insuperable objection to the hypothesis, that such animals as the elephant, rhinoceros and hippopotamus, could have been maintained during the winter season in Great Britain, let their natural clothing be supposed ever so warm. And besides, the bones of these animals, and especially those of the elephant, are nowhere found in such abundance, as in Siberia, one of the most inhospitable climates on the earth, and in which country, at the present day, there is hardly sufficient vegetation to maintain a few elephants, even during the few months of summer; and where that most hardy of all quadrupeds, the rein-deer, can with difficulty maintain itself through the rigors of an eight months' winter. At present, the elephant and rhinoceros, except through the tyranny of man, are never found out of a country perpetually verdant.

With respect to the supposition which has been offered, that these animals might have migrated with the seasons, and thus enjoyed the luxury of a constant vegetation, it is plain that the present geographical situation of England, would invalidate any such hypothesis, unless it can be shown that these animals found a warmer country by crossing the straits of Dover, a distance of more than twenty miles, by water. This, so far as regards the rhinoceros, tiger and hyena, is clearly impossible, and it is well known that the hippopotamus not only lives exclusively in fresh water, but that its unwieldy bulk prevents it from taking long and rapid journeys.

Thus the fact which geology has brought to light, with respect to certain portions of the animal, as well as the vegetable kingdom, appear very clearly to concur in proving, that the climate of Europe was once, at least as ardent as the hottest parts of Africa are at this day; and that there was a time, when Siberia was clothed with a sufficiency of vegetation to support herds of elephants during the whole year.

Causes which have produced a change of climate. With respect to the cause, or causes which have effected so great a change in the temperature of the earth's surface, there are a great variety of opinions.

Burnet, as stated in the abstract we have given of his theory, accounted for this change by supposing that the earth's axis took a new and different position at the time of Noah's flood; but astronomy has shown the improbability of any such change in position.

Most writers who admit a deterioration of climate, suppose with Burnet, that the change was sudden, and that it took place about the period of the deluge. Some, however, and among them Mr. Lyell, believe it to have been gradual, occupying thousands of years, and to have been caused by the changes which have taken place in the relative positions of the sea and land. But in the first place, no such changes as this author supposes are proved to have happened with respect to the sea and land; nor second, had such changes been proved, is it at all probable, such local causes could have been adequate to effect a change so material and universal.

Other theorists, who maintain the deterioration to have been gradual, think that the most reasonable mode of accounting for it, is to suppose that the earth was created in the state of a fused mass, and that it has been cooling ever since.

Sir John F. W. Herschel has recently made some calculations and inquiries, with the view of ascertaining whether there existed any astronomical causes, which might account for the difference between the present and ancient heat of the earth's surface. "Geometers," he says, "have demonstrated the absolute invariability of the mean distance of the earth from the sun; whence it would at first seem to follow, that the mean annual supply of light and heat derived from that luminary would be alike invariable; but a closer consideration of the subject will show, that this would not be a legitimate conclusion; but that on the contrary, the *mean* amount of solar radiation is dependent on the eccentricity of the earth's orbit, and therefore liable to variations.

"Now the eccentricity of the earth's orbit," he continues, "is actually diminishing, and has been so for ages beyond the records of history. In consequence, the ellipsis is in a state of approach to a circle, and the annual average of solar heat radiated to the earth is actually on the *decrease*. But whether this diminution of radiated heat is sufficient to account for the refrigeration of climate, which geological facts appear to prove, is a question which has not been decided."

Allowing that the earth's orbit should become a perfect circle, we are at a loss to see how the mean annual radiation should thereby be diminished. It is the opinion of M. Arago, that the mean amount of solar radiation can never be materially affected by the irregularities of the earth's annual motion.

It would appear, therefore, that we cannot look to astronomy with much confidence, for a solution of the problem in question.

A recent and highly respectable author, Dr. Ure, of Glasgow, believes that the original heat of the earth was dissipated in consequence of the evaporation of the waters of the deluge.

The cooling influence of evaporation, under certain circumstances, is undoubtedly very great, and most probably in many instances, produces effects which are attributed to other causes. In India, ice is produced by the evaporation of water in the open air. It is said that under certain circumstances, by the spontaneous evaporation of one part of water from the surface of thirty-two parts, at the temperature of 62°, the remaining thirty-one parts will be rendered nearly ice cold, and by the evaporation of four parts more, the remaining twenty-seven will become ice.

The effects of evaporation, together with the absence of a large heating surface, is strikingly illustrated in the temperate climate of St. Helena. This island, though less than eighteen degrees from the equator, and on a parallel with the burning plains of continental Africa, enjoys one of the most comfortable and salubrious climates on the earth. At Jamestown, the thermometer, in the warmest season, seldom rises above 80°. In the country, the climate is still more mild, the thermometer, in some seasons, never rising higher than 72°. At Jamestown, the average temperature during the year is from 66° to 78°, the heat at this place, being concentrated by the high rocks which rise above the town. At Plantation house, the average heat is only from 61° to 73°, and at Longwood, the last residence of Napoleon, from 56° to 68°.

The island of Sumatra, though directly under the equinox, presents a similar exemption from the excessive heats with which the interior of continents, situated on the same parallel, are oppressed. The heat, at this island, seldom rises higher than 85°, at any season; while at Bengal, which is situated in 22° north latitude, it is often above 100°.

It is at a distance from the sea, and where the surface is dry, that the greatest accumulation of heat takes place. Mungo Park relates that in some districts in Africa, the ground became so hot by the action of the sun, that even the negroes, though accustomed to that ardent climate, could not bear to touch it with their naked feet; and that he could not hold forth his hand against a current of air which entered the crevices of his hut, without feeling acute pain from its scorching effects.

Dr. Ure supposes that a portion of the ante-diluvian land is now covered by the ocean, and that the heating surface, or dry land on the earth, was twice as extensive before the deluge as it is now, and, consequently, as a whole, that its heating effects were doubled.

We cannot follow Dr. Ure through the detail of facts and arguments which he has brought forward on this subject; but after many additional statements to those we have given, he concludes, "that the facts and observations just detailed, seem adequate to prove that the events of the deluge involved such a change in the terraqueous constitution, as rendered the surface of the globe much colder and moister than it had previously been."—*Geology*, p. 491.

The great and sudden fall of temperature, which the earth suffered at a former time, and which is supposed to have taken place about the period of the deluge, is indicated by the situation and number of fossil bones, belonging to species known to inhabit hot climates, found in northern latitudes.

"The almost incredible number of bones of fossil elephants," says Dr. Ure, "found in northern Siberia, which betray no marks of having been rolled or transported from a distance, attest the existence on its plains of huge herbiverous animals at that distant epoch. These demonstrate that a vigorous vegetation clothed countries now covered with frost a great part of the year, where, even in summer, sterilizing cold and humidity perpetually reign, and where, at present, the reindeer can hardly pick up from beneath the snow its scanty mouthful of moss."

Not only the bones of elephants, but those of the rhinoceros, the mastodon, and hippopotamus, are found in Siberia. All these animals living on vegetables, and, from their sizes, requiring large quantities for their sustenance, it would seem impossible, as we have before stated, that in the present state of the climate, there should have grown a sufficient quantity of nourishment for the support of these animals.

That these animals died where they had lived, and where their remains are now found, is proved by the circumstances that their skeletons are entire, and that their bones show no scratches, or other marks of transportation or friction. That these bones have not lain for a long period in a hot climate, is proved by their state of preservation; many of the elephants' tusks being perfectly sound, and making the best of ivory, for which purpose vast numbers have been dug up and sold. The change of climate must therefore have taken place at the deaths of these animals, or soon after.

That these animals died suddenly, and remained in a cold climate after death, at least some of them, is proved by the circumstance, that the body of an elephant was found on the bank of the river Lena, in 1803. It was frozen in the ice, a large proportion of the flesh being still preserved, and serving as food for the white bears and dogs. Now, since there is no reason to believe that this animal could have lived in a cold climate, and as there is every reason to suppose that he died where his remains were found, perhaps the nature of such a case could not admit of stronger evidence, that there happened a great and sudden change from heat to cold in that country, and that this took place at the time when this animal perished, or soon after.

If it is certain, that this animal could not have lived in a cold climate, and equally so that his body could not have been preserved more than a few days in a hot one, the conclusion is inevitable, that the climate must have changed at the time of his death, or immediately afterwards.

The opinion of Baron Cuvier, entirely coincides with what here seems to be proved. "Every hypothesis," says he, "of a gradual cooling of the earth, or a slow variation, in either the inclination or position of the axis of the globe is inadmissible."

There are many reasons for believing that the animals whose remains are thus found, were destroyed at the time of the general deluge, and also that their bodies were not transported to any considerable distance by that catastrophe. There bones are found on plains and the sides of valleys, where we should suppose their bodies would have been left by the retiring waters, and in many instances they have been found covered by sand or gravel, such as are considered diluvial deposites, and under such circumstances, as to make it improbable that any ordinary flood would have produced similar effects.

On reviewing the facts and circumstances above stated, it is thought that we may fairly come to the following conclusions:

First, That the climate of Siberia was once similar to that of the tropics of the present day.

Second, That at the epoch of the deluge, the climate of Siberia suffered a sudden and material change in its temperature, and that it then became similar to what it is now.

Third, That the deluge was the most probable cause of the destruction of several ancient races of quadrupeds, which inhabited that country, anterior to the flood, and among which, were the elephant and rhinoceros, the bones of which still exist there. And,

Fourth, That the most probable cause of the sudden change of climate in Siberia, and of the decrease of the superficial temperature of the earth generally, was the cold produced by the evaporation of the waters of the deluge.

Farther remarks on Change of Climate. Since the former edition of this work, considerable light has been thrown on the subject of organic remains as connected with "change of climate," by various writers; and from which it appears that some species of animals belonging to genera, usually considered tropical, have been found capable of sustaining much higher latitudes than was before supposed.

It will be remembered, that in nearly every instance, the fossil bones of animals belonging to genera now living, were of species unknown to naturalists of the present day. It may therefore be inferred, that if it can be shown that there are elephants and tigers now living in cold latitudes, the fossil bones of these animals, found in Siberia and other northern regions, might have belonged to such species, and thus that the situation of these bones may be accounted for, without so great a change of climate as has heretofore been supposed.

It has recently been proved, beyond all doubt, that a species of tiger identical with that of Bengal, is common in the vicinity of lake Aral, in Independent Tartary, in latitude 45° north, and also, that this animal is often seen in Siberia as high as latitude 52°. Humboldt, who states these facts, remarks, that the part of Asia now inhabited by this species of tiger, is separated from the Himmaleh by two great chains of mountains, each covered by perpetual snow. These mountains are the Kuenlun, in latitude 35°, and the Mouztagh, in latitude 42°. So that it is impossible that these animals should merely have made excursions from India, and penetrated during the summer to 48° and 53° of latitude, where they are found. In 1828, a tiger was killed on the bank of the Lena, in Asiatic Russia, in latitude about 52°, and in a climate colder than that of Petersburg, or Stockholm. We are not informed whether this tiger was covered with fur and long hair, or not, but it is stated, in the Ehrenberg Journal of Natural Sciences, as quoted by Mr. Lyell, that a new species of panther (*Felis irbis*) has been discovered with long hair, in Siberia, evidently inhabiting, like the tiger, a region north of the Celestial Mountains, which are in latitude 42°.

In 1772, Professor Pallas obtained from the banks of the Wiljui, a tributary of the Lena, the remains of a rhinoceros, (*R. tickorinus,*) taken from the sand, where it must have remained frozen for ages. This carcass resembled a mummy, but emitted a smell like that of decaying, or putrefying flesh. The skin was covered with thick hair, which was of great length about the feet.

The elephant found preserved in ice in latitude 70°, an account of which will be found among that of other fossil quadrupeds in this work, was also covered with a warm coat, consisting of fur and hair. This animal, indeed, seems to have been as well protected from the cold, as is the Musk Ox, of the present day.

Bishop Heber, in his "Narrative of a Journey through the Upper Provinces of India," informs us that in the range of the lower Himmaleh mountains, in latitude between 29° and 30°, he saw an Indian elephant of small size, *covered with shaggy hair.*

Mr. Everest says, (Journal of Asiatic Society,) that the wild elephant is found in the mountains north of Bengal, at the elevation of 4000 feet above the level of the sea, and in 31° north latitude. He also states that he had heard of a solitary instance of an elephant covered with shaggy hair at Delhi, but that he had never himself seen such a phenomenon. It would therefore seem that the individual seen by Bishop Heber must have been of an exceedingly rare species, or variety; since Mr. Everest being a resident in India, and a writer on the subject, would otherwise have obtained further information concerning it. Whatever the climate of Russia and Siberia might once have been, it is certain from the accounts of writers, that it was once inhabited by such vast herds of elephants, as to leave no parallel of the existence of such numbers anywhere at the present day. Tilesius states, that in northern Russia fossil tusks are so numerous, as in all probability to excel in that country alone, all the living elephants now on the earth. These tusks are many of them entirely sound, and are at the present day, collected and sold by thousands for ivory.

Now admitting that these animals were covered with hair, so as to protect them from the consequences of an arctic climate, still, as formerly stated, we are met with the difficulty of accounting for the subsistence of such herds of enormous animals. On this point, Dr. Fleming remarks, "that the kind of food which the existing species of elephant prefers, will not enable us to determine, or even to offer a probable conjecture concerning that of the extinct species. No one acquainted with the gramineous character of the food of our fallow-deer, stag, or roe, would have assigned a lichen to the reindeer."

But as all agree that the whole genera of elephants lived on vegetable food, the difficulty scarcely subsides by supposing the ancient species to have eaten a different kind from those still existing, since all the vegetation of whatever kind now growing in Siberia, would not probably, have supported one in a hundred of the animals whose bones are found there.

With respect to the remains of animals found in very high northern latitudes, as that of the elephant on the Lena in latitude of 70°, it is most probable that at least some, and perhaps all of them were conveyed there by the currents of overflowing rivers.

It must be remembered that the rivers of Northern Russia and Siberia run towards the north, and that therefore the snow in the regions of their head waters and upper courses, being melted by the warmth of spring, while hundreds of miles from their mouths, remain locked in ice, these rivers are every season subject to mighty floods, not only because their channels are thus nearly obliterated, but because the narrow valleys are blocked up by the descending ice.

The Lena and Yenisei, both Siberian rivers, after running at least 2000 miles discharge themselves into the Frozen Ocean, and therefore might transport the frozen carcass of an animal this distance, without its being even softened by the warmth of spring.

On reviewing the facts and circumstances above stated, although it may not be considered necessary to suppose so great a change in the climate of Siberia, as was formerly believed, in order to account for the organic phenomena existing in that country, still there remain facts in abundance, which we think cannot be reconciled with any theory, but that of a great change of climate.

ORGANIC REMAINS.

Organic Remains, include, generally, all such organized substances as are found buried in the earth, as those of plants, fish, shells, and the bones of quadrupeds. The term *Fossil* is often used synonymously with organic, and although the former word strictly signifies any thing dug out of the earth, it is often applied to the petrified remains of plants, and other organized bodies found in strata.

"Of all the appearances which the earth presents," says Dr. Macculloch, "nothing has excited more attention than the existence of animal bodies in strata; while the air of mystery which attended them stimulated curiosity, and may be said to have laid the foundation of geological science. If the presence of animals once submarine, in rocks, and on lofty mountains, was a cause of wonder, and a source of theories, so did the discovery of the bones of large animals, lead to the belief of pre-existing races of giants, while in both cases, philosophy, with history, sacred and profane, were perverted to find explanations.

"The increase of knowledge has given a very different complexion to this subject, and a more rational direction to the pursuit. Yet the geologist seems in danger of forgetting that it is but one part of his science. Its details belong to zoology and botany; and he loses sight of his main object, when he pursues these minutiæ to the neglect of their more interesting connexions with the history of the globe. Still more deeply does he err, when he supposes that a theory of the earth can be founded on what involves so small a portion of its structure and history. It is, doubtless, essential to know these objects; as to arrange and name them, is the grammar of this department. But it is unfortunately true, that, whether the contemplation of minutiæ disables the mind for wider views, or that only a minute mind can be engrossed by such things, the power of profiting by collections and their study, diminishes in proportion to their extent and the activity of collectors, whether it be in natural history or in books."—Vol. i. 406.

DIVISION OF FOSSILS.

Fossils may be divided into *marine* and *terrestrial;* the first including all such as belong to the sea, and the second, such as inhabit the earth. The terrestrial may be again divided into *aquatic* and *terrene*, since not the earth only, but its waters are inhabited by various tribes, familiarly known under the titles of *fresh* water fish, shells, &c. As organic bodies, fossil remains are also divided in *animals* and *vegetables.* The former including all such as had animal life, as quadrupeds, fish, and shells; the latter, plants of every kind found in the fossil state.

Indications of Violent Changes. That the earth on which we live has suffered violent and extensive changes, is almost everywhere indicated by its external appearance; and when we come to examine the interior of its crust, this idea is confirmed in the most positive manner, by the obvious fact that its rocks have been fractured, and its strata dislocated. At what period or periods these mighty changes took place, we have no means of knowing; but that its surface has been materially altered since the formation of the more recent rocks, and subsequently to the creation of organized beings, is clearly proved by their remains now preserved in its strata.

In some instances, very extraordinary collections of bones, remains of fish, vegetables, and other organic bodies, have been found in situations, and under circumstances, which, though indicative of violent revolutions, place all suppositions with respect to their origin at defiance.

Thus, in the valley of the Thames, in England, at a certain locality, in Essex, there is an alluvial deposite, resting on chalk. "This," says Mr. Brande, "contains such a remarkable assemblage of organic remains, some of vegetable, and others of animal origin, as almost to baffle all conjecture as to whence they came, and under what circumstances they were brought together. The remains of sea animals are blended with those of the land, quadrupeds with fish, and fresh water fish with those peculiar to the ocean. Animals of the land, the air, and the water, are assembled together in most unaccountable incongruity; fruits and leaves, hazel nuts and pine cones, are mixed with shark's teeth, crab's claws, and oyster shells."

In the island of Sheppy, there exists a similar assem blage of various species of shells, mixed with fossil fruits. Of the latter, 500 varieties have been found. At Brent ford, phenomena of the same kind, and not less extraordinary, have been discovered. Here exists a collection of sea shells, shark's teeth, bones of the elephant, hippopotamus, ox, and deer, together with fresh water shells; "the whole," says Mr. Brande, "calculated to impress us with the idea of the destruction of a vast *menagerie*, in which animals of all denominations, and from all quarters of the world, had been associated."

FOSSIL QUADRUPEDS.

In their descriptions of fossil remains, authors have more generally commenced with those belonging to the lowest strata, or those which, in the order of time, as shown by the strata, were first called into existence, such as extinct species of plants, shells, &c. But as these are not easily understood, and as there is no advantage to the learner in such an arrangement, we have thought proper to commence with the more perfect animals.

The number of quadrupeds, the classes and orders of which have been determined by Cuvier, solely by an examination of their bones, amount to 150. Of these, ninety species were before entirely unknown to naturalists, and are, therefore, supposed not to inhabit the earth at the present time, their entire races having perished at the period when their bones, found in the most recent strata, were there buried. Ten or twelve of the others so nearly resemble known species, that no doubt remains of their identity. Many of those which remain, present kindred features with known species, but the comparisons have not been made with sufficient care to remove all doubt, and, therefore, it is still uncertain whether their species exist or not.

Of the ninety unknown species, about thirty belong to genera still living, and the remaining sixty to genera entirely new.

With respect to the classes and orders to which these animals belonged, about one-fourth of the 150 species were oviparous (egg laying) quadrupeds, as the alligator, lizard, and tortoise. The remaining were mammiferous, or milk-giving animals, as the elephant and mastodon. Of the latter, more than one-half were non-ruminant, hoofed quadrupeds, as the horse and tapir.

From these facts thus developed, concerning the animals of the primitive, or ante-diluvian world, it might perhaps be supposed that some theory could be formed with respect to the proportions of the different genera, which then inhabited the earth, and by a comparison of these with the genera now existing, we should be enabled to see the difference. But it would be premature to form any hypothesis on this subject at present, since we know not but there are hundreds of extinct species still undiscovered.

Cuvier has proved, as we shall see directly, that the extinct species of quadrupeds are not *varieties* of those now in existence, but that there exist distinct specific differences between them. "A *species*," says he, "comprises all the individuals which descend from one another, or from common parents, and those which resemble each other, as much as they resemble themselves." Hence the *varieties* of a species are the result merely of such changes as take place in the color, size, and fineness of the fur of animals, and which may be caused by a difference of climate, of food, or the domestication of the species; these varieties may therefore produce the exact likenesses of their parents. For example, the dog is a genus; the pointer is one species, and the grayhound is another. Now, every one who is conversant with dogs, knows that pointers may differ from each other in color, size, and shape, and even from the same parents it is seldom that two precisely similar can be found. These are varieties of the pointer, but the species are not changed, for their instincts, habits, and general appearance are the same with those of their parents. The same variations may be observed in the grayhound, and, indeed, all other species of dogs. But if the races are kept distinct, there are no circumstances of climate, or keeping, that will change the grayhound into the pointer, or the pointer into the grayhound. The species are therefore entirely distinct and unchangeable.

"The fox and the wolf," says Cuvier, "inhabit every country from the icy to the torrid zone; they experience in this immense interval every change of climate and condition, and yet the species have suffered no other change, than a slight variation in the beauty of their fur. The same accurate observer compared the sculls of foxes from the north of Europe and from Egypt, with those of

France, but found no appreciable differences. Hence we learn that the species of animals are not changed by time and circumstances, as some have thought to be the case."

Means of distinguishing Fossil Bones. Before proceeding to individual fossil species, it is necessary to describe the method by which naturalists have been enabled, by examining their petrified bones, to distinguish these unknown animals from each other, and from those now living. This art, or science, originated with the acute and laborious Baron Cuvier, and by him was brought to a degree of perfection, to which little has been added by others.

The principle on which this discrimination is founded, is the peculiar, and perfect organization of each species, so that one part is invariably, and exactly adapted to another, and is indicated by it. Each animal constitutes a whole, one systematic cycle, whose parts are in mutual correspondence, and concur to the same definite action, by a reciprocal re-action. None of these parts can change without a symmetrical change in the others; and hence each taken by itself, indicates and gives form to all the rest.

Thus if the organs of an animal are so constituted as to digest only raw flesh, its jaws must be constructed for devouring its prey; its claws for seizing and tearing it; its teeth for cutting and dividing it; the entire system of its organs of motion for pursuing and overtaking it; its organs of sense for descrying it at a distance; and even its brain must be qualified for exercising the instinct of self-concealment, and the art to ensnare its victim. Such is the general condition of the carnivorous temperament; every animal endowed with which, must combine them all, for otherwise its race could not subsist.

For the jaw to seize its prey there must be a certain kind of articulation, which gives prominence to the cheeks, and fits the bones to receive the insertion of strong muscles, for without these any such articulation would be useless. To enable the animal to carry off its prey, there must be a certain degree of strength in the muscles of the neck, and hence results a determinate form in the vertebræ, and the hind part of the head, to which these muscles are attached.

Whoever will compare the bones of a cat with those of a rabbit, will see how these parts differ, and if he will study the subject, he will soon convince himself, why the bones of the rabbit, independently of the teeth, could not have been fitted for the purpose of a rapacious animal.

That the claws may seize the prey, there must be a certain mobility in the talons, and a certain degree of strength in the toe joints, and thence there must result a corresponding distribution of muscles, and tendons, so that lightness and power may be combined. The shoulder bones in such animals must have great firmness, otherwise the legs will not be fitted for the uses of the claws, and this firmness of bone is thus prepared to receive the insertion of strong muscles, by which the required power is given.

It is unnecessary to show how the other parts of a prowling animal are adapted to each other, so that the whole machinery of bones, muscles, joints and tendons, all combine to the accomplishment of the same end. The parts of any animal, are indeed a "collection of wonders," and he who does not behold in them the traces of Infinite Wisdom and design, must either want understanding or sight.

"In a word," says Cuvier, "the formation of the tooth indicates the structure of the jaw, and its kind of articulation; the structure of the shoulder bone, shows the form of the feet, just as the equation of a curve, involves all its properties; and as by assuming each property separately as the base of a particular equation, we should re-produce both the ordinary equation, and all its properties; so the nails and shoulder blade indicate the articulation of the jaw; the thigh bone, and the other bones, taken separately, give the form of the tooth, or are given by it in their turn.

Since the mechanism of every animal involves certain fixed and invariable principles and proportions which belong to the whole race, by ascertaining what these are, we can readily distinguish one tribe or species from another, though the differences may be ever so slight. To the most common observer, the entire skeleton of a horse would be distinguished from that of an ox, by the size and proportions of the whole; and by comparing the thigh bones of the two animals he would readily distinguish these, and thus take one step in comparative anatomy, for now he would be able to distinguish a horse from an ox, merely by inspecting a single bone.

It is plain, from this example, that by the constant examination of the bones of different classes, genera, and species of animals, the observer might attain to great perfection in this art, so that even without comparison, he would be able to decide in an instant, whether a given bone belonged to any living genera of animals or not, and by a closer care and comparison, to point out those differences which distinguish the osteology of one species from that of another.

Are the species supposed to be extinct, varieties of living species? This question has already been noticed, but we would be more particular on a point of so much importance in geology. Of the 150 fossil species, about ninety are said to be extinct: that is, they are not known to exist in the living state, at the present time. Among these is the mastodon, or mammoth, the bones of which have been found in many places in this country. This is an example of an extinct species. It is not found alive in any part of the world, nor does it belong to any species of animals known to exist. If such an animal was still living, even among the most barbarous tribes, there can be little doubt, but some information concerning it, would have been given, at least to one among those individuals, who, within the last few years, have explored most of the before unknown regions, in nearly every part of the world. That the whole race of mastodons are extinct, therefore, there can be no doubt. Nor can there be any question that this animal was a distinct species from the elephant, which it most resembled. This is proved by the size and form of its bones, and especially by its tusks and grinders, many of which have been compared with those of the elephant now living, and the specific differences pointed out.

It has been supposed by some naturalists, that more or less of the unknown fossil species might still exist in parts of the globe which have not yet been explored; but although it may be possible that some of the smaller of these animals may still be living, there is little probability that any of the larger quadrupeds, or perhaps amphibious animals will anywhere be found.

"If," says Baron Cuvier, "we examine what species of quadrupeds have recently been found, and in what circumstances they have been discovered, we shall see that there is but little hope of ever finding those that we have only seen as fossils. Islands, of moderate extent, situated at a distance from extensive continents, have very few quadrupeds, and these always of small size. When they have large ones, it is because they have been brought from elsewhere. Bouganville, and Cook, found only dogs and hogs on the South Sea Islands, and the largest species of the West Indies, was the agouti, (a species of the hare.) In fact, only large territories, such as Asia, Africa, the two Americas, and New Holland, have large quadrupeds, and generally, species peculiar to themselves."

If there remained any extensive countries to discover, we might hope to find new species, among which some might be found, more or less resembling those of which the bowels of the earth have preserved us relics, but it is sufficient to cast a glance over the map of the world, and see the numerous directions in which navigators have ploughed the ocean, to judge that there cannot be any undiscovered large tract of country still remaining.

The ancients were acquainted with nearly all the animals now known, except such as have been discovered in America and New Holland. The Greeks were acquainted with the elephant, and the double and single horned rhinoceros, and both these animals were common at Rome. Heliogabalus exhibited the hippopotamus, and the giraffe or cameleopard: and the two species of camel were known to the Romans in the time of Julius Cæsar. The buffalo, the wild ox, the ox without horns, and the little ox, no larger than a goat, the sheep with the great tail, and the great sheep of India, were all known to the ancients, for they have left descriptions of them.

The Romans exhibited lions, panthers, and tigers, by the hundred; they also showed hyenas, and even the crocodile of the Nile. Even the zebra also, which is found only in southern Africa, graced their shows, and they were well acquainted with the most remarkable species of the ape tribe.

These facts show, that the ancients were acquainted with all the animals of any size or consequence, in the old world, and that naturalists, in later times, although they have reduced zoology to a science, and have described many smaller animals, which were probably unknown to the Greeks and Romans, have still failed to discover any quadrupeds of considerable size, with the exception of those of America and New Holland.

It is quite improbable, therefore, that any of the larger quadrupeds or amphibious animals, now considered extinct, are still anywhere in existence; and since it has been shown that they are chiefly distinct species, and not varieties of those now known, there is no doubt but these entire races have been destroyed by some violent catastrophe.

When, and by what means did these races perish? At what period of the world these extinct species perished, and whose bones are found in many parts of the earth, and by what means a destruction so universal was occasioned, are important questions in geology.

From the comparative ages in the formations in which their bones are found, it would appear that a great proportion of the large quadrupeds were destroyed at the same time, their remains being found contiguous to each other, and in strata, or diluvial deposites apparently of the same age. The most probable cause of this general destruction was that universal deluge, the marks of which we have seen still remain in all parts of the earth. It is true, that no certain proof of this can be adduced, but such a hypothesis will account for most of the phenomena observed with respect to these remains, and which are unaccountable by any other supposition. See *Deluge*.

It is proper, however, to state here, that there exists one example of the extinction of a species in modern times, and this in a gradual manner, or without the intervention of any general catastrophe. This is the Dodo, a large bird, figured and described by many former naturalists. It appears that during the early voyages of European navigators to the East Indies, the Dodo existed in various places, and especially on the island of Mauritius. Linnæus described it under the genus *Didus*. Brooks (Nat. Hist. London, 1783) describes it as a large bird, with short legs, great black eyes, large head, covered with a membrane resembling a hood, or cowl, bill bluish white, of great length, sharp and hooked at the end, body covered with feathers much like those of the ostrich; legs yellow, with four strong toes. It is a simple bird, swallows stones, and is easily taken. Its flesh is good and wholesome, and three or four are enough to dine one hundred sailors. Vol. ii. p. 66.

Cuvier (Animal Kingdom) says that the species *Didus ineptus*, a description of which was first drawn up by the Dutch navigators, has completely disappeared, nothing remaining of it at the present day, but a foot in the British Museum, and a head at the Asmolean Museum at Oxford. This, it is believed, is the only instance in which any species known to naturalists has disappeared.

PARTICULAR FOSSILS.

It is incompatible with the design of this work, to give a classification of those animals whose remains have been discovered and described by different authors. A mere enumeration of their species and varieties, including the shells, would indeed fill a volume much larger than this. We shall, therefore, select such as are most interesting and instructive only, without reference to scientific arrangement.

QUADRUPEDS.

Order *Pachydermata*, or thick skinned. This is the first order of fossil quadrupeds, examined by Cuvier. It contains thirteen genera of non-ruminant, hoofed animals, viz., Elephant, Mastodon, Rhinoceros, Hippopotamus, Tapir, Hog, Horse, Daman, Pecaris, Phacocheres, Anoplotherium, Palæotherium, and Elasmotherium.

Genus Elephant. Of this genus there are three distinct species, two of which, the Indian and the African, still exist, the third having been found only in the fossil state.

1. The Indian elephant is found on both sides of the Ganges, and in Borneo, Java, Sumatra, and other Indian islands. This species has an oblong scull, concave front, small ears, with grinding teeth, marked by ribands, or plate lines, which are waved.

2. The African species are found at the Cape of Good

Hope, Senegal, and Guinea. It has a rounded scull, large ears, and grinders, with lozenge-shaped lines on their crowns.

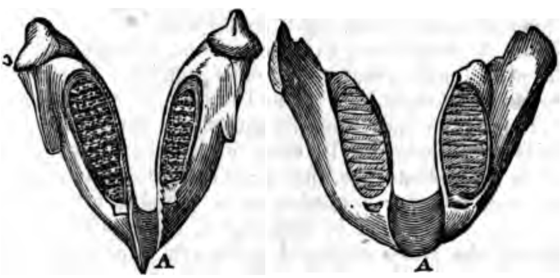
3. Fossil or primeval elephant (*Elephas primigenius.*) This is the mammoth of the Russians. It has an oblong scull, concave front, very long bony sockets for its tusks; lower jaw bone obtuse, grinders parallel, and marked with nearly parallel, and little waved ribands on the crown.

The bones of the last species are found in the fossil state only, the species being extinct.

The fossil elephant more nearly resembled the Indian than the African species, but differed from both in the form of its grinders, the great size of its tusks, and especially in the projection of its tusk sockets, (see fig. 50.) The peculiarity last mentioned, must have very much modified the figure and organization of the proboscis, and given to this elephant a physiognomy, differing much more from the other species than might be inferred from the resemblance of the other bones. Its size was about that of the Indian elephant, viz. from ten to thirteen, or even sixteen feet in height.

In all animals of the same species, and ages, the teeth are precisely alike, in form and number, and therefore whenever we find merely a similarity, and not an identity in this respect, we may know that the species are different, though the genera may be the same. The form of the iaw also differs with those of the teeth.

Fig. 49.



The annexed cuts show the difference between the grinders of the living, and the fossil elephant. That on the left hand, fig. 49, represents the under jaw of the living Indian species; that on the right, the corresponding part of the fossil elephant. The sides of that of the living species, converge nearly together at the lower part, and it has a projecting point at A, furrowed with a long, narrow canal. The teeth also converge, and the inequalities, or ribands on the crowns, are waving lines, running obliquely crosswise. The teeth in the fossil jaw stand parallel to each other, and the canal in front is much shorter and wider, and without the projecting point. The ribands also in these are not oblique, as in the living, but run transversely across the crowns.

In the two living species, the tusk sockets (*alveoli*,) do not extend further down than the end of the lower jaw, so that the chin has room to protrude between the tusks in a pointed projection. But in the fossil heads, on account of the great length of the tusk sockets, the lower jaw has the appearance of having been truncated, or blunted at its lower end, so as to admit of its being closed on the upper one by means of which the lips come together in the act of mastication, contrary from what takes place in the living species.

These, with other differences, in the osteology of the fossil and living elephants, which need not here be detailed, make it certain that the fossil species belonged to a race of animals not now in existence.

They resembled the mastodons, in many respects, but were more nearly allied to the elephants, especially in the form of the grinders.

The grinders of the fossil elephant are often ten or twelve inches long, and have twenty-four ribands, or raised plates of enamel, crossing their crowns.

Fossil elephant bones have been found in a great number of places, and in many different countries. In nearly every part of Siberia, as high as latitude 65°, wherever a river happens to undermine its banks, the bones of these animals are dislodged. In some places, they have been found in such abundance, that large quantities have been transported to other countries, as a valuable article of commerce. Indeed, it is said, that a considerable proportion of the ivory employed in the arts, is of the fossil kind.

Lieut. Kotzebue, in his late voyage of discovery, found the bones and teeth of elephants, preserved in an iceberg, near Bhering straits.

In the valley of the Arno, near Florence, so great was the accumulation of these fossil bones, that it is said the inhabitants formerly used them for making fences between their fields. These bones are also found in many parts of France, in Germany, in almost every part of Italy, the Netherlands, Holland, Russia, Bohemia, in many parts of England, and in the northern regions of North America. A remarkable locality of them was discovered at Thiede, near Wolfenbuttel, where eleven tusks and thirty grinders were disinterred within a short distance of each other. One of the tusks was fourteen feet eight inches long, and bent into a perfect semi-circle. In nearly every gravel pit, around London, the bones of this species are found. They have also been discovered in Brentford, Kew, Wallingford, Dorchester, Abingdon, Oxford, and many other places in England.

This species must therefore have been exceedingly numerous, and widely spread over different parts of the globe.

Elephant preserved in ice. In several instances, the bones of the fossil elephant have been found imbedded in ice; that of Lieut. Kotzebue has just been mentioned. In one instance, the entire body of one of these animals preserved in this manner, has been discovered. It occurred near the mouth of the river Lena, in Siberia. The flesh had undergone no decomposition, the whole animal having been entirely surrounded by the frozen mass. This discovery was originally made by a Tungusian fisherman, in 1798, who saw a large mass projecting from the ice, but so far above his reach that he was unable to ascertain its nature. The next year, going to the same place, the mass was found partly disengaged from its bed, but still the man was uncertain what it might be, as it was more than a hundred feet above him, and inaccessible to his approach. The next year it was again seen, by the same man, but it was not until the summer of 1803, five years after the first discovery, that it fell down on a sand beach of the Arctic ocean so as to be examined.

The fisherman now obtained a prize, for having detached the two tusks, he removed and sold them for fifty roubles.

In 1806, Professor Adams, of St. Petersburg, went to examine this animal, which still remained on the sand beach where it had fallen, but the body was then considerably mutilated, the people in the neighborhood having taken away large quantities of the flesh to feed their dogs; and the white bears had not failed to regale themselves on this antedeluvian delicacy. The skeleton, however, remained quite entire, except that one of the fore-legs, and the tusks were gone. The head remained covered, by the dried skin, and the pupils of the eyes were still distinguishable. The brain, on opening the scull, was found not quite filling its cavity, being somewhat dried. One of the ears was in excellent preservation, still retaining its form, and a tuft of strong bristly hair. This animal was a male, and had a mane of considerable length, still on his neck.

The skin, when detached, was so thick and heavy, that it was with difficulty ten men could remove it. More than thirty pounds of the hair and bristles of this animal were gathered from the beach, where it had been left, and trampled upon by the white bears, when tearing and devouring the carcass. This hair was of three kinds, viz. stiff black bristles, a foot long; coarse hair, of a reddish-brown color, and a woolly covering next the skin of the same color.

The skeleton of this animal was transported to St. Petersburg, and the tusks having been procured, the whole was set up in the museum of that city, where it still remains.

Fig. 50.

The annexed wood cut, fig. 50, represents the head and tusks of this animal, as drawn by Mr. Stokes, who also gave a description of the whole, in the Ed. Quart. Journal, First Series, p. 95.

It will be observed that these tusks are of enormous length, and that they form nearly a circle, differing greatly, both in shape and size, from those of the elephant of the present day. The projection of the tusk sockets, marked *a*, may also be observed in this cut, and which, as already noticed, are peculiar to this species.

The skeleton is about nine and a half feet high, and sixteen and a half feet long; and when it is considered how much the cartilages, flesh and skin, added to his height and dimensions, it is obvious that this must have been an animal of enormous magnitude.

The hair with which this animal was covered, would seem to indicate that it was fitted for a cold climate; and in addition to this instance, Professor Pallas mentions the discovery of an entire rhinoceros, with its skin and hair, well preserved, and which occurred on the banks of a river, not far from the Lena, where the elephant was found. The rhinoceros is described as being covered with thick hair, which was particularly long about the feet.

From these facts, it has been urged by some naturalists, that the bones of the great quadrupeds found in cold climates, and of genera which now only inhabit hot ones, were of species so different from these tribes, that they were fitted for the cold situations where their remains are found; and hence that it is unnecessary to suppose that they were either transported from warmer climates, or that the climates where their bones are now found, have suffered any change. But, as already observed, there remains a difficulty fully as great, as is presented by the theories of transportation, or change of climate; for if Siberia was never warmer than at present, it is impossible to believe that it should have ever produced a quantity of vegetation, sufficient to have supported such herds of enormous animals, even during the summer, and much less during the long winters of that climate. See "*Change of Climate.*"

Genus *Mastodon.* This term comes from two words, which signify a "little hill" and a "tooth," in allusion to the prominences, or tubercles, which the crowns of these grinders present. This form of the crown is similar to that of carnivorous animals; and hence, when little was known of fossil bones, it was supposed that the mastodon had been a flesh eater, an error fully refuted by Cuvier.

Fig. 51.

The form of a mastodon's grinder is represented by fig. 51; the hilly points being a little worn by use. It is here represented one fourth of the natural size, and is from a specimen in the King's cabinet, at Paris. The difference between this and the elephant's grinder, will immediately be seen. The number of such teeth in the jaws of the adult mastodon, was four in each.

The whole of the genus mastodon are extinct; but from their bones, Cuvier has determined six distinct species. These bones have been found in various parts of the world, the species being so different, as in some instances, not even to inhabit the same countries.

The species of this animal are as follows: 1. The Great Mastodon. 2. The Mastodon with narrow teeth. 3. The Mastodon of the Cordilleras. 4. The Mastodon of Humboldt. 5. The Small Mastodon. 6. The Tapiroid Mastodon. To these, Mr. Clift has added two others, making in all, eight species.

The remains of the great mastodon have heretofore been found only in North America. That with narrow teeth, formerly inhabited South America; and at Lima, many of their grinders are preserved in the public cabinet, and shown for the teeth of giants. The bones of the other species occur in various parts of Europe, especially in Italy and Germany.

Dr. Ure states that the first account of the Mastodon, is in a letter from Dr. Mather, in America, to Dr. Woodward, in London, dated 1712, and intimating that bones and teeth of monstrous magnitude had been discovered in

1705, in Albany, in New England; at present in the state of New York on the Hudson river. He imagined them to be the bones of giants. No interest was excited, however, until Mr. Croghan, an English geographer, in 1767, sent several chests of osseous remains to Lord Shelburne, and other persons in London. Dr. William Hunter examined these bones, and published an accurate description of the lower jaw, in the Phil. Transactions for 1768. He demonstrated that the animal in question, while it differed from the elephant, had nothing in common with the hippopotamus. He justly concluded that the tusks and bones belonged to the same animal.

In 1802, Mr. Peale of Philadelphia, having procured numerous bones of the same animal from the neighborhood of Newburgh, on the Hudson river, formed two skeletons out of them, copying in wood those parts which happened to be wanting. One of these still remains in Mr. Peale's Museum, and is popularly known as the skeleton of a *Mammoth.*

At the salt-springs in Ohio, called *licks*, and especially at the Big-Bone lick, vast quantities of these bones have been found. Mr. Croghan, more than seventy years ago, thought he saw there the remains of thirty individuals; but a much greater number from that vicinity have since been found. These bones also occur in Ohio and Kentucky, and it is probable that they exist in all the temperate parts of North America.

In size, the great mastodon was about that of the elephant, though it does not appear, in general, to have been more than twelve feet in height, the Indian elephant sometimes being fifteen. Its tusks, trunk, and feet, and the bones of the whole skeleton were very similar to those of the elephant; the difference being chiefly in the dental system, which, with respect to the grinders, has been above described and illustrated.

The number of grinders in the adult mastodon, as already stated, is four in each jaw. Of these, the two front ones, in the upper jaw, have six points, and the other two in the same jaw have eight. In the lower jaw, the two anterior ones have also six points, and the two posterior ones, ten. But, it appears that the great mastodon had, *successively*, at least four grinders on each side of its two jaws; but as in the elephant, these teeth never appeared all at the same time. Their *succession* took place, in both animals, from behind, forwards. When the posterior one began to cut the gum, the anterior one was greatly worn, and ready to drop out. In this way, they replaced one another. There does not seem to have been ever more than two on each side, at the same time, in full exercise, and in old age, only one. Thus, the effective number of grinders, in youth, was eight, and, in extreme old age, only four. The largest grinders of the mastodon weigh ten or twelve pounds.

Genus *Hippopotamus.* There is only one species of this animal living; but Cuvier has determined two or three others, existing in the fossil state. They are all much smaller than the existing species, one of them being only about the size of a wild boar, while the living one, is about twelve feet long, and five or six feet high, and exceedingly thick set.

There is a peculiarity in the grinders of this animal, which will immediately distinguish them from those of other animals.

Fig. 52.

The lineaments of the crown are three lobed, or trefoil-like, as represented by fig. 52, which shows the form of the second grinder of the left side. This singularity will make the teeth of this genus easily recognised. The roots are concealed by a part of the jaw, the tooth being seven-ninths of the natural size.

The remains of this genus are not nearly so common as those of the elephant, though, in Tuscany, considerable numbers have been found. They have also been discovered in several parts of England, especially in the

Kirkdale cave. Possibly, the paucity of these bones may be accounted for by the circumstance of the amphibious habits of this genus, and their inability to wander to any considerable distances from the water, so that their remains might have been more exposed than those of the elephant, to have been swept into the sea.

Genus *Rhinoceros.* There are three existing species of this animal. 1. That of *India,* with a single horn on the nose, and a rugous, plaited coat; the cutting teeth being separated by a space from the grinders. 2. That of the *Cape of Good Hope,* with two horns, the skin smooth, and without folds, and no cutting teeth. 3. That of *Sumatra,* with two horns, the skin but slightly rugous, thus resembling that of the Cape, but having cutting teeth like that of India.

On comparing the teeth of the living species with those found in the fossil state, Cuvier determined that they were so different as to constitute another species of this animal, and whose remains are now found only in the strata of the earth.

The remains of the extinct rhinoceros were first discovered in digging a well, near Canterbury, in England, seventeen feet below the surface. This was in 1668. Afterwards Professor Pallas found, among a collection of bones at St. Petersburg, four sculls and five horns, belonging to this animal. Since that time, the bones of this animal have been discovered in various parts of England, Germany, and Russia.

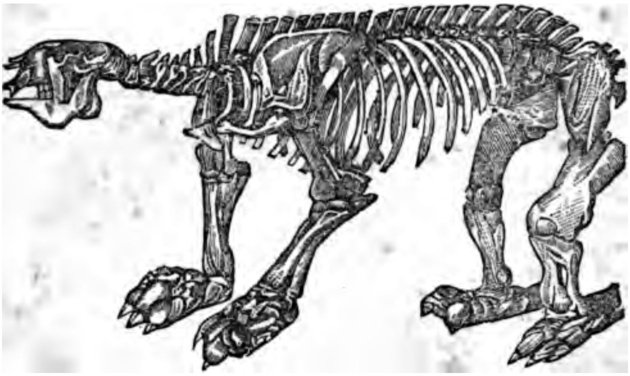
Megatherium. This name merely signifies "a huge wild beast." It is the most rare among all the great fossil animals.

The first skeleton of this singular beast, was sent from Buenos Ayres, in South America, to Madrid, in 1789, with a notice that it was found in the ground about three leagues from that city.

This animal was set up in the Royal Cabinet of Madrid, in the manner which has since been followed by Mr. Peale of Philadelphia, with respect to the American mastodon, and Mr. Adams of Petersburg, with respect to the Siberian elephant.

A minute description of the Megatherium, was published soon after it was mounted, illustrated by five copper-plate engravings. Afterwards a Livoninan anatomist, and a German draughtsman, conjointly, published an exact representation, and a good description of this skeleton.

Fig. 53.



The adjoining cut, fig. 53, from Dr. Ure's Geology, is said, by the author, to present an exact form of this skeleton. It is thirteen feet long, and nine feet high, its size being somewhat less than that of the mastodon.

With respect to the habits of this animal, "the teeth," says Dr. Ure, "prove that it lived on vegetables, and its robust fore-feet, armed with sharp claws, testify that it was chiefly their roots that it sought after. Its magnitude and its talons, supplied it with abundant means of defence. It was not swift in running, but this was unnecessary, as it had no occasion either to pursue or fly. It would therefore be difficult to find in its organization alone, the causes of the final destruction of this genus; and yet, if it still exists, where can it be? How can it have escaped all the researches of hunters and naturalists? Its analogies approximate it to different genera of the edentel, or toothless family of animals. It has the head and shoulder of a sloth—a creature possessing both tusks and grinders; while its limbs and its feet exhibit a singular mixture of characters belonging to the ant-eaters, and the armadillos. It has no analogy, whatever, to the felis, or tiger tribe." *Geology*, p. 549.

This animal had neither tusks nor proboscis, like the mastodon and elephant; this is proved by the great length of its neck, which, it is apparent, could not have supported such apparatus. As its fore parts are exceedingly strong, and its teeth not formed for tearing flesh, its claws were probably employed in digging for the roots of trees, as food, and if so, there is a probability that it burrowed in earth. What a phenomenon in the imagination! An animal, of the size of an elephant, running about under ground, like a mole,—leaving a path after him large enough for a horse and wagon to follow; and, perhaps, at the same time, throwing up a ridge on the surface that would stop the career of a stage coach. If he only burrowed, like a rabbit, what a mountain of earth he must have thrown out!

Megolonyx. This term signifies "*great clawed*," the animal being so named from the great size of its claws.

This is another of the lost animals of the former world. It belongs to the same genus with the last described, but Cuvier, on comparing their bones, found that it was of a different species. It is not so large, by one-third, as the megatherium, but of the same form, in all respects.

The bones of this animal were found in a cavern, in the county of Green Briar, Virginia, much decayed, and only in sufficient number to form a small part of a skeleton.

Besides these skeletons of great quadrupeds, there have been discovered a great variety of others in the fossil state, several of them of large size, as the Elk, Tapir, and some others, but most of them are of less interest than those we have described, and for the descriptions of which, we must refer the reader to more extended works on this subject.

FOSSIL AMPHIBIOUS ANIMALS.

Of the antediluvian amphibia, the crocodile and lizard tribes form the most interesting groups, especially the latter.

Crocodile. Fossil bones of this animal have been found in various countries, and in many localities. In England, Germany, France, and Italy, their occurrence in strata, are not uncommon. They appear all to belong to the sub-genus of Cuvier, which he called *garials*, or long muzzled.

A collection of these bones, made at Honfleur and Havre, in France, are preserved in the museum of Natural History, in Paris. But the most perfect specimen of this fossil is said to have been found near Monheim, in Germany. It is enclosed between two plates of schistose, marly limestone, of a yellowish gray color, mingled with fragments of quartz. It was accompanied with the cast of the tail of a small fish, and the remains of an insect.

The bones of the crocodile are browner than the stone itself. The slab containing this animal is three feet long, and fifteen inches broad, and the form of the head, trunk, and tail, from end to end, is plainly to be seen impressed in the rock, and very little deranged in respect to shape. The upper jaw is armed with twenty-five or twenty-six teeth on each side. The number of vertebræ, or pieces composing the back bone, are sixty-nine; and these are not deranged, except towards the tail.

The remains of the fossil crocodile are found in strata, lying far below those containing any species of quadrupeds, and hence are supposed to be of more ancient date. Some remains of this animal in the Jura mountains, are in limestone so solid as to be susceptible of a high polish.

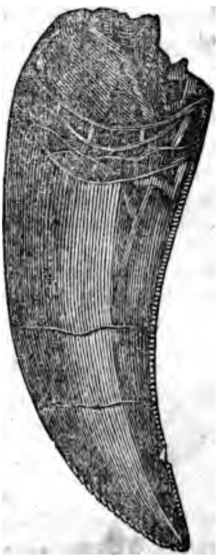
With respect to these bones, Cuvier remarks, that "the presence of an animal, such as the crocodile, apparently belonging to fresh water, in such beds, is a very remarkable circumstance. It is the more deserving of notice, as it is accompanied with the remains of tortoises, all equally inhabitants of fresh water. This fact, joined to several others, proves that there existed dry lands, irrigated by rivers, at an exceedingly remote period, and long before the successions of those tertiary mineral formations, which exist in the neighborhood of Paris.

Megalosaurus. This is one of the saurian, or lizard tribe; the term signifies "great lizard." It appears to be allied to the lizards and crocodiles, but differs from them both. This was an antediluvian monster. far exceeding in size any of the crocodiles of the present day. A fossil thigh bone of one of these animals, which Cuvier measured, was thirty-two inches long; and supposing that the animal was proportioned like others of the lizard tribe, he must have had a total length of forty-eight feet; and from the incisor form of its cutting teeth, this must have been an exceedingly fierce and voracious animal.

The bones of this specimen were found at Stonesfield, in England, among innumerable marine fossils, such as the teeth of sharks, the remains of crabs, sea shells, &c., and therefore there is little doubt but this was a monster of the ocean, though amphibious.

Mr. Mantell, of Lewes, in Sussex, has discovered megalosaurus' bones, of still greater dimensions, one of the thigh bones being twenty-two inches in circumference, whence he concludes that its length must have been fifty-four inches. This, according to the estimated proportions of the animal, gives him a total length of more than seventy-five feet, a size in the animal kingdom, rarely exceeded, even by the whales of the present day, and yet this monster, in all probability, was capable of crawling, or walking, both on the bottom of the sea, and on the dry land, like the crocodiles of our own times. Its height was probably fourteen or fifteen feet, being equal to that of the largest elephant.

Fig. 54.



What sort of engines the antediluvians possessed, which could have withstood or destroyed a fierce reptile, capable of devouring an elephant or a rhinoceros at a meal, we know not. At present, with the exception of our artillery, we possess no weapons capable of preventing the devastations of such a monster.

The teeth of this animal were lodged in distinct sockets. They were curved backwards, undoubtedly for the purpose of the better securing their prey. They were compressed or flattened laterally, with the edge toothed, or serrated, through the whole length of the posterior, or cutting side, and at the point of the anterior side or edge. Fig. 54 represents the tooth of a megalosaurus of the natural size. It is thin on the concave or cutting edge, but thicker on the convex side, so as to give it strength, its shape being similar to that of a pruning knife. An animal seventy-five feet in length, with a mouth containing perhaps more than sixty such teeth, with a disposition like that of the crocodile, must have presented a spectacle of which we postdiluvians can have but a faint conception.

The formation of Stonesfield, where these remains occur, consists of a sandy slate, about six feet thick, lying below several strata of limestone, of different kinds, and about forty feet from the surface.

Iguanodon. This animal approached in structure, more nearly to the Iguana, a large species of lizard, found in the West-Indies, than to any other species. Its length was between sixty and seventy feet.

Cuvier pronounced this reptile to have been the most singular and extraordinary of all the antediluvian wonders yet discovered. Its great peculiarity consists in the form of its teeth, which shows, that notwithstanding its saurian form, it was a herbivorous animal, in which it differed from all the lizard tribes.

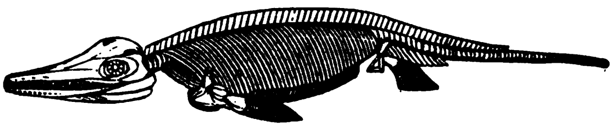
Ichthyosaurus and *Plesiosaurus.* These are two genera of singularly formed sea lizards. Ichthyosaurus is derived from two Greek words, and signifies *marine lizard.* Plesiosaurus means *lizard-like.*

These, among all the fossil animals that have been discovered, are most calculated to surprise the naturalist, by their least resemblance to any individuals now living, and by their singular combinations of structure.

In the Ichthyosaurus we see the muzzle of a dolphin, the teeth of a crocodile, the head and breast of a lizard, the paddles of a turtle, and the backbone of a fish.

In the Plesiosaurus we have the same turtle-like paddles, a lizard's head, and a long neck, like the body of a serpent.

Fig. 55.



Ichthyosaurus. This fossil skeleton is represented by fig. 55. No entire skeleton of this animal has yet been found; but fragments having been collected in the limestone formations in various parts of England, and the whole having been joined, and the absent parts supplied with carved wood, a skeleton, such as is here represented, is composed. It appears that England was the principal sepulchre of this animal, few of its remains having been discovered otherwhere.

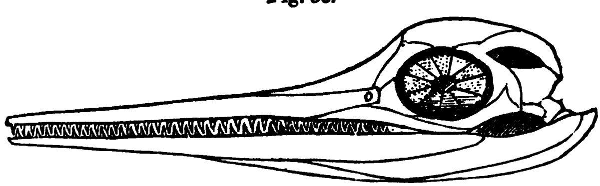
In length, this animal was about twenty feet, and therefore, does not in this respect, compare with several of the antediluvian reptiles. But its singular combinations of structure, together with the vast number of bones composing its skeleton, have rendered it one of the most curious and interesting objects to naturalists which has been presented.

The vertebræ amount to about ninety in number, and the number of pieces of bone contained in each paddle, is 100. These are flat, and placed in contact with each other, like Mosaic work, or a tesselated pavement. It was an amphibious animal, but lived chiefly in the water, as is indicated by the form of its paddles, which hardly could have permitted it even to crawl upon the shore. It is probable, therefore, that although it was an air-breathing animal, if it had the misfortune to be cast upon the shore, it must have remained motionless and died, as whales and dolphins do, under like circumstances.

The teeth of this animal were about half an inch in length, sharp pointed, but not curved like those of the megalosaurus; their number was thirty in each jaw.

But the most striking feature in the appearance of this strange animal, was the enormous size of his eyes, and which must have given him a most terrific physiognomy.

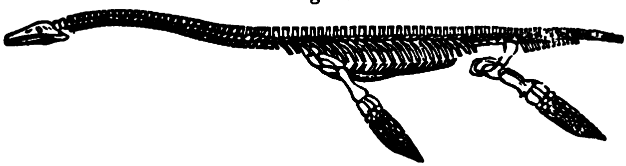
Fig. 56.



The sclerotic, or outer coat of the eye, was beset by a circle of bony pieces, as seen in the adjoining representation of the skeleton of the head, probably in order to give it strength and prominence. These pieces of bone from a character common to birds, tortoises, and lizards, to the exclusion of crocodiles and fishes; and hence, one of the marks by which it is proved that this animal belonged to the lizard tribe. The comparative size of the eye socket, when compared with the other parts of the head, will give us some idea of the frightful appearance of this animal; as will the long rows of curved teeth with which his jaws are studded, of his power to seize and hold his prey. From the dimensions of the head, we may suppose that these eyes were fully as broad as a tea saucer, being probably at least six inches in diameter.

Plesiosaurus. "This genus," says Dr. Ure, "is entirely English, and solely due to the sagacity of Mr. Conybeare." Some vertebræ, mixed with those of the crocodile and icthyosaurus, in the lias of the environs of Bristol, appeared to him to differ from those of both animals. From this circumstance, he was led to make further examinations, and these were continued until a sufficient number of bones had been obtained to show the form and size of this strange antediluvian.

Fig. 57.



The most singular part of its construction, is the immense length of the neck, and the disproportion of this, to the other parts of the system. This is composed of a greater number of bones than the neck of any known animal; exceeding, in this respect, even the swan, which has a greater number than any existing species.

The most entire specimen of the plesiosaurus yet found, is that which came from Lyme Regis. This relic is contained in several blocks of stone, which were once continuous, and which fit each other exactly. The bones have the posture which they would have taken, had the animal been crushed by a heavy weight from above. Its length is nine feet six inches. The number of vertebræ are ninety, of which forty belong to the neck.

The plesiosaurus, in the living state, must have presented a neck resembling a large serpent, with the tail cut off, and the remaining half fastened to a trunk, the proportions of which, differed from those of many other animals. The tail, especially, by its shortness, could scarcely remind one of a reptile, and hence this animal must have displayed a form so much the more singular, as its extremities, like those of the ichthyosaurus, were genuine fins, similar to those of the whale tribe.

That this animal was aquatic in its habits, is evident from its fins, and that its element was the sea, may be equally inferred, from the marine remains, with which its bones are everywhere associated. Its motion on the land, like that of the ichthyosaurus, must have been awkward and difficult, and its long neck would impede its progress through the water. It was an air-breathing animal, and Mr. Conybeare suggests whether it might not have swam along the surface, arching its neck, like the swan, and now and then darting down its head to catch the fish below.

BONE CAVERNS.

Professor Buckland, in consequence of the publication of his great work, "*Reliquiæ Diluvianæ*," has made the subject of osseous caverns highly interesting and instructive. Before the appearance of that work, little was known on this subject, nor was it, indeed, considered by geologists as of much importance. The bones of some animals found in caves, had occasionally attracted notice, but no one appears to have inquired how, or under what circumstances, they could have found their way into such places. Nor was it until after the celebrated cavern of Kirkdale was discovered and described, that the contents of other caverns became the subjects of geological investigation.

We have already given some account of the Kirkdale cave under the article "Change of Climate," for the purpose of showing that England was once the native country of the elephant, rhinoceros, and hyena.

Since the description of that cave, notices of others, containing bones, have become so numerous, that we have not room even for a catalogue of their names and places; and there is little doubt, but these will ultimately be the means of producing a body of geological evidence of much importance.

It appears that all extensive limestone formations, contain more or less such caverns as that of Kirkdale, some of which are of great extent, and have long been admired for the brilliancy of their stalactites, and the pillar-like forms which they assume. The island of Crete contains a great cavern, which has long been the wonder of travellers, and throughout the same island, Tournefort says, there is a *world of Caverns.*

In the limestone districts of England, these caves abound. In Derbyshire alone, Mr. Farey enumerates twenty-eight remarkable caves, and as many fissures locally called "snake holes," or "swallow holes," from their swallowing up the streams and brooks, which sometimes in that district disappear suddenly, without, so far as is known, ever rising again to the surface.

Of the bone caverns of Germany, Cuvier says, "nothing is more truly curious, than the new theatre to which I am about to transport my readers. Numerous grottos, brilliantly decorated with crystalline stalactites of every form, succeeding each other to a great extent, through the body of the mountains, communicating together by openings, so narrow that a man can hardly proceed by crawling on his hands, yet with their floors all bestrewed with enormous heaps of bones of animals of every size—form undoubtedly, one of the most remarkable phenomena which the fossil kingdom can present to the meditations of the geologist, more especially, when we consider, that this scene of mortality is repeated in a great many places, and through far distant lands. No wonder then, that these vaults of death have become the objects of research among the ablest naturalists, and their bony relics have been often described and figured."

Prior to these philosophical inquiries, however, these bones were famed among the populace, and were long dug up, and sold to apothecaries as the bones of the fossil unicorn, and who again portioned them out to their patients as sovereign remedies in various diseases. There is no doubt but this strange traffic, contributed mainly to the investigation of old caves, and the discovery of new ones, long before geologists took the subject in hand.

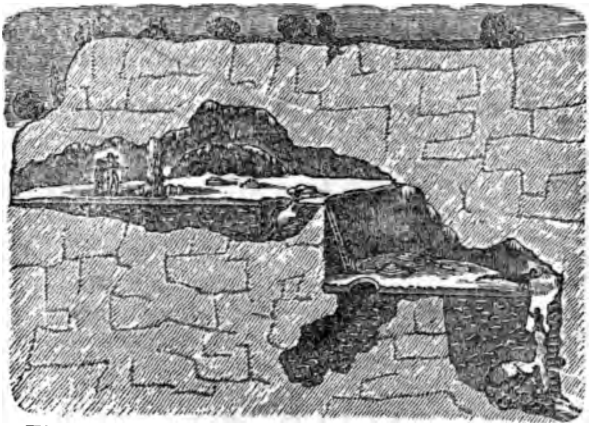
Having already given such an account of the Kirkdale cave as our limits will allow, and to which the reader is referred, we will here notice several other osseous caverns in different parts of the world.

In Germany, there are many caves, where bones have been found, but among these, that of Gaylenreuth has attracted most attention, on account of its great extent and beauty, as well as the number of fossil bones it contains. This cave is situated in Franconia, and in the same neighborhood with several others, the whole of which have been described by Professor Goldfuss, of Bonn, in a treatise expressly devoted to this subject.

The gateway, or entrance to the cavern of Gaylenreuth, is seven and a half feet high, and faces to the east, and of this wonderful place, Professor Buckland gives the following description.

The adjoining section is diminished from that drawn by Professor Buckland, in 1816.

Fig. 58.



The first grotto turns to the right, and is upwards of eighty feet long. It is divided into four parts, by the unequal height of the vaulted roof; the first three are from fifteen to twenty feet high, whereas, the fourth is only four or five. On the bottom of this part, and on a level with the floor, there is an orifice only two feet high, which leads into the second grotto. This runs first southward for sixty feet, being forty feet wide, and eighteen high; it then turns to the west through a space of seventy feet, becoming gradually lower till its altitude is only five feet. The passage to the third grotto is very incommodious, winding through several corridors; it is thirty feet wide, and only five or six high. The loam on this floor is stuffed full of teeth and jaw bones. Near the entrance to it, is a gulf of fifteen or twenty feet wide, into which visiters descend by a ladder. After going down, they arrive at a vault fifteen feet in diameter, by thirty in height; and on the side on which they descend, is a grotto all bestrewed with bones. By going down a little further still, they fall in with a new arcade, which conducts to a grotto forty feet long, and a new gulf eighteen or twenty feet deep. Even after this descent, another cavern presents itself, forty feet high, quite covered with bones. A passage now, of five by seven feet, leads to a grotto, twenty-five feet long, and twelve wide; then an alley twenty feet long, conducts into another cave, twenty feet high, and finally, a grand grotto expands, eighty-three feet in width, and twenty-four in height, more copiously furnished with bones than any of the rest. The sixth and last grotto runs in a northerly direction, so that the whole series of caverns and corridors describes nearly a semicircle.

A rift in the third grotto, disclosed in 1784 a new grotto, fifteen feet long by four wide, where the greatest number of hyenas' and lions' bones were found. The opening was much too narrow to have allowed these animals to have entered it. A peculiar tunnel which terminated in this grotto, afforded an incredible number of bones, and large skulls, quite entire.

The excavation on the extreme right and lowest part of the figure, does not form a part of the original cavern, but has been sunk for the purpose of finding bones. Several cavities have been dug in different directions from this well, for the same purpose, in one of which there is, in the cut, the figure of a man holding a torch.

"The cavern of Gaylenreuth is one," says Dr. Ure, "whose bony relics are best known, in consequence of the researches which have been so long carried on with regard to them by men of eminent science, such as Esper, Humboldt, Ebel of Bremen, Rosenmueller, Goldfuss, &c., as well as by the rich collections which these researches have furnished.

These collections have been examined by that great fossilist, Baron Cuvier, who has ascertained that the bones composing them, belong in the proportion of three-fourths to bears, and that next to these in numbers, were the bones of hyenas, foxes, wolves, gluttons, and polecats. A few, only, of the remains of the feline tribe, have been found in this cave, and still more few, of those of the elephant tribe."

Near this cavern are several others. One called *Hole-berg*, or *hollow mountain*, has eight or ten grottoes, forming a suit of apartments two hundred feet in length, with two outlets. Another called *Wonder hole*, has a circuit of one hundred and sixty feet, and still another called Klaustein, is composed of four grottoes, and is two hundred feet deep. In all these, more or less bones have been found. The rocks in which they are situated are of limestone, like that of Kirkdale, and indeed like those of all other caverns of a similar description.

One of the most interesting facts developed, by the examination of these caverns, and others which we have no room to describe, is, that they all, with an exception or two, contain the bones of the same species of bear, and in a similar proportion to the other bones. This has been found to be the case, even to the extent of more than five hundred miles, at which distance, some of these caves are situated from the others. The exceptions to this general fact exists in two or three caves, situated in England, which contain a preponderance of hyenas' bones.

How are we to account for the existence of so many bones, and of all kinds of animals in these caverns? One of the most natural questions which would occur to the mind, after having read the above account, would be how these bones came into these caverns. The solution of this question is attended with doubts and difficulties.

"It is scarcely possible," says Cuvier, "to imagine any other than the three following general causes, that can have placed these bones in such quantities in these caverns. First, they are either the remains of animals which dwelt and died peaceably in these chambers; or, Second, of animals which inundations and other violent causes carried in; or, Third, of the animals which had been enveloped in the stony strata, whose watery solution produced the caverns themselves, but the soft parts were dissolved away by the agent that scooped out the mineral substance of the caves."

The last hypothesis is refuted by the circumstance, that the strata themselves, in which the grottoes are excavated, contain no bones; and the second, by the entire state of preservation of the smallest prominences of the bones, which precludes the idea of their having been rolled or transported from a distance. We are, therefore, says Cuvier, obliged to return from these to the first cause, whatever difficulties may attend it.

The vast number of bones which some of these caverns contain at the present time, together with the dust of those which have decayed, would pre-suppose that a vast period of time must have elapsed since these houses of death were first inhabited, if indeed, these remains belong to such animals only, as "had lived and died peaceably in these chambers," as Cuvier supposes.

Dr. Buckland supposes that the contents of these caverns are due to two causes, viz., to the deaths of the prowling animals which inhabited them, and to the bones of other animals which these brought home for food, and this, without doubt, is the true theory. The elephants and other large animals, the bones of which are found in these caves, do not inhabit caverns; and if they did, the entrances are often too small to admit them while alive. Such bones most clearly must have been conveyed to such places after they had separated, by the decomposition of the soft parts, and there is, perhaps, the best reasons for believing that these, and perhaps a great proportion of the other bones found in the caves, were carried there by the hyenas and other beasts of prey. We think that the facts and arguments adduced by Professor Buckland, are sufficient to convince any impartial reader, that this was the mode of their transportation into these houses of death.

The immense quantities of organic relics, which have been deposited in some of these caverns, may be, in a degree, conceived of by the following facts.

"In this cavern," (of Kullock,) says Professor Buckland, "the size and proportions of which are nearly equal to those of the interior of a large church, there are hundreds of cart loads of black *animal dust*, entirely covering the whole floor. The quantity of animal matter accumulated, on this floor, is the most surprising, and the only thing of the kind I ever witnessed; and many hundred, I may say thousand, individuals must have contributed to make up this appalling mass of the dust of death."—*Reliq. Diluv.* p. 138.

Of the same cave, Cuvier says, "I have stated that the total quantity of animal matter that lies within this cavern, cannot be computed at less than 5000 cubic feet; now, allowing two cubic feet of dust and bones for each individual animal, we shall have, in this single vault, the remains of at least 2500 bears." We should think that a single cubic foot of dust is more than ought to be allowed to each bear.

We have already stated, at considerable length, under the article "Change of Climate," the reasons of Dr. Buckland, for believing that these caverns were the dens of hyenas, and that the multitude of bones found in them were carried there by these animals. To that article we must, therefore, refer the reader for the sequel of this subject.

OSSEOUS BRECCIAS.

Breccia, in Mineralogy, is a rock composed of angular fragments of other rocks, joined together by some kind of cement. In *osseous* breccia, bones take the place of the angular pieces of stone.

Osseous, or bone breccias, are found in many places on the coast of the Mediterranean Sea, as at Gibraltar, Cette, Antibes, Nice, Pisa, Corsica, &c. These are found filling up the fissures of calcareous rocks. It is a curious fact, that in all these places, as well as in Sicily, Dalmatia, and Cerigo, though so distant from each other, these conglomerated fragments of bone are similar, and appear to have belonged to the same animals. They are the relics chiefly of ruminant animals, such as the deer, mixed with a few lions' teeth, panthers' teeth, and sometimes the bones of rats, and occasionally those of other animals. The pieces of bone are impasted in a red earthy concretion, resembling highly burned bricks, but spongy in texture, from innumerable porous cavities, of various sizes, and which are occasionally interspersed with starry incrustations. As the bones are not pressed together, it is reasonable to suppose, that the cement which contains them, must have been progressively deposited around them as they fell into the rifts of the rocks. The bones have, in general, been broken in pieces before receiving their crust of spar, or their cement. They are entirely separated from their organic arrangement, but exhibit no signs of having been rolled or transported.

The stony fragments which this breccia sometimes embraces, are coarse grained limestone, of a dark gray color, containing now and then veins of white spar, and appear to have been rolled. In size, they vary from that of the fist, to small grains.

These bones do not belong to any existing species of animals. In the bone rock of Gibraltar, Cuvier found one species of deer, and another of hare, both unknown species.

It is unnecessary to be more particular in the description of these breccias, as they occur at different places, having already observed, that they all bear a similar character.

The breccia of Dalmatia is the most extensive of any which has been discovered; stretching along the whole coast of that country. Its structure and aspect is the same as that of Gibraltar.

With respect to the origin of these bone rocks, Dr. Buckland supposes that the bones of the extinct species are those of animals which fell into the crevices of the rocks before the flood, and perished there. The same author has shown that the red cement of the osseous breccia is an earthy loam, differing merely in color from that which fills the caves and fissures of rocks in Germany, and constitutes the diluvial loam on their bottoms.

It appears that something analogous to this breccia, is still forming in different places. At the extremity of Prince's Lines, high in the rock which looks towards Spain, is found a reddish calcareous earth, and the bones of small birds cemented thereby. The rock around this spot, is inhabited by a number of hawks, that in the breeding season nestle there and rear their young; and the bones in this concretion, are probably the remains of the food of these birds. At the base of the rock, below King's Lines, the concretion consists of pebbles of the prevailing calcareous rock. In this concretion, at a considerable depth under the surface, was found part of a *green glass bottle.*—*Ed. Phil. Trans.*

It will be observed that these breccias are peculiar to limestone rocks. Now, lime is known to be soluble in water, in small quantities, and hence the calcareous spar with which these bones are often surrounded and impregnated, is readily accounted for. The soil, or cement, which holds these bones together, is also hardened by the infiltration of the same substance.

Osseous Breccia of Australia. This has been recently discovered. From a communication of Major Mitchel to the London Geological Society, it appears that this breccia bears a great resemblance to that of Europe. The principal cavity where it occurs, is an irregular kind of well, or natural fissure, accessible only by means of ladders and ropes, and the breccia is a mixture of limestone fragments of various sizes, and bones enveloped in an earthy red calcareous stone. But this differs from the breccias of the Mediterranean coast, in this important particular, that the bones of which it is chiefly formed, are those of the kangaroo, wombat, and other animals, which are still living in that country. The bones of the elephant, and also of some species of other animals not known to exist, are occasionally found with the others, but the principal parts are composed of bones of living species. It was therefore probably formed at a more recent period than the breccia of the Mediterranean.

FOSSIL HUMAN BONES.

Cuvier, and other geologists, have expressly declared, that no fossil human bones have ever yet been found, nor have any bones of the quadrumanous, or monkey tribe ever been detected. "It is wonderful," says he, "that among all these mammifera, of which, at the present day, the greater part have a congenerate species, in warm climates, there has not been found one quadrumanous animal; not a single bone, or a single tooth of a monkey; not even a bone, or a tooth of an extinct species of this animal, has ever been detected.

"Neither is there any remains of man. All the bones of the human race which have been collected, along with those which we have spoken of, have been the result of accident, and besides, their number is extremely small, which it certainly would not be, if men had been established in the countries inhabited by these animals. Where then was the human race? Did the last and most perfect work of the Creator exist nowhere? Did the animals which now accompany him on the earth, and of which there are no fossil remains to be found, surround him? Have the lands in which they lived together, been swallowed up, when those which they now inhabit, and of which a great inundation might have destroyed the anterior population, were again left dry?" "To these questions," says Cuvier, "the study of fossils gives us no information."

One might be led to suppose, from the above language of the great fossilist, that every part of the earth had already been explored, and the question concerning fossil human bones, that is, the existence of human antediluvian relics, had been finally settled.

"But," says Granville Penn, "the great question concerning *human remains in a fossil state*, stands now before the world under a new aspect, and entirely different from that under which it stood at the period when M. Cuvier first published his celebrated '*Theory of the Earth*.'"

This new aspect is to be dated from about the year 1820, when the cavern of *Durfort*, and the quarries of *Kosritz*, were laid open for the instruction of science.

Cavern of Durfort. The cavern of Durfort is near a small village of that name, in the Department du Gard, France. It is about 300 feet above the level of the Mediterranean. Its orifice presents itself in a vertical fissure, or crevice, in the surface of the ground, about five feet in length, and one and a half feet in width. The descent is perpendicular, about twenty feet, and must be made by pressing with the back and knees against the rugged sides, in the manner of chimney sweepers. From thence you enter into a narrow passage, which, as it extends, divides itself to the right and left. These two passages are both so low as to make it difficult for a person to penetrate through them. The one on the right leads to the principal chamber, the dimensions of which are only ten or twelve feet in length, and three in height and width. The passage on the left is pursued with still greater difficulty, being considerably lower. No bones are found in either of these passages, but the cave is terminated by a small chamber, three yards square, in which all the human bones are found. They lie in the utmost confusion, in the paste or matter that unites them, and are in quantities so great as to form more than half of the bed. The bones are partly filled with an extremely fine calcareous earth, colored by oxide of iron. The deposite is here raised more than a half a foot above the true floor, which is covered with human bones, some of which are insulated from the rest; a great number are united to the rock, to which they have been fixed by calcareous incrustations. The bones are chiefly those of the head, thigh, and arms. They lie without any relation to the system, and many are wanting, so that an entire skeleton, has never been found. They are not worn, or rolled, so that they could not have been transported from a distance. They are not mineralized, but retain a portion of gelatine. These bones belonged to adults both of men and women, and some of them to children.

How these human bones came in such a place is the main question, and its answer is by no means easy. M. de Serres, the author of the above description, says that the difficulty of the entrance would have opposed an invincible obstacle to the introduction of the bodies after death. The people of the country have a tradition, that at some remote and unknown period, these bones were brought from a distance and deposited there.

Mr. Granville Penn has no doubt but these are antedeluvian bones, and thinks there is as much reason to believe them so, as there is in the case of the elephants' bones in the cave of Kirkdale. "It will be plain," says this author, "to every one who compares the descriptions of the two caves, that the leading circumstances, geologically considered, are so peculiarly analogous, that if we read, in the Durfort account, '*young and full grown elephants*,' &c. instead of '*young and adult human* subjects,' we shall almost seem to be reading the Kirkdale report."

Unless there is some other entrance than that already described, (and after much search, none has been found,) it is difficult to imagine how these bones could have been conveyed into such a cavern, and for what purpose. It is much easier to believe, did many such examples exist, that they were imbedded during the formation of the limestone rock, in which they are found, than that they were conveyed there by human hands. As these bones exhibit no marks of teeth, there is no reason to suppose that they were carried there by rapacious beasts. *Penn's Comp. Estimate.*—Vol. ii. p. 400.

The Quarries of Kosritz, where other human bones have been also found, are in Upper Saxony, and the account is given by Baron Von Schlottheim. The formation is of limestone, accompanied by secondary gypsum. In the fissures or cavities of the limestone, have been found the remains of the antediluvian rhinoceros and hyena, and other extinct species. In the fissures or cavities of the subordinate gypsum, *human bones* have been found, together with the bones of small quadrupeds and birds, at the depth of from sixteen to thirty feet below the surface. These occur in every quarry which has been opened, and not in caverns, but in the loam, which has formed there, and such as envelops the bodies of Gaylenreuth. The Baron supposes that the human bones are not, however, of the same antiquity with those of the antediluvian animals, with which they occur. Still the Baron says, "It is quite evident, that in the country near Kosritz, human bones are found intermingled, without order, with the bones of animals of the ancient world, and with those of existing species; and under precisely the same circumstances, being firmly enveloped and compacted in the loamy deposite, which occupies the fissures and cavities of the bed of gypsum that occurs in that vicinity. All these considerations give, on the first view, a probability to the conclusion, that the other animals were destroyed at the same time with man; an opinion which I have already advanced."

M. V. Schlottheim, afterwards became doubtful of the accuracy of this conclusion from the single circumstance, that remains of *existing* as well as of *extinct* animal species, were found with the human bones.

Had the Baron seen Professor Buckland's account of the Kirkdale cavern, which was printed afterwards, this circumstance alone, probably would not have raised a doubt, since *there* were found both extinct and existing species mingled together, and yet no doubt has arisen that they were not all antediluvian.

These facts and circumstances, in the opinions of several able geologists, leave little or no doubt but those bones were real fossils, and that they belong to a period before the flood, while others think the evidence not sufficient to establish so important a geological fact. The inquiring reader will find this subject fully discussed in "Penn's Comparative Estimate of the Mineral and Mosaical Geology," vol. ii.

Professor Buckland also found human bones, in the same caves with those of antediluvian animals, and yet he seems to suppose that the former were much less ancient than the latter, the human bones having fallen in through some crevice, formerly open, but now closed. Although a strong advocate of the truth of the Mosaic history, he denies the existence of fossil human remains, though, had the bones of some species, considered *extinct*, been found under the same circumstances, no doubt it is believed, would have been entertained of their antediluvian origin. This reluctance to admit their discovery and existence, appears extraordinary and unaccountable in an advocate for the truth of the Scriptures, since, if men and animals were created within a few days of each other, their remains ought to be found together. "It is said," says Dr. Macculloch, "to be a proof of the especially recent formation of man, that his remains are not found in the same alluvia as those of other animals. What support of Scripture is this? That record says, man and animals were created in one short period. If they ought thus equally to be found, and are not, it is evidence against the record, and not in its favor."—*Geology*, vol. i. p. 451.

In what manner bones might be thrown into caverns.—Perhaps every limestone country contains more or less subterranean caverns, which admit streams of water to pass through them, either constantly, or duriug certain seasons of the year.

In the Grecian Morea, it appears, that such caverns are common, and during the late French expedition to Greece, they were particularly examined and described by M. Boblaye, one of the adventurers.

In that country the seasons are divided into the dry and rainy, with nearly the same exactness that they are between the tropics. The rainy season lasts four months, and is succeeded by eight months of drought.

In the elevated districts of the Morea, there are many deep valleys or basins, surrounded on every side by mountains of cavernous limestone.

During the rainy season, the torrents from the mountains, rushing into these basins, would form lakes in ordinary circumstances; but here the water is received into fissures or caverns, called by the Greeks "katavothra," and which lead to subterraneous caves of various dimensions below.

In some of the basins, the apertures not being sufficient to receive all the water as it descends, lakes are formed, which either gradually run off at these apertures, or find other openings at a higher level.

In some places where the water descends through fissures in the bottom of the basin, which is often in the middle of a plain, nothing can be seen in the summer, when the lake is dry, but a deposite of red mud cracked by the heat of the sun in all directions; but more commonly the receiving chasm is at the foot of the surrounding escarpment, and is sometimes large enough to allow a person to enter it in the dry season, and to penetrate far into the interior. Within are often found a suite of caverns or chambers, communicating with each other by narrow passages, as is the case with similar caves in this and other countries. In one of these entrances were observed human bones imbedded in recent red mud, and mingled with the remains of plants and animals now inhabiting the Morea.

In summer these mouths being half closed with alluvial mud, produce a rapid and vigorous vegetation, which is cherished by the moisture of such places. They then become the favorite hiding places of jackals and foxes, so that at one season of the year, the same cavity serves for the den of carnivorous beasts, and at another, the chamber of an ingulfed river.

Near the mouth of another of these caverns, M. Boblaye and his companions saw the carcass of a horse partly devoured by jackals, the size of which prevented these animals from dragging it in; but it was evident that the ensuing flood would float in whatever remained of the skeleton.

Some of these torrents form subterranean rivers, after running many miles come again to the surface; and although the waters are exceedingly turbid when they are ingulfed, the emerging stream is perfectly clear and limpid, the impurities subsiding during the underground passage. The points of emergence are usually along the sea shore of the Morea, but sometimes they are submarine, and at some distance from the shore. When this is the case, the force with which the fresh water rises under the salt, is sometimes such as in calm weather, to form large convex waves, the sand at the same time boiling up to a considerable distance from the bottom.—*Lyell.*

During the dry season, the sea, undoubtedly, takes the place of the fresh water, carrying in marine shells and sand, to mingle with the bones and mud brought down from the land; thus forming a mixture of fresh, and salt water remains.

Should the Morea be elevated by a subterranean force, and these places exposed to the investigations of geologists, there would probably be exhibited the same phenomena that has so puzzled the naturalists of the present day;—a congregation of mammiferous bones, clay, sea sand, marine and land shells, and the whole, perhaps, interspersed with human bones.

From what we have here stated, it may be seen that in the course of centuries, large quantities of the bones of quadrupeds and of men, may be carried into caverns, and there mingled promiscuously: and probably also intermixed with marine productions. And as in limestone countries these caverns are constantly filling up with stalactites, and carbonaceous matter brought in with the water, the wonder with respect to the ingress of organic relics into certain caverns, would seem thus in a degree to be explained.

Lake Cirknitzersee. The fact stated above, that there is a spot on the Morea, where at one season of the year the same cavity serves for the den of carnivorous beasts and at another for the channel of an ingulfed river, brought to mind a still more singular natural curiosity, of somewhat the same kind, as stated by the old traveller, Keysler, which we had heretofore believed was rather fabulous than true. Keysler, however, was F. R. S. of London, and one of the most able antiquarians of his time.

"The Lake Cirknitzersee," says he, "situated in the south-east part of Austria, is one of the greatest of natural curiosities, and has been the subject of many disquisitions of naturalists. It is a common proverb, that one may sow, reap, hunt, and fish, in the Cirknitzersee, within the space of a single year. But what is truly wonderful in this lake, is the manner in which it ebbs and flows. The former happens during a long drought, whether in summer or in winter, and the ebbing continues, commonly for about five and twenty days. The water during this time, is absorbed by eighteen holes or cavities, resembling whirlpools, in the bottom of the lake. The water seems to rush through a crust of the earth into a cavern below. The cavities have each a particular name and period of time when they cease to absorb water. These periods differ, probably according to their different elevations above the lowest surface of the ground. One ceases in five days, one in ten, one in fifteen, and so on, until the end of about twenty-five days, when the lake is entirely dry. Instances have been known of its having dried up three times in the year. When great quantities of rain fall, this lake is again filled by the same cavities which absorbed its waters. If the rain continues, and especially if attended with claps of thunder, the water issues out of these holes with great impetuosity, rising two or three fathoms above the surface. Some of the cavities only absorb, but do not eject the water, while others both absorb and eject, as the lake ebbs or flows.

Notwithstanding the lake becomes absolutely dry, and nothing remains alive in it, yet as soon as it begins again to flow, great quantities of excellent fish, of different kinds, some weighing fifty pounds, are taken in it; a convincing proof that the reservoir which supplies it with water is well stocked with fish. But the most extraordinary fact is, that ducks also are ejected with the water, many of them being seen to rise from two of the cavities in particular. They are of a black color, blind, and almost destitute of feathers, but they are fat, and in about a fortnight's time become fully fledged, receive their sight, and fly away." Keysler's Travels through Germany, &c., translated from the German, and published in London, 1756, vol. iv. p. 213.

FOSSIL REMAINS OF PLANTS AND SHELLS.

It has been supposed, by some naturalists, that there was a gradual and progressive development in the organization of created beings, from the most simple to the most perfect and complex; and in proof of this doctrine, it has been shown that in the strata of the earth, the lowest orders occur first, or are situated at the greatest depth, over which occur those that are less simple, being created afterwards, and so on progressively, to the most perfect or complex, which are found only near the surface.

It is true, indeed, that plants were created before animals, and that the inferior animals were formed before the more intelligent; and it is also true, that, in this respect, the discoveries of geology harmonize most perfectly with the order of creation as recorded by Moses; the several creations, with respect to time, coinciding entirely with the successive order in which their remains are found in the earth. But it will be shown in the sequel, that the general fact of the lower orders being found in the deepest strata, proves nothing with respect to the progressive improvement of organized beings, because in many instances, animals of a more simple structure are found *above* the more complicated. This is particularly the case, with several species of shells, some of the most curious and complex kinds being found in the deepest strata, and far below those of a more simple structure. This fact, while it takes nothing from the coincidence which exists between the scripture narrative of the creation and the discoveries of geology, destroys at once the doctrine of the gradual development of organic life, since the very basis of this doctrine supposes an uninterrupted progress from the most simple structure, towards that of the greatest complexity.

Plants of the lower orders, and many of them entirely different in structure and species from any now existing, have been discovered in situations, which not only indicate, from the nature of the rocks in which they occur, their great antiquity, but also that they were imbedded at a time anterior to the existence of any other organized substances.

Next to the plants, and above them in the order and succession of strata, occur shells of various kinds, and next above these are found the remains of reptiles, fish, birds, &c., and still nearer the surface, the bones of quadrupeds. But we will not here anticipate a subject to which a section will be devoted at the close of this volume.

FOSSIL PLANTS.

Fossil botany has within a few years, been studied with much ardor and considerable success. Most of the plants discovered in deep strata, and which have been attributed to a period before the deluge, are of the cryptogamous* and monocotyledonous† tribes. These occur chiefly in the slates, limestones, and sandstones, together with other formations which are associated with coal; and it is a curious circumstance, that the vegetable impressions from coal strata in North America, New Holland, and various parts of Europe, show a close analogy in the ancient vegetation of these distant countries. Indeed, so far as observations have been made, there exists a similarity in the plants of coal formations, in every part of the world. Most of these plants belonged to tribes or orders now in existence, though in nearly, if not in quite every instance, these species are now nowhere to be found. These species are, therefore, considered as extinct, but at what period, and in what manner they were destroyed must be left entirely to conjecture.

We shall see that some of these ancient plants were highly curious and singular in their construction, and in which they differed entirely from any vegetable of the present day, while others were similar in appearance to those now existing.

The argillaceous nodules found in some of the English coal mines exhibit beautiful and distinct impressions of many unknown species, some of which, however, it is said, have living analogues in tropical climates. When these nodules are carefully broken, the impressions are preserved on both sides, but not as might be expected, displaying each side of the vegetable, but the same side on each broken surface; in one, in *alto*, in the other, in *basso relievo*. The explanation of this curious circumstance,

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* These plants have their fruit concealed and are flowerless, as the mushrooms, ferns, mosses, and sea-weeds.

† As the palms, rushes, lilies, grasses, &c. This term has already been explained.

which long puzzled observers, is found in the vegetable matter, which during its passage through the bituminous change became softened, and having filled its own mould with its melted and subsequently hardened substance; the nodule, on being broken, showing on one side, the surface of the adherent bituminous cast, and on the other, the corresponding mould.

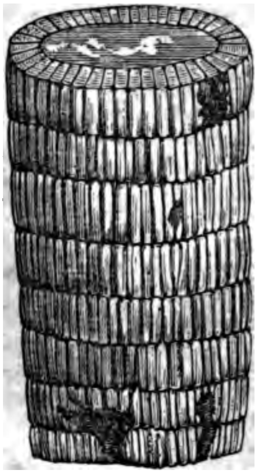
The adjoining cut will give a good idea of these impressions. It represents a species of polypodium, in slate clay, from the coal mines of Lancashire. Sir James E. Smith, considers it the production of a tropical climate, nothing of the same species being known in Europe.

Fig. 59.

It has repeatedly been stated in different parts of this volume, that the cryptogamous plants found in Europe, in the fossil state, indicate by their immense sizes, a tropical climate. The calamites or equisetums, a genus well known to botanists, and one species, to housewives, under the name of *scouring rush*, are examples. The remarkable size of this species, at the period when the earth produced the vegetables which now form coal, would seem to show, that the climate of England, and the higher parts of North America, where its fossil remains are also found, were hotter than any region of the earth is at the present day. The equisetums afford an excellent standard of the warmth of the climate in which they grow, being found at the present day, from the highest northern regions, to the hottest southern; and progressively increasing in size from the pole to the equator.

But even under the equator, they never attain the size of their fossil analogues, the calamites.*

Fig. 60.



The annexed figure, from Dr. Ure, represents the fossil species called by Brogniart, *Calamites approximatus*, on account of the proximity of its articulations. It is found in the coal formations of Newcastle, at Lubec, near Canada, in France, and in Siberia. One specimen from Lubec, is nearly two inches in diameter, but much larger ones, even ten or twelve inches in diameter, are said to have been found. In this climate, it is believed that none of the equisetums now rise higher than four or five feet, with a diameter seldom exceeding half an inch, and generally little more than half this size.

Some of the antediluvian plants, were singularly curious and beautiful, as is shown to us by the impressions, or casts left on stones, or by their petrified remains. Some are ornamented by regularly disposed, straight ribs, arranged longitudinally, or transversely, over their whole surface; some by the decussation, or crossing of nearly straight lines, obliquely disposed; and many, by the alternate contact and receding of gently waving lines, forming areas, regularly, but most singularly varying in their forms, and having in their centres, tubercles and depressions, from which spines have probably proceeded. In others, lines, obliquely disposed, intersect each other at angles, varying in their acuteness, in different specimens, and in, it would seem, an almost endless variety, forming surfaces apparently covered with scales.

One of these, called *Phytolithus verrucosus*, or warty

* The calamites are not considered of precisely the same species as the equisetums, the first being only fossil, and the second only recent; but both are of the same family.

stone plant, has attracted particular attention, but appears to have foiled every one who has attempted to explain its original nature and mode of existence.

Fig. 61.

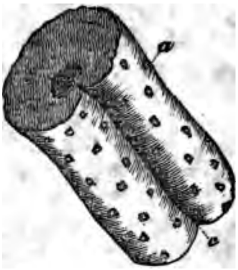
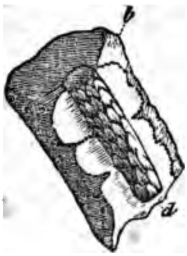


Fig. 62.



The subjoined cuts will give a good idea of this strange antediluvian. It is described by Mr. Martin, to have a sub cylindrical, subramose, tuberculated trunk, fig. 61, with suppressed tubercles set in quincunx order, *a*, having linear, lanceolated leaves, fig. 62, *b*, horizontally disposed. In some parts, is a deep, longitudinal sulcus, or furrow, as seen at *c*, fig. 61; beneath which is a rough imbricated body, of a slender, cylindrical form, exposed at *d*, fig. 62. This, Mr. Martin supposes, after a certain distance, strikes out laterally, and forms a branch: the trunk is then continued for some length, without the furrow, or imbricated body, after which, this again appears, and another branch is thrown out in a different direction.

Various opinions have been entertained respecting this interesting fossil, so unlike any of the vegetables of the present day. Mr. Parkinson had conjectured that it belonged to some body resembling the *strobilus*, or cone of some vegetable, while Mr. Martin describes it as above. The Rev. Mr. Steinhauer has since studied this fossil, and concludes that the bodies supposed by Mr. Martin to be leaves, were cylindrical fibres, which shot out of the trunk, while the plant grew in a horizontal posture. He supposes that it grew in this direction, in the soft mud at the bottoms of lakes or seas—that it had no branches, but sent out fibres on all sides; and that it was furnished in the centre with a pith, of a structure different from the surrounding wood

Fig. 63.

But the ingenious author of these observations has omitted to notice the imbricated or reticulated surface of the central substance, referred to above, and which Mr. Parkinson thinks will afford some information. These configurations undoubtedly depended on the attachment of some parts of the vegetable, and probably were the bases on which were placed those delicately formed tubular processes, represented by fig. 63, *a*, which are seen to pass from the internal substance to the surface of the body.

From all the information that has been obtained, it is supposed by naturalists, that the ***Phytolithus verrucosus*** was a plant of the succulent tribe, differing from vegetables of the present world, by its containing a more solid part within its succulent substance, from which proceeded a delicate organization, by which a communication was preserved with the external surface. It also appears that the species of this genus, distinguished by their characteristic markings, may have been numerous.—***Parkinson's Organic Remains, and Trans. Am. Philo. Soc., New Series***, vol. i.

Fig. 64.

Phytolithus cancellatus. (Cross barred stone plant.) Mr. Steinhauer has taken much pains to detect and explain the different appearances which this species presents. He has ascertained that there are three distinct kinds of configurations proceeding from it, originating in the epidermis, the bark, and that which may be considered as holding the situation of the wood of the plant. The first, or epidermal part, is formed of rhombs, divided by lines, forming a network in a manner difficult to express, either by drawings or descriptions, and which leaves the rhombs still approximate.

The impression of this part, is represented by fig. 64. In the second, or the cortical part, the lines between the rhombs are of more breadth, the ridge broader, and less defined, and forms, with the contracted superior elevation, a protuberance, and the central part assumes the figure of a *squamula*. Fig. 65, represents the matrix or cast of this part. The third or ligneous configuration, differs extremely from the two former, and only close observation determines that it originates from the same plant. The cancillated appearance is here entirely lost; the surface is slightly striated with a scarcely perceptible rising under the central ridge, and a minute, but distinctly raised dot in the place of the depression in the epidermis. It has all the appearance of a peeled plant, which has been furnished with small branches, set in quincuncial order. This is represented by fig. 66.

Fig. 65.

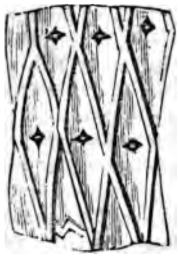
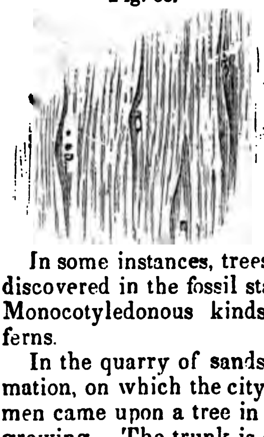


Fig. 66.



Eight species of this genus are described, but the plan of this work forbids further detail.

In some instances, trees of large dimensions have been discovered in the fossil state, but these are mostly of the Monocotyledonous kinds, as the palms and tree-like ferns.

In the quarry of sandstone, belonging to the coal formation, on which the city of Glasgow is built, the quarrymen came upon a tree in its place, and just as it had been growing. The trunk is about twenty-six inches in diameter, not quite round, but somewhat oval, so that the north and south diameter is several inches longer than the east and west. The body of the tree is composed of sandstone precisely similar to the rest of the quarry; but the bark has been converted into perfect cherry coal, which adheres firmly to the stone tree, and renders it easy to remove the rock with which it is incrusted. About three feet of the bottom of the tree has been uncovered; this portion is situated about forty feet below the surface, in a solid quarry of sandstone. The upper part of the trunk and branches have not been uncovered. The roots may be seen dipping down into the earth precisely as the roots of living trees do. Four very large roots may be seen issuing from the trunk, and extending, some of them, about a foot before they are lost in the surrounding stone. There is nothing to indicate the species of tree, of which the mould has been thus preserved. From the appearance of the roots it is obvious, however, that it was not a fir.

This petrifaction demonstrates, that the sandstone has been formed at some period since the growth of large trees, and that the water worn appearance of the quartz pebbles, of which the sandstone is composed, is not a deceitful indication.

Petrifactions. There is a popular opinion, that in the process of petrifaction, wood is changed to stone. The truth appears to be, that as the wood decays, its place is supplied by particles of stony matter, deposited from water; and as those particles are exceedingly small, and the decay of the wood slow, its fibrous structure is preserved in the stone, after the wood has entirely disappeared. Wood never undergoes this change when in a state of soundness and integrity; but only when it becomes spongy by decay, and when all its constituents have disappeared except the woody or ligneous fibre. This is proved by most specimens of petrified wood, which show a partial decay before the process of mineralization began.

There are two kinds of petrifactions; the one caused by the infiltration of *calcareous*, and the other of *silicious* particles.

Calcareous Vegetable Fossils. Lime is not very frequently the mineralizing matter of vegetable fossils; it is, however, sometimes found introduced into the remains of wood in the form of spar, or imperfect crystals; in the compact form, it is also found filling the interior of fossil reeds and succulent plants.

Silicious Vegetable Fossils. These are immediately distinguished from the calcareous, by their greater hard ness, the former giving fire with steel, while the latter are easily scratched with a knife. The silicious fossils are remarkable for the correctness with which the fibres and markings of the wood have been preserved.

The color is generally grayish, or yellowish white, sometimes passing into brown, and is easily broken into sharp edged fragments. It is found in many parts of the world, but the finest specimens are said to come from Hungary. The English, Portland limestone, contains large fragments of wood, petrified by silicious infiltration, the interstices often containing fine crystals of quartz.

These petrifactions prove that silicious matter is soluble in water, under ordinary circumstances, and that it not only takes the form of the woody fibre, but also of crystals.

Dr. Macculloch has shown also, that in many instances, the mosses and other small vegetables, become incrusted with silicious matter, while in their vegetable state, and are thus preserved from decay. But these real cases, must be distinguished from the black, tree-like appearances, which are often seen on the flat surfaces of limestone, and which are produced by oxide of iron, or manganese.

Fig. 67.

The vegetable matter is easily detected by mixing a little of the moss agate, ground fine, with some black oxide of copper,—exposing the mixture to heat, in a glass tube, stopped at one end, and bent so that the other may dip in lime water contained in a vial. If any vegetable matter be present, carbonic acid gas will form, and passing into the lime water, will give it a turbid or milky appearance.

The adjoining cut represents a specimen of moss, apparently belonging to the genus *hypnum*, contained within a silicious deposite, called *chalcedony*. In some instances of this kind, the vegetable form is so perfectly preserved, that the plant seems to float as if in a liquid. Even the green color occasionally is preserved, and, in a few instances, the species has been determined.

FOSSIL SHELLS.

That the student may understand what follows, it is necessary for him to become acquainted with the principles on which shells are arranged, and a few of the terms by which the different parts of a shell are denoted.

Shells, in their recent state, are composed of carbonate of lime, mixed with a little animal or gelatinous matter. In their fossil state, the gelatinous matter is seldom present, though sometimes a small quantity has been detected.

CONCHOLOGY.

Conchology is the science which treats of the structure, arrangement, and properties of shells. Shells are inhabited by *testaceous* animals, and to which they are only partially attached. *Crustaceous* animals are confined entirely within their coverings, each limb, or member being invested by its own peculiar shield, as in the *lobster* and *crab*. Many of the testacea are fixed by an attachment to other substances, as the oyster and muscle; while others have the power of crawling along the bottom, or of moving through the water, as the unio, (fresh water clam,) and the scallop. The animals which inhabit shells are called *mollusca* or *molluscous* animals, but the classification depends, not on the habits or form of the animal, but on the form and other properties of the shell.

The Linnæan system of conchology, which is the most simple of any that has been proposed, divides shells into Multivalves, Bivalves, and Univalves.

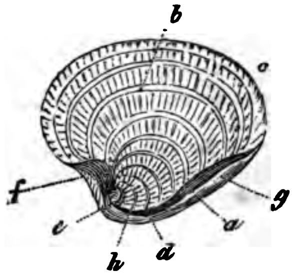
By *valve*, is here meant any single piece of shell, which forms the habitation or part of the habitation of a molluscous animal. Any shell formed of more than two pieces is a *multivalve*. *Bivalves* consist of two distinct pieces, and *univalves* of a single piece.

Fig. 68.

1. Multivalves. This is much the smallest class, but contains some beautiful shells. The genus Lepas, which contains the *common barnacle*, fig. 68, belongs here. The Chiton or coat of mail is another member of this class. The generic description of Lepas is, "Shell multivalve; affixed at the base; valves unequal, erect."— These shells are chiefly parasitic, being attached to extraneous substances, often to ships, pieces of wood, whales, &c. The generic characters of this class are derived from the number and situation of the valves.

2. Bivalves. This class includes all such shells as are composed of two pieces only, whatever their forms or dimensions may be; and in these respects, the species differ exceedingly. The two valves of the Chama gigas sometimes weigh 500 pounds, and from this, there are all grades of size down to that of a grain of sand.

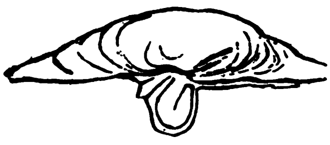
Fig. 69.



Bivalve shells, when their valves are similar in size and form are said to be *equivalved;* if not similar, *inequivalved;* when the anterior part agrees in form with the posterior, they are said to be *equilateral*, if not, *inequilateral*. The valves are connected at their base by a *ligament*, with or without a hinge, the ligament being placed *externally* or *internally*. The *belly*, *a*, fig. 69, is the most tumid part; the *disk*, *b*, is that part between the belly and the *margin*, *c*, which is considered to refer to the external side, or, as it may be termed, when the shell is placed on its base, the *upper side;* then the *umbones* (eminences) *d*, are beneath the hinge, and terminate in the *points* or *beaks*, *e*, which are *incurved*, *reflected*, or *ear formed*. The beaks are frequently in particular shells, accompanied by two external impressions, one of these, the *corslet*, *f*, is on the anterior surface, and is separated from the disk, generally by a ridge, an angle, or a sunken line; and is often distinguishable by its difference of color; it is sometimes spinous, carinated, lamellated, &c., but is more generally smooth, when it is said to be *naked*. The other impression, called the *lunule*, *g*, is placed at the bottom of the posterior surface; it is variously shaped, *oval*, *oblong*, *lanceolate*, &c. The two pieces, forming the shell, are called the *right* and *left* valves. The shell being placed on the hinge with the anterior side forward, that is considered as the *right* valve, which answers to the left hand, the other being the *left* valve. The *length* of a bivalve is from the umbones to the margin opposite; and the *width* or *breadth*, from the end of the anterior to that of the posterior margin. Hence many shells are broader than they are long. Those whose length exceeds their width are called *longitudinal*, and those whose width exceeds their length, are called *transverse* shells. Shells are distinguished by the appellations *free*, when they are capable of moving, and *fixed* when they adhere to other bodies.

Bivalves are divided into three orders, depending on the mechanism of their hinges.

Fig. 70.



First. Those which are furnished with internal teeth at the hinge, but which are *not* inserted into the opposite valves, as in fig. 70. The genus Mya, (to which belongs the common long clam,) and Solen, (razor shell,) are examples.

To the Mya genus, belongs the Pearl Gaper, (*Mya margaritifera*,) a beautiful shell with a pearly lustre, and which occasionally produces pearls of great value. It is found in the large rivers of the northern latitudes, and is not the shell which is the object of the regular pearl fishers.

To this genus also, belongs some shells in considerable request among collectors: but on the whole, the genus is not remarkable for the beauty of many of its species.

Fig. 71.

Second. Shells which have their teeth inserted into their opposite valves, fig. 71. To this order belongs the Cardium, (heart shell,) and the Venus; one species of which is well known in our markets, under the name of *round clam*, and which are taken in great abundance on the shores of Long Island, and sold as an article of food.

Third. Shells, having a hinge, without teeth, as in the well known shells, the oyster and scallop.

The generic distinctions of the bivalves, depending entirely on their teeth, and their genera in the Linnæan system amounting to only thirteen in number, they are easily distinguished from each other. The species depending on the forms and markings are not so readily distinguished.

3. Univalves. This is much the largest class, and contains a great proportion of the shells which collectors seek after with so much avidity, and many of which are exceedingly beautiful in their forms and colors.

Univalves differ greatly from each other in form, size, and coloring. Like the bivalves, their different parts are distinguished by peculiar names, which are applied in scientific descriptions, and by means of which conchologists are enabled to understand each other.

Only the most necessary and common of these terms can here be explained.

The univalves are distinguished chiefly by the form, size, and direction of their apertures, but sometimes by the conformation of the shell.

The univalves are exceedingly numerous, of a great variety of forms; and some of them remarkably beautiful, both in shape and color. The names of the several parts of a univalve will be distinguished by the annexed cut.

Fig. 72.

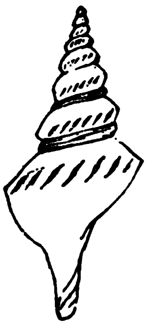
The spire, *a*, in the univalve, fig. 72, is formed by the union of the *turns*, or whorls, *b*, which are counted by reckoning the lower turn, containing the opening below, as the first, and counting on the same line to the top of the spire. The turns in most shells go from the right to the left; when they pass from left to right, which rarely happens, the shell is said to be *reversed*. The line passing round the shell like a screw, and at which the whorls are united to each other, is termed the *suture*. The whorls are *plain*, *grooved*, *crenulated*, crowned with points, &c.

The *back* of the shell, *c*, is the external, tumid part, on the opposite side, and above the aperture. The *body* consists of the whole of the tumid part, *c*, which forms the first whorl. The *opening*, or aperture, *e*, is *circular*, *oval*, *angular*, &c., and it is often the form of this part which determines the genus of the shell. This opening terminates in a groove or notch, which is either *straight* or turned to the *right* or *left*, or *backwards*. When the opening is longer than wide, it is said to be *longitudinal*; and when wider than long, *transverse*. The *edge* or margin of the opening is divided into *right* and *left lips*. The *right*, or outer lip, *d*, reaches from the body, or first turn of the shell, to the base. The *left* lip, *g*, is on the other side of the opening, and is of small extent in those shells, the openings of which are entire. This opening is filled with a body composed of shell, or cartilage, which is attached to the animal, and with which he can close the opening at pleasure, by drawing it in. This is termed the *operculum*.

The little white bodies, popularly called *eye-stones*, are operculums.

Univalves are distinguished into two kinds.

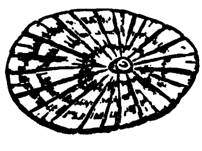
Fig. 73.



First. These which are furnished with a *spire*, as fig 73, and those having no spire.

Those furnished with spires, are again divided into such as have, 1st, their apertures *effuse*, that is, having the lips separated by a sinus, or gutter, so that if filled with water, it would flow out at the back part, as the *conus, cypræa, bulla and voluta.* 2d. Such as have their apertures *canaliculate*, or like a canal, as *buccinum, strombus*, and *murex.* 3d. Such as have their apertures *coarctate*, or contracted, opposed to effuse, as helix, turbo, and nerita.

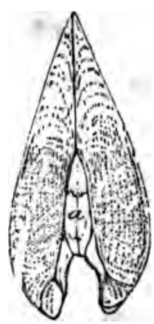
Fig. 74.



Second. Those either having no spires, or irregular, or imperfect ones. The patella, or limpet, fig. 74, is an example.

In this epitome of conchology, we shall describe a part, but not the whole of the thirty-six Linnæan genera, at the same time indicating which are recent, or now living; which are fossil, or extinct; and which are both recent and fossil.

Fig. 75.



Multivalves. Genus *Pholat*, fig. 75. Shell bivalve, inequilateral, and gaping; having small accessory valves, *a*, situated on the hinge and posterior slope; hinge recurved and furnished with a tooth.

The name *Pholades*, imports *seek a hiding*, in reference to the habits of the animals, which live in limestone rocks, or wood, entering when small, and gradually increasing their cells, according to their growth. The largest specimens are found in chalk, which being a soft rock, perhaps admits of a larger growth, in consequence of the ease with which the animal enlarges his cell. There is mystery concerning the means by which these animals penetrate the substance of their future prison, which from the size of the aperture must be done when they are very young. The animal undoubtedly has the power of dissolving the stone and wood by means unknown to man. The idea of friction with the shell, is untenable, since this is covered with raised net work, with the points sharply defined. This shell has not been found in the fossil state.

Fig. 76.

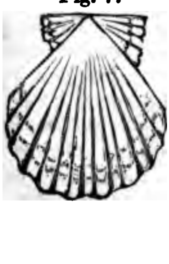
BIVALVES. Genus *Mytilus*, fig. 76. Shell longitudinal, equivalved; the beaks nearly straight, terminal and pointed; hinge without teeth. Shape either folded or lobed, crested or attenuated towards the apex. This is the *muscle* of common language. To this genus belongs the pearl-bearing shell, (mytilus *margaritiferus*,) of the Indian fisheries. The whole genus are inseparably attached to other substances.

The species in which pearls are found, are most abundant, and in the greatest perfection, on the coast of the Persian gulf and of the island of Ceylon. The term pearl oyster is commonly applied to this shell, but incorrectly, as is obvious, since the genus is Mytilus, and not Ostrea.

In the great pearl fisheries which supply the eastern markets, the number of fish annually brought up by divers, is almost incredible. Many of the shells contain no pearls, but some contain two or three. Those of two grains, sell from about 1.50 to 2 dollars each, those of five grains, from 8 to 10 dollars each: those of eight or nine grains are of arbitrary value, because they are very rare. The finest specimens sometimes bring enormous prices, being considered invaluable, and fit only to adorn the persons of eastern potentates.

Of the Mytilus, there are about forty recent, and two fossil species.

Fig. 77



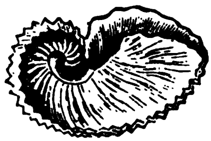
Genus *Ostrea*. Shell bivalve, generally with unequal valves, and slightly eared hinge; without teeth, but furnished with an ovate hollow, and usually with lateral transverse grooves.

This genus includes the scallop, or pecten, fig. 77, which, however, unlike the oyster in the habit of the animal, and the general form of the shell, agrees with it in the mechanism of the hinge, the part on which the generic distinctions depend.

The locomotive powers of the scallop are exerted in a singular manner. On the ground a rapid progress is made by opening and shutting the shell suddenly, and with so much muscular force, as to throw it five or six inches each time. In the water, an equal dexterity is evinced by the animal in raising himself to the surface; probably by the same means, and of directing his course at pleasure. When disturbed he shuts his valves, and sinks to the bottom like a stone.

Of the Ostrea, there are fifty living, and thirty-six fossil species.

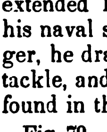
Fig. 78.



Univalves. Genus *Argonauta*. Shell, an involuted univalve; the spire turned into the opening, very thin, with a tubular double dorsal keel, fig. 78.

The art of navigation is supposed to have owed its origin to the expert management of this instinctive sailor. He was observed by the ancients, (and subsequent experience has confirmed the observation,) to raise himself to the surface of the sea, by ejecting a quantity of water, and thus diminishing the specific gravity of his vessel. When floating in a calm, he throws out two or more tentacula, or feelers, to serve as oars. If a favoring breeze springs up, he spreads a fine membranous sail, on two extended limbs, and steering with his other arms, shows his naval skill by numberless evolutions. In case of danger, he draws in a little water, hauls in, and coils up his tackle, and sinks to the bottom. This is rarely, if ever, found in the fossil state.

Fig. 79.



Genus *Patella*. A shield-formed, sub-conical univalve, without a spire; sometimes with a perforation through the summit, fig. 79. Fig. 74, a perforated Patella.

The name *Patella*, is from the resemblance of some species to the knee-pan. There is considerable variety in the forms of the species, but all are fixed firmly to the rocks or stones, by the animal which is covered by the shell.

It is both fossil and recent

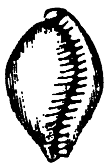
Fig. 80. Genus *Dentalium*. Shell univalve, sub-conical, a little curved, tubular, not chambered, open at both ends. Fig. 80.

The form, as the name expresses, is like that of *teeth*, or tusks, especially like the tusks of an elephant.

These shells are found partly buried in the sand, and the animal, which some naturalists have supposed to be free and unattached to his shell, may be observed to sink deeply into it, in order to avoid danger.

The species are few, and entirely recent.

Fig. 81.



Genus *Cypræa*. Shell univalve, involute, obtuse, smooth; aperture effuse at both ends, linear, toothed on both sides, longitudinal, fig. 81.

This genus is remarkable for the high polish, and often beautiful colors, with which it is adorned in its native state. Many of the species are quite common, and therefore not so highly prized by collectors as the more rare. They are often set for snuff boxes.

The inhabitant of this shell, it is said, has the power of quitting it, and of forming a new one better fitted to his necessities or convenience. "The Cypræa live deeply buried in the sand, from whence, it is said, at the full moon, and during its increase, they leave their habitations for the benefit of conchologists, and crawl forth in a state of nakedness, to expatiate on the rocks above, and to begin a new dwelling." This accounts for the great numbers and high state of preservation in which these shells are found. Naturalists, however, doubt the ability of these animals to leave their shells.

The name of this genus appears to be derived from that of the Cyprian goddess, on account of the great beauty of the species.

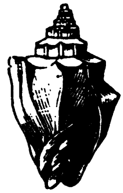
Fig. 82.

Genus *Bulla*. Shell univalve, convolute, unarmed; aperture sub-coarctate, or a little contracted, oblong, longitudinal, entire at the base, fig. 82.

The shell of this genus is enclosed in a mantle, or fold of the animal, instead of forming an exterior shield, as in most cases.—Some of them are river shells, but they mostly live in the sea, buried a few inches in the mud.

The name *Bulla*, a *bubble*, is descriptive of the swelled, or puffed form of the shells of most species.

Fig. 83.

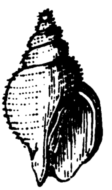


Genus *Voluta.* Shell univalve, convolute, columella or pillar plaited or screwed, the lower plaits being the largest; it has neither lip nor umbilicus, fig. 83.

These shells are easily discriminated by the plaited columella, and by which they are particularly distinguished from the genus Conus. The plaits are longitudinally inclined and not nearly horizontal, as in the genus Murex. The name of this genus is expressive of the form of the shell *voluta*, "rolled up cylindrically." The genus contains many shells of considerable beauty, and, on the whole, is among the most elegant known.

The recent species are numerous, besides which eighteen fossil species are known.

Fig. 84.



Genus *Buccinum.* Shell univalve, spiral, gibbous, or protuberant, aperture ovate, ending in a canal turned to the right, with a short beak; interior lip flattened, fig. 84.

The direction of the canal towards the right, that is, *from* the exterior lip, is very characteristic of this genus. The name Buccinum, signifies a *trumpet*, or *horn*, but is often misapplied, since many of the species are less like a horn than those belonging to other genera.

This genus is divided into several families. The shells of some having little resemblance to each other in form; but a reference to the peculiarity of the beak will generally distinguish this genus. Fossil and recent.

Fig. 85.

Genus *Strombus.* Shell univalve, spiral, expanded; aperture having the lip unusually dilated, and ending in a canal, inclined towards the left, or *from* the pillar, fig. 85.

One species of this genus is well known under the name of *Conch-shell*, the interior of which is of a beautiful pink color, and was formerly in fashion in ornamental jewelry.

Some members of this genus might easily be mistaken for Murices, or Buccina; but the Strombi have a depression, or sinus, on the dilated wing, which is separate from the groove at the base of the shell, next the pillar. Attention to this will lead to the distinction. It is both recent and fossil.

Fig. 86.

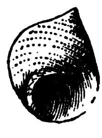
Genus *Murex*. Shelve univalve, spiral, often formed with longitudinal membranous sutures; and beset with spines; aperture terminating in a canal, either straight or turned up backwards, and not inclining to the right or left, fig. 86.

The very peculiar form of the aperture or canal, is a very distinctive feature in this genus. This is oblong-oval, or perfectly oval, and does not gradually contract into a canal, like the Strombi and Buccina, but suddenly opens into it at the same, or nearly the same, width, which it retains through the whole length of the beak.

The famous Tyrian purple was extracted from an animal inhabiting one species of this genus. A single vein near the head contains the coloring liquor; but the art of dyeing, in latter times, has disclosed more beautiful and much less costly colors than this produces.

The name Murex means *rough*, or rock-like, a designation which fails to apply in many of these species. It is both recent and fossil.

Fig. 87.



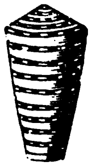
Genus *Turbo*. Shell univalve, spiral; aperture contracted, round, and entire. Fig. 87.

One of the best distinctions of this genus is the round aperture. The shells often closely resemble those of the Trochus genus, but, in these, the aperture is angular, often the only mark of distinction between the two genera.

The Turbo might at first be mistaken for the spire of another shell, but its unbroken base and round aperture will generally distinguish the genus. The name Turbo, means any thing which *whirls around*, as a top, in reference to the spiral form of the genus. It is both recent and fossil.

Genus *Conus*. Shell univalve and turbinate. Aperture effuse, longitudinal, linear, toothless, and entire at the

Fig. 88.

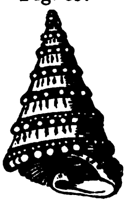


base. Columella smooth, base attenuated, sometimes marked with oblique grooves. Aperture sometimes dilated; whorls, mostly flat, often channelled, rarely crowned.

The great beauty of this genus, both in form and coloring, renders it highly interesting and valuable to the lovers of the science. The rare species are sought after with avidity by shell collectors, and the most beautiful kinds often sell for considerable sums. The Conus *gloria-maris*, and the Conus *cedonulli*, sometimes bring from twenty to twenty-five guineas for single shells.

The name Conus, *a cone*, refers to the shape of the genus.

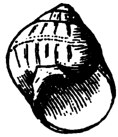
Fig. 89.



Genus *Trochus*. A spiral, sub-conical univalve; aperture four sided, and somewhat angular, having the upper part of the margin converging towards the pillar, which is oblique. Fig. 89.

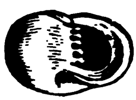
In some species the aperture tends to an oval form, but these are distinguished from the Turbines by a tooth-like projection. It must, however, be confessed, that there is much difficulty in distinguishing some specimens of these two genera from each other. In general the Trochi have the form of a pointed cone, capable of standing nearly erect on their bases. The word Trochus has a similar meaning to Turbo—the common name is *top shell*, or *button shell*, the shape being similar to that of a common spinning top or an ancient conical button.

Fig. 90.



Genus *Helix*. Shell univalve, spiral, translucent, brittle; aperture coarctate, or contracted, lunate or circular, having the segment of another circle taken from the whole area, fig. 90. The common land snail is a good example of this genus. The whorls are contiguous, and the body of the shell *always* forms a lunate projection into the aperture, and this character will distinguish the Helices from the Trochi and Turbines. Another mark of the genus is tenuity, or thinness and translucency.

Fig. 91.

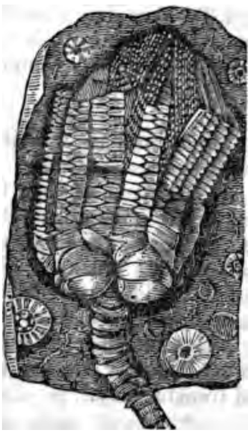


Genus *Nerita*. Shell univalve, spiral; gibbous, flat underneath, aperture semi-orbicular, or semi-lunar, having uniformly the pillar lip, or columella straight. Fig. 91.

The Nerita is a genus well characterized, and therefore easily distinguished, the straight pillar lip being a uniform mark, which at once separates them from the Helices, which their forms most resemble. Nothing can exceed the beauty and delicacy with which some of these shells are marked, or the rich tints of color with which others are stained. It is both recent and fossil.

Extinct Fossil Shells. Such shells as have not been found in the recent, or living state, are considered as extinct. It is obvious that this criterion must, however, in the present state of knowledge, be exceedingly uncertain, since further investigations most probably will show that many species now considered as lost, will be found still living. Had all the shells unknown to Linnæus, been considered extinct, a great proportion of those now in the cabinets of collectors, would have been among the lost number. Still there is, perhaps, no other rule by which naturalists can be guided, than to consider every unfound species of shell, as well as of quadrupeds, extinct, though there is a thousand fold greater prospect of finding new species of the former, than of the latter.

Fig. 92.



Encrinite. This is a genus of singular and curious animals which being found among the lower strata of rocks, are supposed, by those who think there were successive creations, to have been among the first inhabitants of this earth.

The Lily Encrinite, fig. 92, is a beautiful fossil, so called from its resemblance to the form of that flower. It was an acephalous or headless animal, attached by a root-like base, to other substances. This base was jointed as seen in the figure, and on its top were placed five wedge shaped bones, which constitute the smooth circular central part, around which are disposed five other pieces, called *ribs*. On the upper edge of these are placed bones forming two arms, each of which divide into articulated fingers, and tentacula, or feelers, which, when closed, bear a lily-like appearance, (as in the figure,) and when expanded, form nearly a circular net of jointed meshes. These on closing, would secure the prey and direct it into the stomach, which, probably, was situated in a central cavity, at the upper part of the base. These animals appear to have had considerable range for the seizure of their prey, without possessing absolute locomotion, the peculiar mode of articulation, affording them a great degree of mobility, with considerable security against dislocation.

These remains are found in that species of limestone called oolite, at Stonefield, in England, and are often in such abundance, that a considerable proportion of the rock appears to be formed of them.

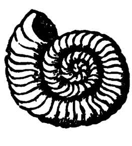
No living analogue of this animal is known.

Fig. 93.

Belemites. This is a conical, spindle-shaped stone, of brown radiating spar, generally terminating at the small end in a point, and having at the larger end, a conical cavity, naturally retaining a conical testaceous body, divided into chambers, by plain concave partitions, and pierced by a siphuncle, or orifice, fig. 93.

This extinct fossil occurs in great abundance in the kind of limestone called *lias*, in several parts of England. It is also found in the newer limestone groups of this country.

Fig. 94.



Ammonites. A multiocular, or many celled, spiral shell, with contiguous apparent turns; the chambers being divided by winding partitions, and pierced by a siphuncle or winding orifice, placed at the outer side, fig. 94.

More than seventy species of this fossil are found, and have been determined and named by the English geologists. It is found in the limestones of different names and ages, and also in chalk and clay. No living analogue of this genus, has ever been discovered.

Fig. 95.

Orthoceratites. A multiocular, and slightly bent, cylindrical, or slightly conical univalve shell; the chambers separated by a plain septa, concave towards the larger end, and pierced with a siphuncle, fig. 95.

This is considered one of the earliest creations, by those who suppose that the days of creation, were indefinite periods, and yet it is a shell of great complexity, showing that the most simple organizations, do not necessarily belong to the lowest strata.

Fig. 96.

Nautilus. A many celled spiral univalve, the turns contiguous, the outer one including the others; the chambers separated by plain, or nearly plain partitions, placed transversely, and concave outwards; these are perforated by shelly tubes, connected by a tubular aperture, running across the chambers, so as to form a complete siphunculus, fig. 96.

To observe the chambers and siphuncle, the shell must be sawn into two parts longitudinally. It is both fossil and recent.

The name Nautilus signifies sailor, and under this term was formerly included the Argonauta, which, from its supposed skill in sailing, gave name to the whole.

The great difference in the internal structure of the shells have induced subsequent conchologists to separate the genera. The present Argonauta is the true sailor, though the credit is popularly given to the "Nautilus" which it is said, "taught men how to sail."

There is a considerable number of species of this genus, both fossil and recent, some of which are so small as only to be defined by means of a microscope, while others are nearly a foot in diameter.

Fossil Insects. Insects, owing to the delicacy of their structure, and the nature of the substance which enters into their composition, appear, generally, to be unfitted to sustain those changes which convert animal substances into fossils, and hence few insects have been found in this state. The crustaceous coverings of the bodies and limbs, and the hard wing-cases of a few genera, are the chief, and perhaps the only fossils which can be referred to this class.

Fig. 97.

The *Trilobite*, or what is called in England the *Dudley Fossil*, fig. 97, is considered by some an insect, but by others a bivalve shell. Its superior covering, the only part distinctly preserved, is oblong, ovate, convex, and marginated; the anterior, wider part, is gibbous, and furnished with two semilunar tubercular projections resembling eyelids; and posterior to, and on the inner side of each of these, are two round tubercles. Adjoining to this part, commences a series of scale-like transverse slips, so disposed, that the three rows of these connected slips, form three longitudinal transversely divided lobes, gradually diminishing to the lower termination. In some specimens, the fossil is nearly globular, showing that the animal had the power of coiling or folding himself together, like the millipede. It is doubtful how this animal accomplished locomotion, since it is not certain that any indications of legs and feet have been observed. This insect fossil has been found four or five inches in length, though the common size is much less.

It occurs abundantly in the organic limestone formation at Trenton Falls, New York.

Fossil Fishes. Mr. Parkinson says, that "The fossil remains of fishes are found in such various states, under such different circumstances, and in the formations of such distant periods, as cannot but lead the zealous inquirer to expect that he shall derive from their examination, information of considerable importance."

The fish, in some specimens, are found nearly entire, the harder parts, "all in their natural situations, with their scales, and even skin preserved. In others, all the other parts are removed except the skeleton, the bones of which either retain their original relative situations, or have undergone considerable distortion, or even dislocation. In some instances, not only separation of these parts has taken place, but the greater part of the skeleton has been removed."—*Organic Remains*, 277.

There is, probably, no class of animals, the remains of which are found in the fossil state, that are capable of being referred to so many living analogues as fishes. According to Mr. Lacepede, more than thirty Asiatic, African, and American species, have been found in the neighborhood of Verona, in Italy. The most celebrated locality of fossil fish is at Monte-Bolca, in Italy, and it cannot be doubted, that the catastrophe, whatever it might have been, which caused this vast accumulation of the finny tribes, must have been almost instantaneous, and that the fishes were not only suddenly deprived of life, but immediately afterwards buried in the deposite where they are now found. This appears from the singular circumstance, that one fish was found in the very act of swallowing another, having apparently had not sufficient time before it died to let go its prey. Now, when any fish (especially if furnished with an air bladder) dies, it remains at the bottom of the water for two or three days, it then rises to the surface, decays, and the bones sink to the bottom. Hence, if some time had elapsed between the death of this fish and its burial, it would, instead of being caught in the earth, have rose to the surface of the water, and at least separated from the victim it was about to swallow. This is probably the reason why fossil fish are so rare, even among strata known by other remains to have been deposited from the sea. They first rise to the top of the water, after being deprived of life, where they remain until the flesh is so decomposed, that the bones separate, and are dispersed. We may, therefore, conclude, that in most, if not in all instances, where fossil fish are found, they must have died and been buried by some extraordinary catastrophe or convulsion.

Besides the proof just adduced of the suddenness of the revolutions which have entombed fishes, in almost all cases, the remains have been found in postures indicating a violent death. Thus, at *Eisleben*, in Thuringia, where there is a locality of ichthyolites, the fish are in every possible attitude, some of them three feet long, often lying on their backs, or recurved into constrained positions, with their heads crushed and disfigured. The strata enclosing them is a marly slate, impregnated with copper and bitumen.

The fish at Monte-Bolca are by some thought to owe their destruction, and the origin of the rock in which they are enclosed, to an adjoining volcano. The formation in which they are found is a marly slate. This, though not volcanic, might have arisen from the disturbance of a volcano. The remains as now found, show that most of the fish were enclosed in the earth while in an entire state, and many of them are still so perfect, that their generas have been determined, as the following list, among others, found there, is sufficient to show. The shark, ray, file-fish, sun-fish, globe-fish, trumpet fish, pike, silurus, herring, pipe-fish, cod-fish, blenny, goby, mackerel, bull-head, gurnard, gilt-head, perch, flounder, flying-fish, eel, dory, and many others.

Thus it may be observed, that although the remains of most quadrupeds are those of extinct species, a great proportion of the fossil fishes are those of living genera.

Arrangement of shells in strata. Although, as stated at the beginning of this article, the succession in which organic remains occur in the strata from below upwards, coincides, in a general sense, perfectly with the succession in which they were created, that is, plants, and "the moving creature that hath life," and the birds, were formed before the quadrupeds and man; still this general fact proves nothing with respect to the "successive development of organization," as some have attempted to show. Could it be proved that from the most simple organization, found in the lower strata, there was a regular gradation towards the most complex, there might exist some ground for a pretence, that there had been a gradual and constant improvement in the works of creation, leading to the atheistical supposition, that *nature* had improved by experience. But in detail, this gradual development of organization does not hold true, since animals of a more complex structure are often found in deeper strata, or below those which are less so.

"It has been conjectured by some naturalists," says Mr. Parkinson, "who had become convinced of the comparatively late creation of land animals, and of man, that the peopling of this planet had commenced in enduing with the principle of life beings of the simplest forms and organizations, and that by the influence of certain external causes. acting through passing ages, those changes had been gradually wrought in succeeding animals, from which have resulted the numerous differences which constitute the various tribes, rising from the almost lifeless sponge to the highly complex and more perfect animal, man. On this hypothesis, it might be expected that those beings which had possessed life under its most simple modifications, would be found in the earliest strata; and that in proportion to the lateness of the period at which the strata had been formed, would be the degree of complexity in the organization of the inhabitants whose remains they contain. But investigation has ascertained that such a conjecture, with respect to shells, is ill-founded. In the carboniferous and mountain limestone are discovered the remains of shells, of apparently the earliest creation, which are unexpectedly found, with hardly an exception, to exceed in complexity of structure all the shells which have been discovered, either in any subsequent formation, or living in our present seas. It is in this early creation that those shells are found which possess that complicated structure, very rarely found in shells of this day, which enabled their inhabitants to rise and sink with them in the water. Such are the many chambered univalves, the *Nautilus, Ammonites, Orthoceratites*, &c."—*Parkinson's Org. Remains*, p. 254.

The hypothesis of the gradual development of organic life, which it is thus shown cannot be sustained by facts, is both skeptical and unphilosophical. Its object is to prove that after the simplest form of plants and animals had existed for ages, from these there gradually resulted other plants and animals of more complex kinds, and so on in progressive improvement, until both, during the lapse of myriads of ages, arrived at their present state of perfection. It is skeptical, because it either acknowledges no Creator, or denies his power to form at once the most perfect beings; as though the same power which created an oyster, wanted the experience of millions of years to form quadrupeds and man. Thus showing that the work of creation, for this reason, instead of being finished in six days, required millions of years. It is unphilosophical, inasmuch as it supposes that new genera and species, of different and more complex kinds, have been derived from others which were less so; whereas, in truth, we find that nature is invariable in this respect; not a solitary instance being known where this has happened either in plants or animals. Will any one, in his senses, believe that the oak ever sprung from the polypod or mushroom, that the flying fish came from the sponge, or that man began his race in the form and capacity of an ape? If this is ridiculous, the doctrine of progressive organic development is equally so, since it is founded on these very suppositions.

Alternating Marine and Fresh Water Shells. It has been supposed that in various parts of Europe, there was sufficient evidence of alternating marine and fresh water shells, imbedded in strata, and that, therefore, those parts of the earth where such phenomena exist, must, at some remote period, have been alternately covered by salt and fresh water. In France, there occur beds of gypsum and marl, in which are found the remains of quadrupeds, and above these occur marine shells; above which there is another fresh water formation.

The gypsum and marl being considered fresh water deposites, it is supposed that the bones found in them, belonged to animals which inhabited the shores of the lake, which once existed there.

From such facts, Cuvier and Brongniart inferred, that these different beds demonstrated the repeated alternations of the sea and of fresh water on the same tract, and that while the sea deposited marbles and slates, the lakes in their turn formed gypsum, marls, &c. But while maturing such opinions, these naturalists found it necessary to admit, that gypsum might be formed from salt, as well as from fresh water, and finally, that marine and river shells were really mixed together. Still Cuvier maintains the alternation of fresh and salt water formations; which doctrine is, however, strongly opposed by several naturalists of great ability. Metherie objects entirely to the supposition, that because the bones of land animals, and fresh water shells, are found in these formations, that therefore there must have existed a fresh water lake, but sees no difficulty in supposing that both were carried where they are now found, by the current of a river, which also deposited the matter in which they exist, in the sea, the water gradually retiring as the deposition was formed.

M. M. Brard, and St. Fond, are of opinion, that all the shells found in these depositions, originally existed in the same water; but that in process of time, perhaps from the increase of the saltness of the sea, a separation took place, the inhabitants of the shells which are at present found in the fresh water formation, having migrated to situations more congenial to their natures.

A dispute now commenced between these naturalists, and Cuvier and Brongniart, on the points of distinction between marine and fresh water shells, and in the course of which, the reader will find, 1st. that some shells live both in fresh and salt waters; thus, the Patellæ of rivers and those of the sea, differ hardly at all in their shells. 2nd. That in many other instances, besides that mentioned by Cuvier, land and sea shells have been found mixed with each other; thus, at Grignon, Lamarck found forty-eight river and land shells, among those which were decidedly marine, and all of them in the fossil state. 3d. It appears that the comparative thinness of land and river shells, as a distinctive mark between them and those of the sea, though often a true test, is not always so. And 4th, it appears that Cuvier and Brongniart had founded their opinion of the fresh water origin of the upper bed of gypsum, in the Paris formation, on the presence of *two shells only*, which they considered, of course, to be of fresh water growth; but one of which, Lamarck supposed to be a sea shell.

Now all these appearances may readily be accounted for, even admitting that there do exist fresh and salt water formations over each other, by supposing that such places were once the estuaries, or outlets of rivers, into the sea. At the mouth of every river may be found more or less fresh water shells, mixed with those of the sea. It cannot be otherwise, since the current floats these light bodies, after being separated from the animal, to considerable distances, and of course must occasionally deposit them among those thrown along the coast by the sea. It would hence seem, that the revolutions of the earth, insisted on by Cuvier, and in consequence of which the sea is supposed several times to have changed its bed, and to have alternated on the land with fresh water, are no longer to be considered, in accounting for the changes which the earth has undergone.

It has been already shown, that the facts observed at the mouth of the Rhone, will account for the mixture of marine and land shells, under the most common circumstances. See "Delta of the Rhone in the Sea."

COINCIDENCE OF GEOLOGY WITH THE MOSAIC HISTORY.

Almost from the commencement of geological investigations, designing men have attempted to show, that the physical history of the earth, and that of the creation, by Moses, could not be reconciled—that the former presented facts which were incompatible with the statements of the latter, and therefore, that revelation and reason were here in direct opposition.

Hence it was, that in the early history of this science, the church looked with jealousy upon these investigations, and even went so far as to restrict philosophers in their pursuits, or at least in their publications, and to denounce those who pretended to make discoveries, which they could not reconcile with the Mosaic record.

At that time, it is true, that little was known on this subject, and these alarming facts have long since been shown to accord entirely with revelation. But as the earth has been more extensively explored, new and unexplained facts have been constantly unfolded, and these, in their turn, have been made to bear against revelation; and have consequently, in many instances, operated against the free inquiries of those who had determined not to lift their hands against the Holy Scriptures, though they were made to believe, that geology presented facts which could in no way be reconciled with the common understanding of revelation.

Judging from the effects of causes now operating on the surface of the earth, it has been supposed impossible, that the deep strata of its crust could have been formed within the period assigned by the sacred history. The whole earth, indeed, seemed to bear such marks of antiquity, as could not be reconciled with any hypothesis of its recent origin. *Time* was, therefore, wanted: for the cosmogonist found that it was impossible to bound his speculations within the narrow limits allowed by the sacred historian. It was consequently necessary that he should either come out boldly and deny that authority, or invent some new interpretation of the text, by which the scope of his speculations should be free and unbounded.

In this dilemma, the celebrated theorist, Whiston, in about 1696, first proposed that the book of Genesis should be so interpreted, as to allow theoretical geologists full and ample scope for their cosmogony, without being suspected of heretical opinions; and thus were the Scriptures made to bow down before geology.

This, we believe, was the first innovation which was made upon the Mosaic history, for the accommodation of geologists; but certainly not the last; for at the present day it is the practice of some philosophers, and even those who profess their belief in the truth of the Scriptures, to interpret them for the express accommodation of their own understandings.

Now, if a geological, or any other fact, contradicts the Scriptures, they are not the words of truth, and if this is the case, let the fact be shown; for if the Scriptures contradict the truth, they cannot be of divine origin, and, therefore, ought not to be the rule of our faith; for it is certain, that truth can never be inconsistent with itself. But before we reject or misinterpret this record, let us be certain that our facts are true ones, and that they do not coincide with the plain and obvious meaning of the sacred text.

We have the satisfaction of believing, that the systems of Inspiration and Nature have both emanated from the same Divine authority, and that when both are understood they will harmonize with each other; and it will be our object to show, in the following pages, that even taking the Scriptures in their most obvious sense, there is no want of harmony between inspiration and natural phenomena, so far, at least, as relates to the Mosaic history, and the facts of geology.

Our knowledge of the primitive or ancient world, is derived entirely from two sources, viz. first, The history of the creation by Moses, as contained in the first chapter of Genesis; and second, The investigations of geology.

The information to be derived from Genesis is of various kinds, and of the highest importance, since it is the only source whence we gain any consistent account of the origin of the universe and of ourselves. We shall, however, confine ourselves chiefly to such parts as relate to geology, and shall proceed with the understanding that this history is from an inspired pen;—that it is written in a manner by which its great outlines are adapted to a plain and common apprehension, and that the author, in this respect, intended his words should be received in their most obvious meaning.

CREATION OF HEAVEN AND EARTH.

"In the beginning God created the heavens and the earth." Gen. i. 1.

That is, in the beginning of *time*, the earth was created, for, before this, there was nothing by which time could be measured, or its beginning dated. All was eternity.

"The earth was without form, and void, and darkness was upon the face of the deep." V. 2.

How long the earth continued without form, and in darkness and chaos, we have no means of knowing. Had this information been of importance to man, God would have revealed it to Moses, and he would have recorded it for our use. On this point, therefore, we have a right to conjecture, and may believe, without the least violation of the sacred text, that the materials of which the earth is composed, were created a thousand, or a million of years before they were brought into a form fit for the habitation of man.

That the earth was not from eternity is shown by the first words of the history; for eternity has no *beginning*, and what is *created* cannot always have been. Besides, we have the direct testimony of inspiration, that there was a period when the earth did not exist. "Before the mountains were brought forth, or ever thou hadst formed the earth, and the world, even from everlasting to everlasting, thou art God." Ps. xc. 2. Hence, although we are bound to believe that this world had a beginning, and was a part of the work of creation, still there is nothing on record which restricts us with respect to its antiquity. Theoretical geologists may, therefore, allow themselves full scope in this part of the history, with respect to *time*, provided they do not go beyond the "beginning." The primitive rocks, in which no organic remains exist, we may consider, without violation of Scripture authority, as having been millions of years in forming, but it is much more reasonable, we conceive, to suppose, that at some unknown period they were, like the other parts of creation, brought into existence at the immediate command of the Creator; for, not being stratified, there is no reason to believe that their formation was a work of time. The secondary rocks, containing the remains of organized beings, stand in a different relation with respect to time. These show, by their stratified structure, that they were gradually deposited from a fluid, and, therefore, that time was consumed in their formation. But every one who believes the Scriptures, is bound to believe also, that since these rocks contain organized substances, they were formed since that period, when it was said, "Let the waters, under the Heaven, be gathered into one place; and let the dry land appear," for, before that period, there is no account of the creation of either plants or animals.

Whence did the first Light emanate? And God said let there be light; and there was light. In Hebrew, "light was." V. 3.

This is the first particular creative act stated in the history; the first verse containing merely a general declaration that the heavens and the earth had been created; the manner in which the latter was brought from its chaotic state, into a condition fit for the residence of organic beings, and the succession in which these beings were created, forming the succeeding narrative.

Various opinions have been advanced, concerning the nature of this light, and the source whence it proceeded. Some have supposed that it was electrical, and others that it was phosphorescent, and, in both cases, that it did not emanate from any particular point, but that it was diffused through the space surrounding the earth. Others again have believed that it proceeded from a meteor, which was created for the purpose of enlightening the earth during the first three days, and before the sun was called into existence. But there exists no analogy for such a hypothesis; and it would even be derogating from the Wisdom and Power of Him who, three days afterwards, set the great lights in the firmament, to suppose that He should have made an evanescent one, for the use of the earth, while as yet it contained neither plant nor animal. There is no instance recorded, where the creative fiat has been employed for such a purpose, nor does the language of Moses necessarily imply, that the sun and moon were not created at the time when God said, "let there be light." When we come to the fourth day's work, we shall attempt to show, that the luminaries had a previous creation, but were first made to shine upon the earth on that day.

"And God divided the light from the darkness." V. 5. Whatever might have been the source whence this light proceeded, it is plain from this declaration, that it could not have been generally diffused around the earth, for had this been the case, it is impossible for us to apprehend how it could have been divided from the darkness. On the contrary, the terms of the record lead to the belief, that at this time the earth had commenced her diurnal revolutions, and the light emanating from a fixed point, was divided from the darkness by the first succession of day and night. This, indeed, is affirmed by what immediately follows. "And God called the light, day; the darkness he called night; and the evening and the morning were the first day."

Creation of the Firmament. "And God said, let there be a firmament in the midst of the waters, and let it divide the waters from the waters." V. 6.

Firmament. Heb. Expansion. The original word is *Rakiah*, which comes from a root, signifying *to stretch out, or expand like a curtain.* It also means, *to make hard and firm by treading, stamping, or beating with a hammer.** But it appears to be the former signification only, which applies to the present case.

It is apparent that Moses intended to adapt his account of the creation to unlettered common sense, and to describe natural events as they would have struck the eye of a common observer. Hence the firmament is called *heaven*, because it is over our heads, and for the same reason, the sun, moon, and stars, in v. 15, are said to be placed in the *firmament.* Now heaven, as the word is here employed, means nothing more than the blue vault of the sky; and therefore is synonymous with firmament. Firmament is the atmosphere which we breathe, and

* Bush on Genesis.

which science has taught, reaches to the height of about forty-five miles from every part of the earth's surface. The stars are millions of miles beyond this firmament, but since they are seen *through*, they appear to the eye to be placed *in* it, and the Mosaic history is adapted to this illusion. This is one among many existing proofs, that the narrative of the creation was intended to describe natural phenomena as they meet the eye, rather than to give a system of physics to the minds of philosophers.

"And God made a firmament, and divided the waters which were under the firmament, from the waters which were above the firmament." V. 7.

By this act, the atmosphere was made to absorb a part of the waters which had previously covered the earth, and thus to elevate them above the surface. The quantity of moisture contained in the atmosphere, differs greatly in different countries, and at different times; but that it is capable of elevating large quantities of water, is sufficiently proved by the fall of dew and rain upon the earth. The atmosphere is incapable of absorbing any of the solid ingredients with which the water on the earth is mixed; a striking mark of design, for were the salt of the sea taken up with its waters, and thrown upon the earth, in the form of rain, not only almost the whole vegetable kingdom would be destroyed, but also all terrene animals.

MOSAIC, AND NATURAL SYSTEMS OF PLANTS.

After the sea was formed, by the gathering of the waters into one place, and the dry land made to appear, the earth being thus prepared for the growth of vegetation, and the residence of organized beings, then "God said let the earth bring forth grass, and the herb yielding seed, and the fruit tree yielding fruit after his kind, whose seed is in itself upon the earth; and it was so." V. 11.

Here we find a remarkable coincidence between the divisions of the vegetable kingdom, by Moses, and the most improved systems of natural botany, at the present day.

In the 11th verse, instead of grass, the Hebrew means *tender*, or *budding* grass,* or grass sprouts; thus apparently intending to include all the small, or inferior plants,

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* Marginal reference.

with which the earth is clothed, and which to common observation spring up without seeds, or are propagated by their roots. Many low plants, of the moss kind, also bear capsules, which appear like buds, though they produce no flowers, or visible seeds; and these, in popular language, would come under the general denomination of grass.

The terms, therefore, warrant us in concluding, that in this division the author intended to embrace, generally, those plants which give verdure to the earth, but whose seeds were concealed, or not apparent, and thus to distinguish them from "the herb yielding seed," or those whose seeds form the most obvious part of the plant. If there is nothing unreasonable in this conclusion, then this division includes those tribes now known under the title of Cryptogamous, or flowerless plants.

In this division, there are neither flowers nor apparent seeds; reproduction being effected by parts, termed *sporules*, as in the flags, ferns, mosses, &c.

The "herb yielding seed," by the most obvious construction, applies to that division of plants now called Monocotyledonous, or such as produce seed, with a single cotyledon or seed lobe, as wheat, barley, and the grasses. In many of the useful plants of this class, the part most apparent is the seed, as in the saccharum, (sugar cane,) sorghum, (broom corn,) oat, wheat, rye, millet, &c., and hence, "seed-yielding plants," would be one of the most natural distinctions between these, and the cryptogamia, and smaller grasses, where the reproductive parts are either entirely concealed, or so small as to be apparent only by close inspection.

"The tree yielding fruit, whose seed is in itself," that is, in the fruit, is a description which clearly forms a third division of the vegetable kingdom. This division was undoubtedly intended to include the larger vegetables, or trees, properly so called, and the description applies with singular accuracy to many of the most common fruit-bearing plants, in most parts of the world. The apple, pear, peach, almond, grape, bread-fruit, orange, chestnut, bean, pea, melon, and many other domestic, as well as wild plants, which from the most ancient times have been best known, and most esteemed, bear their seed within their fruits, and are thus readily and naturally distinguished from wheat, barley, and other plants of this kind, where the seed is apparent to the sight.

This division, therefore, corresponds to the present class in Natural Botany, called the Dicotyledonous, or plants whose seeds consist of two cotyledons, or seed lobes, and which class, besides those already mentioned, includes many of the largest and most important vegetables.

Thus we arrive at the surprising fact, that the three grand divisions of the vegetable kingdom, made by Moses, not merely bear an analogy to the most improved Natural Systems of Botany, of the present day, but that the two systems, in their great outlines, are nearly identical; and it is worthy of notice, that the existence of this analogy is owing to the perfection to which natural botany has been brought, by the recent investigations of profound naturalists. Thus do philosophers, unawares, confirm the inspiration of the scripture, for there is not the slightest probability that the system of Moses could have been founded on botanical knowledge then existing, and therefore could not have been derived from any human source.

We do not pretend that the descriptions of Moses are so definite as to include all the plants of each of the present classes, to the exclusion of all the others. But that his definitions apply to the most common and useful vegetables of each class, and are such as to form natural distinctions between these, which would be apparent to a common observer, it is thought we have made fully to appear, and thus to have shown that the progress of a human science towards perfection, has only served to approximate its great outlines more nearly to a system founded on an inspired knowledge of nature, and written 3000 years ago.

From this we may infer the impropriety of wresting the plain and obvious meaning of the Scriptures, so to make them agree with what we call scientific facts, and especially on subjects still in controversy, as are many of those belonging to geology. If we will but let the sacred writings stand until our sciences become perfect, we shall then see their coincidence, and if we do not, it will be in time to amend the Scriptures so as to make out the agreement, when it is clearly proved that science is right, and Scripture wrong. We refer here, particularly, to the translation of the days of creation, into indefinite periods, a subject which we shall examine in its proper place.

The discoveries of geology, with respect to the order in which fossil plants, shells, and bones occur, show a consistency with Scripture, little less extraordinary than that we have shown to exist between the Mosaic and modern botany.

In the order of creation, we have seen that plants of the lowest grades were first brought into existence, and that those of the more perfect kinds were formed afterwards. In the strata of the earth, the same corresponding order exists; the Cryptogamous plants being found deepest, and below those of the Monocotyledonous tribes; while above these, the Dicotyledonous species occur. We shall throw the details of these, and other coincidences, into the form of a table, a few pages hence.

Sun and Moon made to appear. The work of the fourth day consisted in setting the great lights, and also the stars, in the firmament.

"And God made two great lights, the greater light to rule the day, and the lesser light to rule the night; he made the stars also." V. 16.

"And God set them in the firmament of the heaven, to give light upon the earth; and to rule over the day." V. 17, 18.

The original word for *made*, is not the same with that rendered *create*. The latter term signifies *re-form*, or *renovate*, while the former more often implies *constituted, appointed, or set apart.**

The language does not, therefore, necessarily imply that the sun and moon were *created* on the fourth day, but only, we conceive, that they were made to appear and act as rulers over the day and the night, at that time. If we suppose, with others, that Moses stated the story of the creation, as it would have appeared to human eyes at the time, these luminaries would undoubtedly have looked like a new creation; when, in truth, they might have existed from the time when it was said, "Let there be light."

We infer this from the circumstance, that the newly formed earth must have been surrounded with dense vapors, since, until the third day, the atmosphere rested entirely on a continuous ocean of water. The mist spoken of afterwards shows that the newly formed earth supplied

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* Bush on Genesis.

the firmament with abundance of moisture, for some time after the dry land had appeared. We know that, at the present day, aqueous exhalations are peculiarly dense on the ocean, and that they often hide the heavenly bodies for many successive days. Hence, when nothing but oceans existed on the surface of the globe, with the same atmosphere which we have at this day, it certainly cannot be unreasonable to conclude, that the sun and moon might have been entirely obscured, and prevented from throwing their direct rays upon the earth, for the space of three days. During this time there would have been a diffusive light, while the sources whence it came would be invisible.

Now, on the third day, the dry land appeared, and, therefore, the source of these exhalations became diminished, so that they, of course, became less dense than before. Under such circumstances, from what we observe of meteoric phenomena at the present time, we should expect that by the fourth day the exhalations and clouds would entirely disappear, and that the sun would shine forth in all its splendor. To the eye of an imaginary spectator, therefore, this would appear as a new creation, since the sun had never before shone upon the renovated earth; and, at night, the moon and stars would appear under the same aspect.

This supposition accounts satisfactorily, we think, for the division of light from darkness on the first day, and the succession of day and night, by the diurnal revolution of the earth afterwards, for as, at the present time, when the face of the sun is invisible, there is still a division of light and darkness, or day and night.

Hence, as it is not incompatible with the terms of the history to believe that the sun and moon were created on the first day, is it not more probable that this was the case, and that "the light was divided from the darkness," by the first revolution of the earth, than it is, that a phosphorescent light was created expressly for the use of an uninhabited earth, for so short a period, and during which, we cannot account for the succession of day and night?

Signs, Seasons, Days, and Years. Besides "dividing the light from the darkness," and "ruling the day and night," the sun and moon were to be for "signs, and for seasons, and for days, and for years." V. 14.

The vicissitudes of the seasons are caused by the annu al revolution of the earth around the sun, together with the obliquity of the earth's axis. It is, therefore, the real motion of the earth, instead of the apparent motion of the sun, by which these changes are produced. The language is, however, in conformity with that employed in other parts of this history, the effect being attributed to the motion of the sun instead of to that of the earth.

In addition to the effects which these changes have upon the face of the earth, and the interests of the husbandman, the four seasons were particularly noticed in ancient times, because they fixed the periods of the sacred festivals.

The length of the year, is the time occupied, by the earth, in making one complete revolution around the sun, during which the sun appears to make 365 diurnal revolutions around the earth. The sun, therefore, in effect, is the cause of the seasons, the days, and the years; for, without his light and heat, none of these changes would take place; and, to this day, when it is universally known that the diurnal and annual revolutions of the sun are only apparent, his motions, in common language, are still spoken of as real, and time is every where measured by his motions instead of those of the earth. Thus, we say, the "sun rises in the east," and "sinks in the west," &c.

That the historian here meant, we should understand by the word *day*, the time included between two settings of the sun, or a period which we call twenty-four hours, instead of an indefinite period, as some have claimed, for the days of creation,—that, by the word *seasons*, he intended the common seasons of the year; and that by this term, was signified, from spring to spring again, or a term of 365 days, we believe no one will deny, who desires to give the Scriptures a fair and honest interpretation.

Creation of Creeping and Flying Things. On the fifth day, "God said, let the waters bring forth *abundantly* the moving creature that hath life, and fowl that may fly above the earth, in the open firmament of heaven." V. 20.

This is often rendered *creeping*, instead of *moving* creature. The root, in Hebrew, (sheretz,) is said to be derived from a verb which signifies to *bring forth* or *multiply* abundantly, so that the translation ought not to be the *creeping*, but the *rapidly multiplying creatures.**

The meaning is obviously intended to include the larger reptiles, as well as all the small animals inhabiting the water, as insects, worms, and shell fish, many tribes of which are known to be exceedingly prolific. The rapidity with which some shell fish, as the oyster, multiply, may be inferred from the vast numbers which are consumed for food; and there is reason to believe that other species, which are placed without the ordinary reach of man, or which he does not use for food, are equally prolific. The great thickness and extent of some strata, composed almost entirely of shells, are a sufficient proof of the almost infinite fecundity of these animals.

The word rendered *fowl*, (in Hebrew *oph*,) and by which its meaning is limited to the birds of the air, is said more properly to signify *flying thing*,† and that the original will admit of such a meaning as to include flying insects, appears from Levit. xi. 20. All *fowls* that creep, going upon all four. We may therefore understand that flying insects, as well as shell-fish, reptiles, and birds, were created on the fifth day.

Creation of Mammalia and Man. On the sixth and last day of the creation, the "beasts of the earth," "cattle after their kind," and lastly *man*, were brought into existence.

The "beast and cattle" are supposed to include the whole division of what are now called Mammalia, or milk-giving quadrupeds, the amphibious quadrupeds having been created on the fifth day.

Coincidences between Genesis and Geological facts. Having thus taken such notices of the history of the creation as our object requires, we will next proceed to show the coincidences between the successive creations, and the results which geology has been the means of unfolding.

It was long since remarked by geologists, that impressions of ferns, and other cryptogamous plants, were found

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* Professor Jameson's Ed. New Phil. Jour. 1832. † Ibid.

in the deepest secondary strata, or in the first deposited earth which contained any signs of organic life; while on the other hand, it was well known that the bones of mammiferous animals existed only near the surface. Successive discoveries have completed the series, and have shown that there exists an exact correspondence between the order of creations, as stated by Moses, and of the fossil remains of vegetables and animals discovered by geology

The basis of the following table is contained in Professor Jameson's new Philosophical Journal, published at Edinburgh, in 1832. In the references to Genesis, the events on which geology can throw no light, are in italics.

In the original table there is no reference to the distinctions which Moses has made with respect to the different kinds or classes of plants, and which we have shown to form the most striking coincidence between scripture and science. This coincidence, so far as we know, has never before been shown to exist in detail, and this discovery, if we may so call it, has not only been added to the table, but the whole has been enlarged about one half, by additional quotations from different authorities.

TABLE

OF COINCIDENCES BETWEEN THE ORDER OF EVENTS, AS DESCRIBED IN GENESIS, AND THOSE UNFOLDED BY GEOLOGICAL INVESTIGATIONS.

IN GENESIS.	No.	DISCOVERED BY GEOLOGY.
Gen. i. 1, 2. In the beginning God created the heavens and the earth. And the earth was without form and void; and darkness was upon the face of the deep; and the spirit of God moved upon the face of the waters.	1	It is impossible to deny that the waters of the sea have formerly, and for a long time, covered those masses of matter which now constitute the highest mountains; and further, that these waters, for a long time, did not support any living bodies.—*Cuvier's Theory of the Earth.* Again, " Thus it is rational to believe, that shells and fishes did not exist at the period of the formation of the primordial layers."—*Cuvier's Rev. of the Globe*, p. 68.
V. 3, 4, 5. *Creation of light.* 6, 7, 8. *Creation of the expansion*	2	It is unnecessary to stop to prove, that our continents have once formed the bed of the sea; there is no longer any division

IN GENESIS.	No.	DISCOVERED BY GEOLOGY.
or atmosphere. 9, 10. The sea formed by the gathering of the waters into one place, and the appearance of dry land.		of opinion among naturalists upon this point.—*De Luc, Lett. Geol.* p. 301.
12. Creation of tender, or budding grass. 12. Herb yielding seed. Wheat and barley are monocotyledonous plants. 12. And the fruit tree yielding fruit after his kind, whose seed is in itself. Pears, apples, peaches, chesnuts, are dicotyledonous plants.	3 3	Cryptogamous plants in coal strata.—*Many authors.* In the formation of coal and anthracite, the vegetables are almost all cryptogamia, as ferns, equisetums, &c., and plants of the monocotyledonous tribes, some of which were of arborescent species, now no longer existing.—*Adolphe Brogniart.* There may be a connexion between an extraordinary profusion of monocotyledonous plants, and a youthful condition of the world.—*Lyell,* vol. i. p. 147. *Brown coal* is formed of large trees, whose texture is still to be discerned, and from scattered leaves, they undoubtedly belonged to dicotyledonous families.—*Count Sternberg.* (Brown coal is considered a more recent formation than common coal, or anthracite.)
14 to 19. *Sun, moon, and stars, set in the firmament, to divide the day from the night, and to be for signs, and for seasons, and for days, and for years.*		
20. Let the waters bring forth abundantly the moving creatures that hath life.	4	Shells in the Paris basin.—*Cuvier.* Shells in Alpine and Jura limestone.—*Humboldt.* Fish in Jura limestone.—*ib.* Shells and vegetable remains are found in the next order below those of fish and oviparous reptiles.—*Sir H. Davy.* Teeth and scales of fish in Tilgate sandstone.—*Mr. Mantell.*
Creation of flying things.	5	The remains of birds with those of fish and oviparous reptiles.—*Sir H. Davy.* Bones of birds in Tilgate sandstone.—*Mr. Mantell.* Elytra of winged insects in calcareous slate at Stonesfield.—*ib.*

IN GENESIS.	No.	DISCOVERED BY GEOLOGY.
21. Creation of reptiles. Every living thing that moveth, which the waters brought forth abundantly.	6	Bones of crocodiles at Manheim.—*Von Bush.* Bones of saurian animals at Stonesfield. *Mr. Mantell.* Remains of sea turtles and lizard like animals, at St. Pierre.—*Dr. Ure.* It will be impossible not to acknowledge, as a certain truth, the number, the largeness, and the variety of the reptiles which inhabited the seas, and the land, at the epoch at which the strata of the Jura were deposited.—*Cuvier.* There was a period when the earth was peopled by oviparous quadrupeds, of the most appalling magnitude. Reptiles were the lords of the creation.—*Mantell.* Animals analogous to the frog, toad, and salamander, existed when the strata were disordered by the revolutions of the globe. —*Dr. Ure.*
24, 25. Creation of mammalia; the beast of the earth after his kind, and cattle after their kind.	7	Bones of mammiferous quadrupeds are found only when we come to the formations above the coarse limestone, which is above the chalk.—*Cuvier.* The remains of quadrupeds of extinct species, occur next above those of birds and oviparous reptiles.—*Sir H. Davy.* It is only in the loose and slightly consolidated strata of gravel and sand, and which are usually called *diluvial* formations, that the remains of animals, such as now people the globe, are found.—*Sir H. Davy, Consolations of Travel.*
26, 27. Creation of he human race.	8	It is a fact, that as yet no human bones have been discovered among fossil remains.—*Cuvier's Rev. of the Globe,* p. 81. But found covered with mud, in the caves of Bize.—*Journal.* The great question concerning human remains in a fossil state, stands now before the world in an entirely different aspect from what it did when Cuvier published his work.—*Granville Penn.* Human bones, supposed to be fossil, have been found in the caves of Durfort and Kosritz.—*Outlines of Geology.* In some few instances human bones occur, but the era to which their possessors ought to be referred, has not been satisfactorily ascertained. Though some are more modern, others seem to claim an antediluvian antiquity.—*Sharon Turner.*

IN GENESIS.	No.	DISCOVERED BY GEOLOGY.
		In the delta of the Ganges human bones have been found ninety feet deep.—*Von Hoff.*
Genesis, chapter vii. The Deluge of Noah. "And the waters prevailed exceedingly upon the earth; and all the high hills that were under the whole heaven were covered." V. 19. The deluge happened A. M. 1656, being 2348 years before the Christian era, and 4184 before 1836.	9	If there be any thing determined in geology, it is, that the surface of our globe has been subjected to a vast and sudden revolution, not longer ago than five or six thousand years.—*Cuvier's Rev. Globe*, p. 180. A universal deluge seems clearly proved by the utter extinction of the primeval race of animals.—*Dr. Ure.* The Alps and Carpathians, as well as every other mountainous region which I have visited, bear the same evidence of having been modified by the force of water, as do the hills of the lower regions.—*Dr. Buckland.* Geology fully confirms the scriptural history of the deluge.—*Prof. Silliman.*

The numbers 4, 5, and 6, we will not conceal, are liable to be interchanged among themselves, in respect to place, and we shall derive no argument from them, farther than what arises from the circumstance, that they are all placed in one group. Still the number of coincidences here shown between the order of the epochs of creation assigned in Genesis, and that discovered by geology, are calculated not only to excite the attention of scientific men, but also that of theologians, as forming an additional argument to the truth of inspiration.

Human science, in the probability of chances, as illustrated by La Place, has put us in possession of an instrument for estimating the value of these coincidences; and we* feel amply entitled to take advantage of it for that purpose, for no case could well be pointed out, where it would be more correctly applicable than in this, where the coincidences assume a definitely successive numerical form. We are entitled to adopt even the language of La Place, and to say, "by subjecting the probability of these coincidences to computation, it is found that there is more than sixty thousand to one against the hypothesis, that they are the effects of chance."†

"It is thus, then, that the discoveries of geology, when more matured, instead of throwing suspicion on the truths

* Jameson's Journal. † System du Monde, Book V.

of revelation, as the first steps in them led some to maintain, have furnished the most overpowering evidence in behalf of one branch of these truths.*

DAYS OF CREATION.

At the commencement of this article, we noticed that hypothetical geologists required more time than was allowed by Moses, to account for various phenomena which the earth presents; and that so early as the time of *Whiston*, it was proposed so to interpret Genesis, as to leave geologists full scope for their speculations.

From that time to the present, there have not been wanting authors, who either through motives of self-convenience, or a desire to reconcile science with revelation, have ventured to call the days of creation, periods of great or indefinite length.

To believers in revelation, this cannot be an unimportant subject. If the very commencement of the book of inspiration can be interpreted in a sense so entirely different from its plain and obvious meaning, what portion of scripture conveys truth to the understanding? And if the translation does not convey the intended meaning of the author in this case, where are common readers to look for such meaning?

We propose, therefore, to examine the question, whether the terms in which the Mosaic history of the creation is written, will, by any fair interpretation, allow the belief that the periods therein called *days* were intended to mean indefinite time, or whether they were periods of more than twenty-four hours.

If the Scriptures are true, they must be so in their most plain and obvious sense, and if any scientific fact contradicts this sense, then, to a common understanding, they do not convey the truth.

If an author uses the same terms in different places, and apparently in the same sense, we are bound to believe that he means the same in every case. If he intends to convey different ideas by the same terms, standing in similar connexions, and this without warning his readers,

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* Jameson's Journal.

he cannot be a correct writer, because he is not only inconsistent with himself, but cannot be understood, and therefore he is not to be credited.

It is believed that no one will deny, that whatever may be said of the prophecies, the narratives of the Old Testament were intended, by their authors, to be understood by ordinary capacities, nor will it be claimed that the author of Genesis has been so inconsistent with himself, as on that account to raise a suspicion of his veracity.

This author has not only given us the history of the creation of all things, but also of the destruction of the ancient world by a flood of water.

Whoever reads the account of the latter, will there find, that "the flood was forty days upon the earth," or that it rained forty days; and that "the waters prevailed upon the earth an hundred and fifty days." And, whoever reads the account of the creation, will there find that the whole work was performed in six days, each day's work being described by itself, and the day carefully numbered, that in so important a work, there should be no doubt either with respect to the succession of the several creations, or to the time occupied in finishing the whole.

Now these narrations being from the same pen,—being also continuations of the same general history; and the word *day* being employed in the same unqualified manner in both cases, no reader can doubt, if the translation conveys the meaning of the historian, that he intended they should be understood to signify the same periods of time in both narratives.

From the statements of Moses, therefore, we are as fully entitled to the belief, that the waters of the deluge prevailed upon the earth for an indefinite period, or that a day of the deluge was a thousand years, and thus that its waters covered the earth for the term of 150,000 years, as we are to believe that a day of creation was an indefinite period, or a term of a thousand years, and thus that 6000 years were occupied in the work of creation.

If the terms of the history allow any difference with respect to the length of the days, this would certainly be in favor of those of the deluge, since the plural is there employed, while the singular only is used in the description of the creation, and each day is expressly confined within the "evening and morning." But no one, we believe, has proposed to consider the days of the deluge of greater length than twenty-four hours, though from the words of the record, we cannot perceive why they should not, equally with those of the creation, claim to be periods of a thousand years.

But it is needless to extend these considerations. If the words of Moses were intended to mean that a day of creation was a period of a thousand years, or any other period, more than a natural day, why have not the translators so rendered it? No man in his senses will pretend that Christianity required one translation and geology another; or that the Hebrew is better understood at the present day, than at the time when the Bible was translated.

Finally, with a few exceptions, it is the universal belief of the Christian world, and ever has been, that the work of creation occupied only six natural days, and this alone is a sufficient proof that the common translations convey no other meaning. The exceptions, therefore, could not have been derived from the translations, and we shall show directly, that they could not have been derived from any fair construction of the original.

Does the word DAY, *in Gen.* i. *admit of any other interpretation than the common one?* We think it has been shown above, that if the history of the creation has been fairly translated, it is impossible its author should have intended to convey by the word *day*, any other meaning in that history, than a period of twenty-four hours; and that this is proved by the universal understanding of the Christian church, and of the Christian world. But since some declare that this universal understanding is owing to a misinterpretation, or at least, that the terms of the original will admit of a construction different from the common one, we will here inquire of commentators, how far this is true.

Mr. Faber's Theory making the Mosaic days 6000 *Years.* The most conspicuous theologian who interprets Moses, so as to extend the days of creation to periods of great length, is Mr. Faber, an English writer, well known as the author of the "Three Dispensations," and other works, some of which are in common use, and in high estimation, in this country.

Mr. Faber says, "that the six demiurgic days, instead of being nothing more than six natural days, were each a period of very considerable length, may be proved partly by *analogy of language*, partly by *the very necessity of the narrative*, partly by *ancient tradition*, and partly (and that most decisively) *by the discoveries, or possibly the rediscoveries, of modern physiologists*."

With respect to the analogy of language, Mr. Faber says, that in Scripture, nothing can well be more indefinite than the term which we translate by the English word *day*. Sometimes it signifies *a single revolution of the earth round its axis;* sometimes it denotes a *revolution of the earth round the sun*, or what we call *a natural year*, &c.

"The question therefore is," says he, "what specific period it describes in the Mosaical history of the creation." If God labored six natural days, and rested on the seventh natural day, the very terms of the statement will imply that he resumed his labors on the eighth natural day, or on the first day of the following natural week. But did he resume his labors on the eighth natural morning? "Most assuredly he did not, and if he did not resume his labors on the eighth natural morning, then his Sabbath, or day of rest, extended beyond the seventh natural day, therefore a single natural day could not be the measure of the divine Sabbath."

"But at what time did the divine Sabbath, thus plainly extending beyond the limits of the seventh day, terminate?" asks our author, and to himself replies, "In good truth, its termination has not even yet arrived; for the creative labors of God have never been resumed." To show the truth of this, Mr. Faber quotes from the heathen "Institutes of Menu," as follows: "*He, whose powers are incomprehensible, having created the universe, was again absorbed in the Supreme Being, changing the time of energy for the time of repose;*" and then says, "The time of God's energy was doubtless the period of the creation." We are sorry that Mr. Faber is obliged to quote Indian heathenism instead of Scripture to support his doctrines. But leaving this to the reader's own comments, we will pass at once to the author's conclusions on this part of the subject.

From the above data, he says the divine Sabbath has not yet terminated, nor will it terminate, until "the predicted dissolution of the present order of things."

"Thus it appears," says he, "that the divine Sabbath, instead of being limited to a single natural day, is in truth a period commensurate with the duration of the created universe; what that duration will be, no one knows save the Father only." 2 Peter iii. 10, 13. But this we know, that the world has existed about 6000 years. "The divine Sabbath, therefore, is a period of not *less* duration than six millenaries."*

Having come to this odd conclusion, Mr. Faber goes on to show that the analogy of language requires us to "interpret homogeneously the seven days, which constitute the *great week of God.*" Hence, as the Sabbath day was a period of not less than 6000 years, so each of the other days must have been periods of at least 6000 years.

Thus, does the learned Mr. Faber call upon his fellow Christians, whether geologists or not, to believe that He who said, "Let there be light, and light was," "who brought all things out of nothing by the word of His power," occupied at least 36,000 years in creating this little earth, a mere speck, a mote, when compared with his other works, the "hosts of heaven," the universe.

Let us look for a moment at the bearing of this theory. Since "the ways of God are equal," there is every reason to believe, that if time was required in the creation of this earth and the garniture thereof, a proportionate quantity of time was also required in the creation of the other planets of our system, for there is not the least probability, that if the creative power required at least 36,000 years to form our earth, that the same power could at the same time have been at work in the production of the other planets. Mr. Faber's theory does not allow such a supposition; for no reason can be assigned, why the process of creation occupied so long a period, except the want of power to finish it in a shorter time; and therefore since the entire power of the Creator must have been occupied on our earth, it is plain that no other work could have been accomplished at the same time.

Now since there are twenty-eight planets in our system besides the Earth, if we consider the latter of a medium size, then the time occupied in creating the whole would be twenty-nine times 36,000 years, without refer-

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* Three Dispensations, vol. i. 115, 116.

ence to the creation of the sun. But the sun contains 500 times as much matter as all the planets put together, and therefore, according to Mr. Faber's doctrine, we cannot see why it must not have occupied 500 times as long a period for its creation as all the planets.

According to this doctrine, then, it must have taken nearly five hundred millions of years for Him who said, "Let the dry land appear," and it was so, to have created and made this our solar system. What time then must have been occupied by the same creative power in the formation of those myriads of worlds which the vault of the heavens contain, for "He made the stars also." But enough of this. And now if Mr. Faber's theory does not fairly lead to such conclusions, then the folly of drawing them must fall on the writer of this book, and not on himself

But whether our present conclusions are true or false, we will call upon any man, even on our author himself, to reconcile another bearing of his theory with itself, or in other words to show how it is possible that a definite portion of time should be perpetually increasing in length. Thus, Mr. Faber says, that the length of the Sabbath is the length of all the other days, and that God having rested from his labors 6000 years at the present time, therefore each day of creation is now, or was, 6000 years long. But he goes on to inform us that the said Sabbath has not yet terminated, nor will it terminate until the predicted dissolution of the present order of things; or in the language of Menu, "the time of repose has not yet changed for the time of energy."

Now since the length of the Sabbath, and all the other days, depend entirely on the length of time which God has rested, or will rest, from his labors, then it plainly follows, that had Mr. Faber written his theory at the expiration of twenty-fours hours after the last creation, the length of the days, according to himself, would have been only twenty-four hours long, for the same reason that he makes them 6000 years long at the time he did write. And so he who lives 6000 years hence, and reads Mr. Faber's theory, will find that according to it, the days of creation were 12,000 years long, and so on, until "the time of repose is changed for the time of energy."

Does any *ancient tradition*, or any *discovery of modern physiologists*, warrant a grave and learned author to employ such logic as this?

Again, if the days of creation were 6000 years long, then we must believe that it was 18,000 years after the waters were gathered, and the dry land made to appear, before man was created—that it was 12,000 years after the creation of plants before animals were brought into existence, and that it was 12,000 years after the sea was formed before it brought forth the "moving creature."

But Mr. Faber finds, *from the very necessity of the narrative*, that a considerable portion of time must have elapsed between the creation of plants, and the creation of animals, otherwise the herbivorous tribes must have perished for want of food.

In this part of his theory, it must be confessed that the author has shown a marvellous degree of sagacity, having discovered this *necessity* in a passage where less acumen, or less anxiety to support a theory, would certainly have looked for it in vain.

The words of the narrative which afford this necessity, are found in Gen. xi. 5. "God made every plant of the field before it was in the earth; and every herb of the field before it grew." The remaining part of the same verse explains this, "for the Lord God had not caused it to rain upon the earth, and there was not a man to till the ground." This plainly showing, that although the process of vegetation usually requires rain and tillage, yet in this case it was perfected without either.*

It was plainly, from the words of the text, a miraculous creation of full grown vegetables, without the planting of seeds, and without the process of vegetation.

It appears from this verse, says Dr. Adam Clarke, that God created every thing, not only perfect as respects its nature, but also in a state of maturity; so that every vegetable production appeared at once in full growth, and this was necessary, that man, when he came into being, might find every thing ready for his use.

Now although nothing can be more obvious than that the sacred historian intended we should understand by this language, that the first plants did not pass through the gradual process of growth as they afterwards did, but that they were called into existence in full maturity, yet from these very words, Mr. Faber infers that we are un-

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* Bush on Genesis.

der the *necessity* of concluding that the whole vegetable kingdom was created in the form of seeds; and because in the ordinary course of nature, these seeds could not have grown in time to have supplied herbivorous animals with food, which were created two days after; so these days must have been at least 6000 years in length, for otherwise the cattle of the field would have perished for want of food.

Now, independently of what we must consider a total perversion of the meaning of the text, this interpretation is utterly inconsistent with what follows, for it is clear, if we are guided by analogy, (which is one of the corner stones of Mr. Faber's theory,) we must allow that the animals were created in the young state, as well as the plants, and granting this to have been the case, then it is plain that the seeds would have vegetated into herbs, at least as soon as the young animals could have been fitted to partake of such food.

But that the animals were created in full maturity, as well as our first parents, no one can have the least doubt, otherwise who nursed and brought them up, since they had neither fathers nor mothers.

It is unnecessary to follow Mr. Faber in further details. The propriety of his interpretation he has attempted to prove, as already stated,

1. *By analogy of language.*
2. *By the very necessity of the narrative.*
3. *By ancient tradition*, and
4. *By the discoveries of modern physiologists.*

With respect to the last ground of proof, he quotes Cuvier on the revolutions of the globe, to show that the earth has undergone great changes since its first creation, and which no one denies. But on this point he advances nothing new, or which in the least degree shows the necessity of his new interpretation. It is therefore needless to follow him through this portion of his argument.

And now, in taking leave of Mr. Faber, we must be allowed to express the astonishment we have felt, that a Christian writer of his reputation should have so far lent himself to the support of a theory, as to have seen in *ancient traditions*, or the *discovery of modern physiologists*, a sufficient reason for giving the sacred Scriptures a meaning, which otherwise he does not pretend they could have had. What! a man professing to teach the sacred truths of the Bible, and yet warping its plain and obvious meaning, for the express purpose of making it agree with heathen philosophy, or his views of modern naturalists! we hope that no successor of Mr. Faber's will ever venture on such hazardous ground.

Is it not enough that infidels profess to be wise above what is written; and do not Christians put weapons into the hands of unbelievers, when they turn the plain and obvious meaning of the sacred text aside, even for the sake of argument?

The discoveries of modern geologists, so far from calling for new interpretations of the Bible, are constantly confirming its truths as commonly understood.

Let us then adhere to Moses, until we find some *fact* which clearly proves a discrepancy between revelation and nature.

Prof. Silliman's Theory. We are aware that several American geologists, who deservedly stand high in public estimation, and who also revere the Sacred Scriptures, still see in the mechanism of the earth a necessity of extending the days of Genesis to longer periods than twenty-four hours. Among these are Professor Silliman of New Haven, who has given the world his views on this subject.

His communication contains, at considerable length, a detail of the geological facts, which he considers incompatible with the common reading of Moses. Also, copious extracts from "Mantel's Geology of the Southeast of England," and from "Prof. Jameson's Edinburgh Journal."

The latter is understood to be the production of Prof. Jameson himself, and is a critical examination of the Hebrew text, with respect to the word which we translate day, and in which, with Mr. Faber, he comes to the conclusion that it may signify a long period of time, though he does not pretend to fix its length.

On this subject of Hebrew criticism we have nothing to offer; but he who can read the English translations of the Bible, cannot but have observed, that the word day is there often made to signify long periods. "They that shall come after him shall be astonished at his *day*," Job xviii. 20. In this case, it undoubtedly means the period of a man's life; and the same use is made of it in common language everywhere. How often do we hear persons, both old and young, say, in "*my day* such a thing was unknown." "In my day such a thing would not have been tolerated," &c., meaning the whole period of their past lives.

In these cases we employ the word to mean a comparatively short, though an indefinite period of time, in the same manner as the Scriptures do, and from which we perhaps have derived this mode of expression. But when we say a day, or first day, or second day, we mean a natural day, of twenty-four hours, and this, and no other, according to the best philologists, is the meaning of Scripture. But this point we must refer to the criticism of Prof. Stuart, which will be found a few pages forward.

With respect to the geological facts which Prof. Silliman has brought forward, in order to show a physical necessity for extending the length of the Mosaic days, we had seen most of them stated in other works, and had considered that although, perhaps, some of them could not be satisfactorily explained in the present state of geological knowledge, yet that not one of them, taken separately, presented a single point which any man could show to be contradictory to the common reading of Genesis.

If we take, for an example, Mr. Mantel's account of the Portland and Wealden formations, (p. 28, 29,) which are among the strongest cases Prof. Silliman has adduced with respect to apparent age, who will say that, under the existence of former circumstances, these formations were not began and finished within the compass of a few centuries, or at most, of a few thousand years.

It is true, that the deep vegetable soil, containing pebbles and the roots of petrified trees, the stems of which shoot into the limestone strata above,—the fossil remains of a tropical forest; and the alternate elevation and submersion of the island itself, would seem to show that a lapse of ages was required to produce the phenomena which the geology of Portland exhibits.

And so, also, of the Wealden formation. Its diameter of 200 miles, and its thickness of 2000 feet, would seem to point back to a very remote age for its commencement.

But let us see, for a moment, what *evidence* these phenomena exhibit of the lapse of time.

With respect to *vegetable soil*, Mr. Mantel says it *appears* to be such. But allowing the fact, who will ven ture to predicate any definite length of time on its formation. Possibly it was washed into its present location; and if not, if it was formed by the decay of vegetation, even then certainly, no immense length of time is required for its production, for the artificial mounds of Ohio, which contain undecayed human bones, are covered with a soil so rich as to produce the largest trees of the forest. And besides, it is understood that the Portland soil was formed under a tropical climate.

Neither can great portions of time be predicated on water-worn stones, since those on our shores must have been formed since the commencement of the present "order of things," which all naturalists agree was comparatively within a recent period. And it is most probable those found in recent strata were formed before the creation of organic existences, and while yet "darkness dwelt upon the face of the deep."

With regard to silicious petrifactions, into which the trees were changed, it is acknowledged that we know nothing with certainty, of the length of time required to produce this change on the Portland fossils. But reasoning from analogy, we may conclude that this process occupied only a century or two at most, since we know that the silicious springs of St. Michaels, one of the Azores, have the property of incrusting vegetables with an external coat of silex in a very short time, perhaps in a day or two, and that as fast as the wood decays, its place is supplied with silicious matter, until the whole is replaced by solid stone.

It is known, also, that the ends of cedar posts which are set into the ground, sometimes become petrifactions, before their upper parts are entirely decayed.

We may therefore believe, that where this change is effected at all, the entire process is completed in a few centuries. It is probable, at any rate, that the process must cease with the entire absence of the woody matter.

As to the deposition of the limestone, embracing these petrifactions, we have again no means except that of analogy, of judging at what rate it took place, and therefore, perhaps there are as many reasons for believing that it required only centuries, rather than thousands of years, for its formation.

We know that limestone is constantly forming at the present day, by the deposition of its particles from water.

Thus, in Tuscany, a certain spring, or rather springs. deposit solid limestone, at the rate of at least half a foot per year, making a formation of 500 feet thick in 1000 years, or of 3000 feet thick in one of Mr. Faber's Mosaic days.

In reference to the submersion and re-elevation of Portland, we have given an account of a parallel instance in the Temple of Serapis, which occurred within the historical era. See p. 129.

Now, when we consider that the several processes forming most of the phenomena exhibited at Portland Island, might have proceeded at the same time, viz. those of petrifaction, fossilization, and the deposition of limestone, where is the necessity of disturbing the common reading of the sacred historian in order to gain a series of ages to account for such phenomena?

Who knows what preparations took place for the present order of things, while "the earth was without form and void?" and what man can say what violent changes, what dislocations of the lower strata, and what upheaving of mountains, were effected, when God said "Let the waters under the heaven be gathered together into one place, and let the dry land appear?" Undoubtedly the most tremendous convulsions took place at that command, by which hills and mountains were elevated, and the great valleys of the earth formed.

Days of Creation indefinite periods. But while Prof. Silliman sees a *necessity* in the mechanism of the earth, for extending "the days of creation to periods of time of indefinite length," (p. 65,) he finds in various parts of the Scriptures themselves, full *liberty* to make such an interpretation.

With respect to the word *day*, he says, it could have had no application previous to the revolution of the earth, before an *illuminated* sun, which did not happen until the fourth day. But we think it has been shown, that when God said, "Let there be light, and light was," then the sun was created. If our arguments have convinced the reader that this was so, then this objection is done away.

But Prof. Silliman has brought many passages of Scripture where the word *day* evidently signifies a longer term than twenty-four hours; in some instances the whole of a man's life; in others it is used for a set time, or short period, though its length is not defined. Examples are, "So also shall the son of man be in his *day*,"—"Rejoiced in my *day*,"—"One *day* is with the Lord as a thousand years, and a thousand years as one *day*,"—"These are the generations of the heavens, and of the earth, when they were created, in the *day* that the Lord God made the earth and the heavens,"—"Shall accomplish as an hireling his *day*,"—"Whose *day* is come when iniquity shall have an end,"—"He will not spare in the *day* of his vengeance."

In all these cases, and more might be selected, it is plain that the word day is not confined to the period of twenty-four hours.

But we would inquire what analogy of language, or of meaning, exists between "one day is with the Lord as a thousand years," and "the evening and the morning were the *first* day, or *the* second day." Or indeed, how the use and meaning of the word day, in any of the above passages can show that the same word, when defined as it is in the narrative of the creation, between the morning and the evening, signifies an indefinite series of ages.

If a man says, "On the *first*, or *second* day of my arrival, I saw the king;" and at the close of his narrative tells us, "I have suffered many and great perils in my day," who would understand him to mean by these different uses of the same word, the same periods of time. And yet we can see no reason why this is not as fair an exegesis of the traveller's account, as that of Genesis, when it is maintained, that because Moses at the close of his narrative employs the language, "*in the day* that the Lord God made the heavens and the earth," therefore the terms of time which he had before defined as the *first day*, and the *second day*, signify periods of indefinite length.

That the sacred historian understood Him, under whose inspiration he wrote, to mean that the world was created in six natural days, all parts of the narrative, both of the creation and the deluge, amply testify. Professor Silliman allows that Moses so understood it.

"It is granted," says he, (p. 70,) "that Moses might have understood the word, (day,) according to the popular signification, and that this sense would be the most obvious one to every mind not informed as to the structure of the globe; even those who are learned on other subjects, but ignorant of geology, always adopt, in this case the literal and obvious meaning."

We are utterly at a loss what to say of this concession of the learned Professor. Is it so then, that the servant of the Lord God, who wrote down the words of inspiration as they were communicated to him, was so deficient in knowledge or understanding, as to stand corrected by the geologists of the present day? Who committed the error? Who made such a mistake as to put a single day for myriads of years,—for time indefinite? Was it Moses? Certainly not, for he only acted as the instrument by which God communicated to this wicked world the narrative of the creation and the fall of man. Did Moses misunderstand the intent and meaning of the inspired communications, or is his language such that it may convey error instead of truth? If so, why have not errors been found in other parts of his narrative. Who then made this mistake? Before we venture a reply to this question, had we not better ascertain more certainly that our *facts* are clearly incompatible with the sacred history as it stands, and as it is commonly understood, and as Moses understood it?

Coal Formations. But, says Professor Silliman, "In the usual mode of understanding the account, all the immense deposites of coal, and of vegetable and aquatic animal remains, with their vast strata and mountains must have been made within seventy-two hours, for there was no dry land until the third day, and consequently no vegetables." (p. 69.) * * "According to the popular understanding," he continues, "the transition and secondary mountains, with their coal beds, plants, and animals, were therefore formed in two or three natural days, by physical laws, which is incredible, because it is impossible." (p 70.)

It is believed that no one, who has given the least attention to this subject, ever supposed that these deposites were made within three days. Nor does the history render such a belief at all necessary. Coal is constantly forming at the present day, as is proved by specimens of lignite partially converted into that substance. The different formations in which coal is found, show also by their different ages, that coal has been formed at various periods of time.

When God said, "Let the earth bring forth grass, the herb yielding seed, and the fruit tree yielding fruit after his kind," there is no doubt but the dry land which had so recently been prepared, was immediately covered with vegetation, from the herb, to the largest trees of the forest, and these all in full maturity. How soon after this, those violent changes commenced, which swept these vegetables into lakes and estuaries, to form the first, or lowest beds of coal, is unknown to us; nor can we now ascertain what periods of time elapsed between the formation of different beds of coal lying one over the other, twenty or thirty of which are pierced by some coal shafts. The fact, however, of superincumbent coal beds is sufficient to prove, beyond all doubt, that the vegetables of which they were formed, were deposited at different periods of time.

It is agreed by all naturalists, that the origin of coal was wood, but no one has yet shown what the conditions or circumstances were, under which one is converted into the other, and much less the *time* which nature requires for such a process.

Now, supposing (and no one can show to the contrary) that the wood of which the oldest beds of coal are formed, was gathered immediately after the last day of creation; then, according to Dr. Hale's Chronology, we have 2256 years for the carboniferous process, down to the time of the deluge; and 3155 years more for the same process to continue down to the Christian era, making 5411 to the latter period; the whole forming a lapse of 7245 years at the present time.

It is true that many coal beds are at great depth from the surface, and the strata by which they are covered are ancient, though not primitive formations; while other carboniferous deposites are clearly of a more recent date.

But since it is impossible to determine what periods of time are required to convert wood into coal, or how much time elapsed between the depositions of vegetable matter forming the older and newer beds, and as we know nothing of the circumstances or degrees of heat, under which this conversion was effected, so it is in vain to conjecture from any analogy observed at the present day, at what period of the world the process commenced.

As we understand the inspired historian, there is allowed us little more than 7000 years in which to account for the formation of coal beds and their phenomena, and yet, since these beds were formed at a period when tropical plants grew to enormous sizes, under high northern latitudes, and when this globe was subject to mighty convulsions, they might have been formed and covered with the intervening strata, within the term of two or three thousand years.

With respect to vegetable and animal remains found in limestone and other secondary rocks, we are equally ignorant of the periods at which they were entombed, and, therefore, in reference to time, they must be placed on the same ground with the coal formations.

At the close of his treatise on the "Consistency of Geology with the Sacred History," Professor Silliman has the following

"REMARK."

"Suppose that there are inhabitants at the poles of the earth, how might they understand the days of creation? to them a day of light is six months long, and a night of darkness is six months long, and the day made up of night and day, covers a year, and it is a day, too, *limited by morning and evening*." (p. 80.)

As this stands alone, and closes Professor Silliman's treatise, we are led to suppose that the question it contains was considered important and unanswerable. We must, therefore, view it as deserving a special reply; and if we should succeed in solving the problem to his satisfaction, we hope thus to become the humble means of advancing Professor Silliman one step towards a coincidence of opinion with Moses, in respect to the days of the creation.

In the first place, since there are no inhabitants at the poles, the supposition itself is without foundation, and therefore we might justly, on this ground, give an evasive answer; but taking no such advantage, we will suppose that the poles *are* inhabited, then let us see whether the people would, or would not, be sensible of the diurnal revolutions of the earth.

Our answer requires it to be remembered, that the sun always shines on just one half of the earth, and, therefore, that the vicissitudes of summer and winter—of light and darkness, at the polar circles, are caused by the alternate approach and recession of these parts towards and from the sun's light.

Now, as the Arctic and Antarctic regions alternately enjoy the light of the sun, so they must of necessity be alternately immersed in the dark shadow of the earth. But this alternate change cannot take place without throwing these parts into such a position with respect to the sun, that his rays will reach both poles at the same time, which takes place twice in each year, to wit, on or about the 21st of September and the 21st of March, therefore, at these seasons there is a diurnal succession of day and night at both poles.

Besides, as the earth gradually turns each pole in succession towards the sun, so the line dividing the annual darkness from the light, must by degrees recede from and approach each pole; and as the earth turns constantly on her axis, and as the light of the sun alternately reaches 23° beyond each pole, it is clear that before the seasons of total night and entire day at the poles, there must be there a period when day and night succeed each other, making together twenty-four hours, as they do at the equator.

Thus it is plain that were the poles inhabited, the people there, equally with those of the equator, would be acquainted with days, "*limited by morning and evening*."

These inquiries and remarks have not been made in a spirit of contradicting the opinions of others, but under the sober conviction, that geology as yet presents no facts which, when carefully examined, will be found to conflict with the Mosaic history of the creation, as it is commonly received, and as it is allowed the sacred historian himself understood it.

Scripture proof that the Mosaic days were of common length. Unless these days were of common length, how can the sun and moon "be for signs, and for seasons, and for days, and for years?" If the days were six thousand years, or indefinitely long, what must have been the length of the scripture seasons and years?

Again, "six days shalt thou labor and do all thy work, but the seventh day is the Sabbath of the Lord thy God; in it thou shalt do no work. *For*, in six days the Lord made heaven and earth, the sea, and all that in them is, and rested the seventh day. Wherefore, the Lord blessed the Sabbath day, and hallowed it."—Exodus xx.

Thus it appears that this commandment was expressly founded on the fact, that the heavens and the earth were created in six days, and is designed to be in imitation and in perpetual commemoration thereof. "Six days shalt thou labor and do all thy work." "*For* in six days the Lord made heaven and earth." But the seventh day is the Sabbath, "in it thou shalt not do any work," *for* the Lord rested on the seventh day, and "therefore blessed the Sabbath day and hallowed it."

Now the commandment to work six days, and rest on the seventh, being in commemoration of the work of creation, and of the resting of the Creator, after it was finished; we would inquire whether this command is not, in effect, an express declaration that the creative days were of the same length as those on which men were commanded to labor, and to rest. If, therefore, it is discovered, that this is not the case, then we may humbly conceive that the command itself, though religiously observed through all generations to the present time, is no longer binding upon us; for if the days of creation were periods of 1000 years, then by the terms and connexion of the command, men are required to labor 6000 years, and to rest 1000 years. The command, therefore, being an impossibility, we are not bound by its requirement.

But the express declaration of the inspired writer, that "in six days the Lord made heaven and earth," cannot by any mode of exegesis be made to apply to other than ordinary days, for this declaration refers to a period, when the commandments were given to Moses, that is, about 2500 years after the creation, and therefore long after the ordinary course of nature had been established. These days, therefore, could only have referred to such as belonged to that period.

Criticism of Prof. Stuart. We have already extended this subject much further than was originally intended, but still, the question whether the Hebrew word, translated *day*, in the history of the Creation, admits of any other meaning, remains to be more particularly examined.

In this examination we must depend entirely on the opinions of Hebrew philologists, and we are gratified that it is in our power to offer such authority, on this part of our subject, as that of Prof. Stuart, of Andover, first stating, that the Hebrew word *yom* is that which is translated *day*, the plural of which is *yamim*.

On this word, Prof. Stuart writes to the author as follows:

"The inquiries you make concerning the word *yom*, in Genesis i., I will briefly answer. It does *not* signify an *indefinite* period of time, but always some specific and definite one, when employed as it is in Gen. i., in the singular number. It sometimes means a specific day of the week; sometimes *to-day*, that is, this day; sometimes a specific day, or season of calamity, joy, particular duty, action, suffering, &c. It is only the plural *yamim*, which is employed for time in an indefinite way, as, in many days to come, days of my life, &c. But even here the plural, in most cases, is a limited one—limited by some adjective, numeral, &c., and *yamim* signifies, therefore, a limited portion of time; often it stands for a *year*.

"In general, the Hebrew word that means either *day* or *days*, corresponds quite well with our English word, by which we translate it. Thus, when we say, in the day of his calamity he will repent; in the day of his prosperity he will rejoice; in the day when God will judge; all the days of his life; his days will be short; in past days; at a future day; &c., we express ourselves in all respects as the Hebrew Scriptures do.

"But when the sacred writer in Gen. i. says, the *first day*, the *second day*, &c., there can be no possible doubt, none, I mean, for a *philologist*, let a geologist think as he may,—that a definite day of the week is meant, which definite day is designated by the numbers, *first*, *second*, *third*, &c. What puts this beyond all question in philology, is, that the writer says specifically, that the *evening* and the morning were the *first* day, the *second* day, &c. Now, is an evening and a morning a period of some thousands of years? Is it in any sense, when so employed, an indefinite period? The answer is so plain and certain that I need not repeat it.

"Plain as it is, however, I have never seen a geologist notice it. He has his reasons, no doubt, for this, and one reason, also, may be, that he analyzes his rocks and his coal strata somewhat better than he does Hebrew roots. What have *a priori* speculations, however, to do with such a matter? If Moses has given us an erroneous account of the creation, so be it. Let it come out, and let us have the whole. But do not let us turn aside his language to get rid of difficulties that we may have in our speculations.

"When the great Lord of the Sabbath ordained that the *seventh* day of the week should be kept as holy time, because 'on the seventh day, God rested from all his work, and finished his work in six days,' how, in the name of common sense, did Moses expect, in communicating such a command, that the people of Israel would understand him as meaning a period of 6000 years, for each of the days in which God created? And if they did so understand him, what reason could this be for the Hebrews to keep holy every seventh day of the week? The whole thing bears on the face of it the appearance of something monstrous and incredible. No philologist can ever believe it.

"Then as to the taste of such a conceit. The Creator, 'who spake and it was done; who commanded and it stood fast,' who said, 'let there be light, and light was;' this great and glorious Creator—the Almighty God, 36,000 years in making a world!

"Andover, 5th Feb., 1833."

Mr. Penn's Criticism. It is believed that few, at the present day, will venture to throw themselves into the scale of philology in opposition to Professor Stuart; and yet to show the coincidence of authority on this point, we will quote the opinion of another able critic, who, at the same time, has spent many years in geological inves tigations.

In the sequel of twenty octavo pages, which Mr. Granville Penn* has written on this subject, he comes to the following conclusions, and which the reader may observe are precisely those of Prof. Stuart.

"The Hebrew noun *yom*, which means day, is always *definite* in its import, and essentially excludes the wide and extensive notion which we attach to the English word *period*. The peculiar signification of *yamim*, the plural of *yom*, is a point totally irrelative to the present question, which turns exclusively upon the singular *yom;* that singular noun, which is the word used by Moses in his history of each day of the creation, and which alone we have to consider, *never*, in *any single instance*, denotes a year, but

* Author of the "*Comparative Estimate of the Mineral and Mosaical Geologies.*" London, 1825, 2d Ed.

only each of the individual parts of a year, which lie between two sun sets. It is true, that it is sometimes represented as denoting *time*, but in that case it always denotes and defines actual time, or time actually impending—and we might with just as much foundation affirm, that the Greek singular *hemera*, the Latin *dies*, the French *jour*, or the English *day*, are terms peculiarly indefinite, and would be more accurately expressed by *periodus*, *periode*, and *period*, as to affirm it of the Hebrew singular *yom*.

Since then *yom* in the singular, is the term applied by Moses to each of the six days of creation—since the operations executed in each of those days were creative acts, to which acts *time* could contribute no co-operation—and since the series of those six days, with the following seventh day, were specially presented, as the exemplar of seven days, to be perpetually observed from thenceforth, in sequence and succession, in imitation and commemoration of them—there is no ground whatever, either in *true criticism*, or *true philosophy*, that will at all either authorize or justify an interpretation of the days of creation different from that which they received from the age of the historian until a recent date—namely, a measure of time lying between two sun-sets.*

Thus it appears beyond all doubt, that the Hebrew word *yom*, which is translated *day*, as it is employed in the Mosaic history of the creation, cannot be extended to a period beyond twenty-four hours, without a gross misinterpretation, or wilful violation of the plain and obvious meaning of the sacred writings.

WHAT ARE THE GEOLOGICAL FACTS WHICH CONTRADICT THE COMMON UNDERSTANDING OF GENESIS.

Having, we hope, shown to the satisfaction of the reader, that the hypothesis of a longer period than six natural days, for the completion of the work of creation, is not only unwarranted by the terms of the common translations, but is entirely incompatible with many other passages of Scripture; having also proved by the best philo-

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* *Comparative Estimate*, vol. i. p. 288—295.

logical authorities, that the terms in which the history of the creation was originally written, cannot be made to signify that a day of creation was a period of more than one diurnal revolution of the earth; we will now examine some of the facts and circumstances, which have been supposed not to coincide with the common reading of Genesis.

We have shown in the preceding work, that it is not an uncommon circumstance to find shells, plants, and the bones of various animals, in the deep strata of the earth, and we have stated that many of these are of species now unknown, and are, therefore, considered extinct.

Some authors who are professed believers in the truths of inspiration, have proposed to account for these appearances, by supposing that there have been many successive creations before the earth was brought to its present form, and sometime between that period called in Scripture, "the beginning," and the time when the present races were created. In this manner it has been proposed to avoid the difficulty concerning the Mosaic days; to account for the extinction of the lost species during the lapse of ages, and thus give geologists ample time to reconcile all the appearances which the earth presents, both with reason, philosophy, and scripture.

The only ground on which it can be claimed that such a hypothesis may be reconciled with Scripture is, that we are not bound to believe the work of creation detailed by Moses was the first, since we are nowhere told that this was the case; and, as it is plain, that the heavens and the earth were created before that time, that is, in the "beginning," why may we not suppose that animals of the lower orders, such as live under water, might not also have been created at that time? It appears to us, however, that this doctrine cannot be adopted by those who acknowledge the inspiration of the Scriptures; for, besides its want of coincidence with what is implied in the history of the creation, namely, that the work was commenced on the first day and finished on the sixth, we are expressly told in Ex. xx. that the whole creation was begun and finished within the compass of six days.

We are bound, therefore, by the terms of the Scriptures, to believe that every organic substance, found in the strata of rocks, however ancient they may appear to be, and whether of plants, fish, or quadrupeds, originated within the six days of creation, mentioned by Moses, and that these are the exact representations of their parents then made, or the parents themselves of all similar races now existing.

It is in vain to undertake to support the Scriptures by denying some parts and adopting others, as best suits our convenience. As well may we reject the whole at once, for if one part is false, all are so. Hence, if we can believe that a single plant or shell, found in the earth, was created before the period alluded to in Genesis, it would be useless to declare our assent to the truth of the Scriptures generally, (and, at the same time, account for this appearance, by supposing a more ancient creation than is mentioned by Moses,) since the account he gives excludes any such idea; and, consequently, the two facts cannot be made to coincide with the history. To suppose, therefore, that the organic remains of strata were formed before the time alluded to in Genesis, implies a denial of the truth of that history.

Strata supposed to be more ancient than is allowed by Moses. Some of the secondary strata which have appeared to geologists to claim a more remote antiquity than the Mosaic history allows, are of the following kinds:

First. Limestone, containing shells of extinct species, and which, from their situations, bear marks of great apparent antiquity. " It must always have been evident to unbiased minds," says Mr. Lyell, " that successive strata, containing, in regular order of super-position, distinct beds of shells and corals, arranged in families, as they grow at the bottom of the sea, could only have been formed by insensible degrees, *in a great lapse of ages.*"

Second. The great number of different strata, observed in some formations, and occasionally amounting to several thousands, are, in the opinions of others, sufficient to indicate a lapse of time which the sacred history does not recognise.

Third. The great amount of alluvial matter, known to exist in some lakes, and the formation of land on the borders of certain seas, (considering how slowly these depositions take place, have been thought to indicate more time than can be accounted for by the common understanding of the Scriptures.

Fourth. Allowing that every kind of limestone has been formed of shells, how is it possible, inquires another, that at their present rate of increase, such immense mountains of this rock could have been formed within the period of 6000 years?

Fifth. The coal formations, being supposed of vegetable origin, seem to prove that plants were in existence at a period vastly more remote than their creation, according to the Mosaic history.

Lastly. The fossil remains of various animals, the species of which are now supposed to be extinct, and which appear to have been in existence before the creation of man, are thought to show that more time elapsed before, or during the progress of the creation, than is indicated by the vulgar understanding of Genesis.

These, and a great variety of other circumstances and appearances, have been declared, by some naturalists, to be entirely inconsistent with the supposition that organized beings were only brought into existence within the recent period of 6000 years.

The reader will observe, that the evidence, if so it may be called, in all these cases, is merely circumstantial, and entirely dependent on the opinions of the observers; and that hence, while some could see nothing in the *facts,* which might not be accounted for within the period of a few thousand years, others would see appearances which could be reconciled only with the lapse of ages.

Our ignorance concerning the formation of strata. In reasoning on the facts which the strata of the earth present, we are under the necessity of bringing them to the test of some hypothesis which we may adopt, and which we believe most likely to account satisfactorily for them, by considering the circumstances under which they appear to exist. For, having never witnessed the formation of such rocks, we are obliged to reason entirely from analogy, and to draw our conclusions from such parallel facts, as our own experience, or that of others, may happen to furnish us.

Of the actual circumstances under which these strata were formed, or the *time* necessary for this purpose, we are entirely ignorant, and this is acknowledged by the most experienced geologists.

On this subject, Daubuisson speaks as follows: "The nature of this cause, and the manner in which it acted, are most likely *removed for ever from our knowledge;* no effect of the same kind is ever now produced. All the circumstances of the divisions of the mineral masses into strata, both in the primitive and actual states, are very far from being known to us; and we are constrained to say, that to determine respecting stratification, its circumstances and its laws, still remains a problem to be resolved, and is, perhaps, the most important one in geology."*

"We are," says Baron Cuvier, "in the most absolute ignorance, respecting the causes which have occasioned the diversity in the substances of which strata are composed. We are unacquainted even with the agents which may have held some of them in solution; and it is still disputed respecting several of them, whether they owe their origin to the agency of fire or water."†

De Luc speaks to the same effect. "These strata," says he, "the formation of which has entirely ceased, must have been the effects of primordial causes which no longer subsist."‡

Notwithstanding such opinions, and sounder ones do not exist on this subject, still there are those who, not contented with knowing the facts as they are, begin to conjecture concerning the manner in which these formations were deposited, and bringing every thing down to the test of their own knowledge, wisdom, and experience, come forth with a body of facts which show most clearly that the common understanding of some parts of the sacred writings must be entirely changed, to accord with these discoveries, otherwise the whole Christian code will be in jeopardy. Thus declaring that the Creator, in the formation of this world, could not have subjected matter to natural laws which men cannot now explain, without jeopardizing the whole moral code which, in mercy, he has given us.

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* *Daubuisson, Book* 1, p. 352. † *Prelim. Disc.* p. 27

‡ *De Luc, Lett. Geol.* p. 72.

"It is revolting to *reason*," says Mr. Granville Penn, "and, therefore, to *true* philosophy, to observe how strenuously physical science, though expatiating on the wonders of creation, has labored to exclude the Creator from the details of His own works, straining every nerve of ingenuity to ascribe them all to secondary causes; and with what undisguised relief of thought, it exchanges the idea of God for that of nature."*

So far as we know, all writers who have brought geological phenomena to contradict the common reading of the Scriptures, have reasoned on general circumstances and appearances, rather than on particular facts. Whether this has arisen from a tenderness towards the Scriptures, connected with a desire to keep such glaring facts as exist from the knowledge of the world, for its moral good, we do not pretend to know. But we do not hesitate to believe, that no one has yet published a single geological *fact*, which, when fairly and candidly examined, would in the opinion of sound judgment and discretion, be found to stand in the light of such proof, against the common reading of Genesis, as would be required to invalidate the foundation of any well grounded opinion, commonly received among men.

Inferences from organic strata. Concerning the strata containing shells, although their appearance proves nothing with respect to the period at which they were formed, (any further than that this must have been since the creation of the living remains which they contain,) or the time occupied in their formations; still, from certain circumstances, we may fairly draw several conclusions concerning them. Thus, the fact that they contain shells, shows that they were formed under water; and since one series of strata rest upon another, this proves that the lowest series were formed first. The shells, and the stratified structure of these rocks, also indicate that the matter of which they are composed was deposited from water.

As a matter of hypothesis, we may infer also, that the lower strata of these rocks were formed during the time when the earth was passing from a state of chaos, to that more perfect condition which it assumed, during, and

* Comparative Estimate, vol. i. p. 117.

after the creation of animals; for, at that period, there is reason to believe that the agitation of the waters consequent upon the changes which took place, would cause them to transport and deposite large quantities of loose matter from one place to another. Meantime the *rapidly multiplying creatures* of the water, which undoubtedly were originally created in all parts of the sea, might be supposed to have been swept along with the turbid waters, and fallen to the bottom with their deposites. Nearly all parts of the earth show that the present dry land has been thrown up from the bottom of the sea; but evidently not at the same time, and the fact that these elevated strata contain shells, shows that this land was under water at the time, and perhaps long after the creation of animals. The convulsions by which these strata were elevated, may be well supposed to have occasioned movements in the water, by which depositions of great depth, containing shells, might have been made in a short period.

No geologist can prove at what epoch these elevations of land took place. Some have supposed, indeed, that the shells they contain were formed while "darkness was upon the face of the deep," and before "the waters were gathered together into one place." But this, as we have shown, supposes a creation anterior to that detailed in Genesis; and, therefore, as the strata themselves contain nothing which contradicts the hypothesis, that they were formed after the creation of animals, it is most reasonable to believe that this was the case.

With respect to the great number of different strata which some formations present, no practical geologists of the present day, would ever propose to offer them as indications of absolute time. Dr. Macculloch, in his account of the "Western Isles," has described a tract of country, which, says he, "may be considered as exceeding twenty miles, on a line taken transversely to the bearings of the strata; and throughout this space, computing from enumerations taken at different places, there are probably not less than 40,000 strata." This great number is owing entirely to displacements occasioned, probably, by subterranean convulsions. "It is probable," says the author, "that this tract consisted once of a series of horizontal strata, of, perhaps, four substances only; and that, in consequence of numerous displacements, they have assumed the complicated and deceptive appearances which they now present."* These four substances are quartz rock, mica-slate, chlorite-slate, and hornblende-slate.

In another part of his work, the same author says, "Geologists have endeavored to compute the antiquity [that is of the earth] by various means, often by very 'childish chronometers,' when deposites of peat, and accumulations of stalactites, have been adduced as measurers of time. Thus, also, by measuring the annual depth of earth deposited in the valley of Egypt, it has been attempted to fix the period at which the Nile begun to flow. But this is equally vain; since the multitude of modifying causes must render all such deposites useless, even as the means of an approximation, independently of the fact that all are not the produce of rivers."†

This is considered a sufficient reply, with respect to computing time by the number of strata.

Limestone formations. But if, as many have supposed, limestone is an animal product, the vast masses of this rock, which occur in most countries, are much the strongest proofs which the earth exhibits of her antiquity. The oldest limestone, however, exhibits no marks of organic origin, but is arranged among primitive rocks, as may be seen by the tabular arrangement in the preceding volume. It is the secondary limestone only which contains shells, and it cannot be denied, that, in some instances, considerable beds of this species, appear to be almost entirely composed of these remains. But there is much difference in this respect, in different formations which are considered of the same age. In the oolitic group of Western Europe, shells are very abundant, while in the Italian, Alpine, and Grecian limestones, which represent the same series, very few organic remains are found.‡ It may be difficult to account satisfactorily for this disparity, if these rocks were formed at the same time and of the same materials.

Possibly, however, the Italian limestones were formed at the mouths of ancient rivers, whose waters passing through primitive limestone countries, brought down calcareous matter, which being deposited in a shallow sea, might embrace the shells there growing. At the same

* *System of Geology*, vol. i. p. 93. † Vol. ii. p. 60.
‡ *De la Beche, Man. Geol.* p. 323.

time we may suppose, that the European limestones were formed in deep water, out of the reach of such calcareous deposites; and, therefore, consists entirely of shells.

Beds of shells formed by sea currents. But the great difficulty on this subject, is to conceive how such vast beds of organic limestone could have been formed of shells, without requiring millions of years for their growth. It was in consideration of this subject that the Editor of the Quarterly Review, vol. xlii., (1829,) declares that the earth, instead of being millions of *years*, was millions of *ages* in forming.

The idea of geologists, who require so much time for these formations, appears to be, that the shells must of necessity have grown and perished in the exact places where their remains are now found, and that one generation must have lived on the remains of the other, in succession, until they formed the masses which we now see.

But there is not the slightest probability, from the very nature of the case, that this was the mode in which these masses were formed. For, in many instances, we find them of considerable thickness in the centre; gradually becoming thin towards the edges, and of small extent; the very form a mass of shells would have assumed had they been swept together by currents of the sea, and quite different from that which would have been produced had they lived and died on each other. In the latter case, there is no reason why these masses should ever assume the form of hills, but, on the contrary, we should naturally suppose that in similar climates, and under the same circumstances, these testacea would increase as rapidly in one place as in another, and thus that the strata they formed would be widely extended, and every where of the same thickness. Whereas, we find that beds of shells, in the same vicinity, are often entirely insulated. Besides, many of these shells are known to be such as burrow in the sand and mud, and unless we suppose that these masses were formed by currents, we are under the necessity of believing that such species forsook their natural haunts, for the purpose of living and dying on the remains of their ancestors.

Besides, we know from the reports of naval men, who have been employed in surveying sea coasts in various countries, that beds of shells are constantly forming at the bottom of the ocean, by the agency of the currents, and sometimes at the depth of several thousand feet.

In the strait of Gibraltar, Capt. Smyth found shells at the depth of 950 fathoms, carried thither probably from comparatively shallow parts, by the strong current which flows through that channel. Capt. Vidal detected on the coast of Ireland large quantities of shells, at depths varying from forty-five to 190 fathoms; and also in the same region a bed of fish bones extending two miles along the bottom of the sea, in eighty and ninety fathoms of water.

"Analogous formations," says Mr. Lyell, "are in progress in the submarine tracts extending from the Shetland Islands to the north of Ireland, wherever sounding can be procured. A continuous deposite of sand and mud, replete with broken and entire shells, echini, &c., has been traced for upwards of twenty miles to the eastward of the Faroe Islands, usually at the depth of from forty to 100 fathoms. In one part of this tract, fish bones occur in extraordinary profusion, so that the lead cannot be drawn up without some vertebræ being attached. This 'bone bed,' as it is called by the surveyors, is three miles and a half in length."*

The sea, undoubtedly, is almost every where forming beds of shells by its currents in the same manner, and which in the course of a few centuries at longest, might reasonably be supposed to form stratified organic rocks, of hundreds of feet in thickness, cemented by the sedimentary matter of rivers, with which the sea abounds on every coast. How, then, does it become necessary to allow ages of time for these formations.

The objection that has been brought against the theory of accumulation by currents, in the fact that many or most of the shells still retain their sharpest angles and most delicate parts uninjured, will be found of little weight, when the circumstances are considered.

All shells will swim in water of sufficient depth, even after the animal has perished; and, under water of moderate depth, most species will float to great distances without the slightest injury. In several extinct species, which are found in the greatest abundance in limestone, the specific gravity of the shell was so near that of water,

* Vol. iii. p. 295.

that the animal had the power of raising or sinking itself at pleasure, probably by drawing in or throwing out a little of that element. Such were the many-chambered univalves already described and figured, the *Nautilus*, the *Ammonites*, and the *Orthoceratites*.

On the coast of England, in places where the current is so swift as to remove deep channels in the regular strata, and where rocky masses are often precipitated into the sea, there still live fragile shells and tender zoophytes, (corals and sponges,) in abundance, and in the midst of these violent movements.*

There is, therefore, we conceive, no difficulty in supposing, that shells might have been swept into beds from great distances, and still retain their finest lines and sharpest angles. Those which we find on beaches, where they have been constantly exposed to the friction of the sand, by the motion of the surf, bear no analogy of circumstances to those which remain in deep water.

Vast number of shells created. Under the hypothesis, that all secondary limestone has originated from living existences, and has been formed within a few thousand years, we must believe that vast numbers of these tribes were originally created, and that they have multiplied with great rapidity.

With respect to the number created, we are bound to believe that it was peculiarly great, from the terms of the history, for in no other instances is the same language employed. "Let the waters bring forth *abundantly* the moving creature," are the words of the command; and we shall see, in this case, a coincidence between the Scriptures and the facts of geology and natural science, not before noticed.

As the terms of the command were general, ("Let the *waters* bring forth,") so must have been the effect; and we are therefore bound to believe, that this creation was not confined to particular portions of the sea, but that the waters in all parts of the earth brought forth an abundance of living creatures, and we need not stop to show that shells are included in this creation.

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* *Lyell's Geology*, vol. i. p. 308.

Rapid progress of Conchology. There is reason to believe, that no department of nature is so abundantly supplied with species and varieties, as Conchology. It is true that there are at present, more known species of plants than of shells, but the facility of collecting the former, together with the connexion which botany has with medicine and domestic economy, makes it the more interesting and important science. Yet, it is believed that the comparative number of new species of shells, recently discovered, have been much greater than those of plants.

Perhaps some judgment may be formed of the progress of conchology, and the vast number of species which probably still remain to be discovered, by comparing the system of Linnæus with that of Lamarck. The former naturalist describes only thirty-six genera of shells, while the latter has determined and described two hundred and fifty genera; and many new species have been discovered within the few years since the last work was written. Hence we may infer, that conchology is only in its infancy, at least with respect to the number of species known, and that it is probable, thousands of species, if not of genera, still remain to be discovered in this department of nature.

The number of known species belonging to some of the Linnæan genera are already very numerous, and new ones are almost every day accumulating. Of the genus *Conus*, Mr. Mawe names 170 species, and of the genus Voluta 200 species, and of each of these, there are numerous varieties.*

The subject of fossil conchology has still more recently attracted the attention of naturalists, but when we come to examine the catalogues of extinct species, which have already been determined, and consider that these have been discovered in those few places on the earth, where excavations have been made, chiefly for economical purposes, we cannot avoid being struck with an idea of the vast multitude of these species which the earth contains, the most of which still remain unknown.

Of the genus Ammonites, there have been determined and named 159 species, not one of which are now sup-

* Mawe's Conchology, p. 87—105

posed to be in the living state.* Of the genus Cerithium, seventy fossil species are known, and of the genus Terebratula, fifty species have been determined, and catalogues of both given.†

In the oolitic limestone alone, there has been already discovered and described, not less than 1000 species of shells, a great proportion of which occur in England.‡ In the Paris basin, the species long since enumeratad, amounted to 1200, and an equal number have been found in the more modern formations of the subapennine hills.§

Now, when it is considered that these investigations have only just commenced, and that the parts of the earth which have been examined are mere points, when compared even with the secondary portions of the whole; when we remember, also, that most of the recent species known, have been picked up along the shores rather by accident than through any scientific design; and that the wide oceans, the distant reefs, and the deep waters, are still unexplored,—and when we compare these circumstances with that of the number of shells already known, we cannot but conclude, that there must be in the earth, and in the sea, thousands, perhaps millions, of species, which the eye of man has never yet seen.

From this vast number of species which it is thus certain have existed, or do still exist, we are led to see the propriety of the peculiar language which Moses employs with respect to the first act of the fifth day's creation; for since all these species were commanded into being at that time, the term *abundantly*, as applied to these animals, and these exclusively, has a literal and appropriate meaning.

It has been shown under the article, "Change of Climate," that the temperature of the earth was formerly much greater than at present, and it is well known that shells of the same tribes increase in size, in some proportion to the heat of the climate where they are found. It is also a general law, that animals multiply most rapidly in hot climates. It may, therefore, be fairly inferred, that much larger quantities of organic limestone would have

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* De La Beche, Manual, p. 364. † See Parkinson's Fossil Organic Remains. ‡ De La Beche's Catalogue, Manual, p. 323—369. § Lyell's Geology, vol. i. p. 151.

been formed during the same period, anciently, than at present. But who knows what beds of this rock are now forming in the depths of the oceans, and who will know until they are elevated for the inspection of geologists?

Conclusions from the above facts. From all the facts and circumstances thus stated, may we not draw the following inferences.

First. That testaceous animals were originally created in great abundance, and in every part of the sea.

Second. That these animals increased much more rapidly under the ardent heat of the ancient world, and attained much larger sizes than at present.

Third. That beds of shells were formed by the currents of the sea, and not by their accumulation upon each other, by natural increase.

These inferences being admitted, may we not conclude, that it is possible all the shell limestone which is known to exist, might have been formed by constant accumulations within the period of the nearly 2000 years which have elapsed between the creation and the deluge.

Secondary limestone not always formed of shells. It is not necessary, we should suppose, that all secondary limestone has been formed of shells, for we find that this process is constantly going on at the present day, by means of water containing carbonaceous particles. It has already been stated that the waters of San Filippo formed strata of solid carbonate of lime at the rate of *thirty* feet in *twenty* years,* and which, therefore, during the period above named, supposing the same process to continue, would form a mass of limestone 3000 feet thick, which would exceed any known limestone formation in depth. In various other places, similar depositions are forming.

It has also been stated in the preceding volume, that limestone, containing shells, is now constantly accumulating at the delta of the Rhone, in the Mediterranean. Large masses are continually taken up from that place, of arenaceous rocks, cemented by calcareous matter, including multitudes of shells, of recent species. A cannon was

* Lyell's Geology, vol. i. p. 204.

also discovered and taken up at the same place, imbedded in *crystalline* limestone.*

The Coral islands and reefs, also exhibit vast accumulations of calcareous matter, which at the present day are constantly increasing. That on the coast of New Holland extends in an uninterrupted course to the length of 350 miles, and with others, form a continuous line of 1000 miles in length, varying from twenty to sixty miles in breadth, and is probably from 1000 to 1500 feet in depth. This, if thrown up from the bottom of the sea, would form a mountain of organic limestone, of far greater extent than any now known to exist on the face of the earth.†

Now this immense mass of organic calcareous matter has been forming only since the commencement of what geologists call "the present order of things," or since the sea has occupied its present bed, and which all agree was not at a very remote period, certainly not more than 6000 years ago, and yet this is acknowledged by geologists to be the most extensive range of organic mountains in existence. "It far exceeds," says Dr. Macculloch, "any that are known in the extent of its range."‡

When such a formation is seen and known, or acknowledged, to be but of comparatively recent origin, why is it necessary, to suppose that other organic formations, which took place in the depths of the ocean, and of which we know nothing except by conjecture, should have required millions of years for their production?

The truth is, that no man can prove at what period the ancient rocks were formed, by their appearance, or by any series of intrinsic circumstances attending them, nor can he show, with any degree of certainty, how long a period was required for their production. All agree that the organic rocks were formed under the waters of the ocean, and, therefore, that their growth was concealed from all observation. The few analogies that can be adduced of similar formations, seem to show that the lapse of many ages is not required to produce extensive calcareous formations. Who knows what exists in the bottom of the ocean at the present day? or what geologist will deny that the elevation of a few square miles of land

* Lyell's Geology, p. 234. † See the preceding vol. p. 64.
‡ System of Geology, vol. i. p. 339.

from the middle of the Atlantic, might not entirely change all existing theories with respect to the age of the earth?

Doctrine of successive creations. The doctrine of a succession of creations, by which some writers have proposed to account for the organic relics which they suppose more ancient than those described in Genesis, is not only opposed to the implied meaning of Scripture, as already noticed, but, if we are not mistaken, it contradicts one of the most important and interesting series of facts which geology has unfolded, and which we have taken especial pains to establish in the preceding pages, viz. that there exists, in the strata of the earth, a regular gradation of organic substances, from the lowest plants to highest orders of animals, and that, in this respect, there is an exact coincidence between revelation and geology. Now, if there have been many successive and distinct creations, each creation must have been either of the same kind as that which took place before it, or of a different kind. If, for instance, the first creation was cryptogamous plants, of one species, and the second creation, plants of the same tribe, of another species, the first becoming extinct before the second came into existence; then we are to suppose that the soil and climate of the whole earth was everywhere the same, and that for thousands of years it was fitted for nothing but cryptogamia. This would only seem to show that one species was ordered out of existence, merely that another might be created, under precisely the same circumstances, and thus, that the Creator, for thousands of years, (if so long is required by the theorist,) occupied the earth only with the lowest vegetables. When plants of the higher orders came into existence, we have to suppose a recurrence of the same corresponding process; and so of the testacea, amphibia, and mammalia, the earth being fitted for each class in succession, and no other, and that many species of each class were alternately created, and permitted to go out of existence.

That the doctrine of successive creations can be true on no other grounds, is shown by the well ascertained geological facts, above mentioned, viz: that the order in which organized remains occur in strata, from below upwards, is thus: cryptogamous plants, dicotyledonous plants, testacea, amphibia, and mammalia.

Now had different parts of the earth been prepared for each of these classes at the same time, or had a creation, at the same epoch, consisted of plants, testacea, amphibia, and mammalia, the remains of these ought now to be found in series of strata, by themselves, and when these became extinct, to be followed by another series in the same manner, whereas we find, in truth, that the lower strata, never contain the relics of the more perfect animals, but only those of plants, shells, &c.

The doctrine of successive creations, therefore, cannot be maintained as geologically true, unless we suppose that the lower orders only were created; then annihilated, and again replaced; and that the same law was followed with respect to the other orders of creation; for on no other hypothesis, will the several creations correspond with the succession of remains which the strata contain.

This notion, if not ridiculous, is at least derogatory to the Wisdom and Power of the Creator.

Does not reason as well as *religion*, therefore, dictate, that before the Holy Scriptures, or any part of them, are wrested from their plain and obvious meaning, (or from the sense in which they have been universally understood by the whole Christian world,) in order to adapt them to what have appeared to some to be geological facts, that these facts should be more clearly established than they appear to be at present? Will it not be in time to change the meaning of Moses, when geology clearly shows, that, with all his inspiration, he was in an error? or, at least, until geologists agree with respect to the points in which he was mistaken? Still. we are entirely opposed to the suppression of any geological fact because it seems to bear against revelation. Let the whole truth come forth, in a fair and impartial manner, and if the Scriptures cannot stand against it, let them fall. No truth is impious, nor will facts, in the light of the present age, ever convict their discoverer of heresy.

We do not deny the remote antiquity of the earth; it was created at the "beginning," and, therefore, as formerly remarked, men may speculate with safety on the changes it suffered while "it was without form, and void, and darkness was upon the face of the deep." Here, revelation is no guide with respect to time, and theorists may call millions of ages to their aid in accounting for the phenomena which the ancient world presented. But, from the period when plants and animals were created, we have a guide, at least, with respect to certain parts of the earth's history, which no one may contradict by mere inferences, and from which guide, no believer in revelation can depart with propriety or safety.

We have no room, at present, to notice the other rea sons which have been brought to show the great antiquity of secondary strata, nor is this necessary, since they are chiefly predicated on grounds already examined.

Opinions of Geologists with respect to the antiquity of the present form of the Earth.—In concluding the subject of the Mosaic days, and the earth's antiquity, we will cite the opinions of two or three geological writers, who appear to have carefully investigated these points.

Dr. Ure.—"We may," says Dr. Ure, "ask, why we should claim, in behalf of our globe, a more ancient origin than that assigned by the inspired chronologist? Will its rank, dignity, and importance, be enhanced by a remote genealogy? Is not this a taint of the pride of ancestry common to the whole family of man? But how can it be safely gratified? Even lynx-eyed science can pierce the dark veil of creation no further than common vision."

Again, "it is to be regretted that any commentators of Scripture, misled by the fancied necessity of certain geological schemes of stratiform superposition, should have vexed themselves and their readers, in torturing the Hebrew words for day, and evening, and morning, into many mystical renderings. That Moses attached no such vague meaning to the creative days in Genesis, is evident from the language of the fourth commandment in Exodus, 'Six days shalt thou labor,'" &c.*

Dr. Macculloch.—Says Dr. Macculloch, "They who have attempted a conciliation, by altering the lengths of the periods, have taken an unnecessary, as well as an unwarrantable liberty of interpretation; since they thus wrest the plain words of Scripture to their own evil purposes;

* *New System of Geology*, p. 11.

too ignorant to perceive the unbounded hazard of such a principle. And it may surprise them to be told, boastful as they have been, that they have not even read with understanding the plainest passages of a book, which is far more often read than considered, and much too often read for the purpose of confirming a religious hypothesis, not for discovering the truth."*

Baron Cuvier. "We see," says Baron Cuvier, "that even in confining themselves to the limits of Genesis, naturalists have a wide field before them; they soon found themselves in difficulties, and when they had succeeded in attributing to the six days of creation, indefinite periods, ages costing them nothing, their systems took a flight proportioned to the intervals which they could dispose of."†

Ignatius Paradisi. Ignatius Paradisi, a learned ecclesiastic of Florence, has advanced a theory by which the facts established by Cuvier concerning the revolutions of the globe, are reconciled with the Mosaic cosmogony.

The first of these revolutions, is that which displaced the materials of which the surface of the globe is formed, from their original position;—elevating the mountains, and forming the great valleys which the earth now presents. At this time "darkness dwelt upon the face of the deep," no organized beings had been created, and hence among the primitive rocks no fossil remains are found.

The second revolution, or series of revolutions, formed the strata now called secondary, and in which are included innumerable remains of plants and animals. Hence, these revolutions took place after God had said, "Let the earth bring forth grass," and "Let the waters bring forth abundantly the moving creatures that hath life."

Geologists have attempted to show, that between these revolutions, there must have been an indefinite series of ages, and an equal number of creations and annihilations of organized beings, at least before the races now in existence were brought into being.

But, says Paradisi, it does not seem reasonable to attribute to a long duration of time, the production of those

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* *Geology*, vol. ii. p. 62. † *Revolution of the Globe*, p. 28.

phenomena of the causes and agents of which we are entirely ignorant. We find, at first, that "The earth *was* without form and void," Gen. i. 2, and how long it was in this state, we are not told. But when the "Spirit of God moved upon the face of the waters," then took place those first revolutions, the origin and cause of which, geologists have so vainly attempted to conjecture. With respect to the agents employed to effect this revolution, we are entirely ignorant. It is sufficient for us to show that nothing in geology is opposed to the expressions of revelation, but, on the contrary, that all the new discoveries tend to confirm its truth.

Who will not perceive, in the expression, "The Spirit of God moved upon the face of the waters," the origin of these first revolutions, for the historian immediately proceeds to describe the effects produced. "Let there be light." "Let there be a firmament." "Let the waters under the firmament be congregated," and "Let the dry land appear."

To see, in an instant, light divided from darkness; waters formed into seas, and the dry ground appearing at the command of the Omnipotent, what is it but to exhibit the most violent changes.

Could the work of the third day, when the mountains were elevated, the waters gathered, and the dry land made to appear, have been performed without convulsing the earth to her centre? And how vain would it be to seek to reduce such phenomena to the ordinary laws of nature? As vain as to attempt to explain, by the laws of vegetation, the sudden production of ripe fruits; or by those of animal physiology, the instant creation of a man in full size and vigor. Says Cuvier, "the methods of nature are changed, the thread of her operations is broken, and none of the agents she now employs, could have produced her ancient works."

The second series of revolutions happened when our earth was clothed with vegetation, and full of living beings, with the exception of man, having also many species of animals now extinct. These revolutions are indicated by the remains of plants and animals, found in the strata of our globe.

At this period, only a single pair of our race were in existence. They were placed in the garden of Eden, but they sinned and fell. "Cursed be the ground for thy sake," said God to Adam; and who can tell what horrible revolutions this earth was made to suffer, when this awful malediction was pronounced? We may believe that with the exception of such as were in paradise, every creature which had life, perished, and that the whole earth was changed into a dreary desert, fit only to produce briars and thorns. In this awful change ought we not to see that revolution which buried such innumerable numbers of plants and animals in the strata of the earth, and whose remains we find at this day?

"Thorns and thistles shall it bring forth to thee; and thou shalt eat the herb of the field," was the terrible sentence which the sin of man brought upon the earth, and upon himself.

We know with certainty that the earth has suffered a revolution, which buried the productions of her surface in its ruins; and it is a fact of sacred history, that this same earth was cursed of God, and that in consequence of that curse it was suddenly and entirely transformed, and laid waste. Nor can any known cause, except this curse, be assigned with any degree of probability to account for this revolution. Why, then, have recourse to a long succession of ages to explain such phenomena? Time is not of itself an agent of nature. No extent of time can give to nature, forces which it does not possess, nor agents of which it is manifestly destitute.

If we inquire where was man, and the animals which survived this revolution, the historian informs us. They were all in the Paradise of delights. Without inquiring into the site of Paradise, it is evident that it was separated from the earth which was cursed. This appears evident from the expressions, Plantaverat autem Dominus Deus, Paradisum Voluptatis; *But the Lord God had planted a Paradise of pleasure;* and afterwards, Tulit ergo Dominus Deus, hominem et posuit eum in Paradiso voluptatis. *Therefore the Lord God took man and placed him in the Paradise of delight.* It evidently follows that Paradise was a very different place from that earth which was cursed, and which was afterwards destined to be the abode of Adam and his posterity. Here, therefore, our first parents dwelt with all the animals which survived the catastrophe consequent upon the curse God had pronounced. The fossil bones which are found so abundantly at the present day, belonged to animals which had been dispersed over the earth. These all perished, and hence many of their species remain extinct, while the species which were in Paradise are those which now exist. Paradise was then the only place of refuge, as the ark afterwards was during the deluge. Thus may these singular phenomena be explained by the sacred history, and under its faithful guidance do we recognise the second series of revolutions, exhibited by the aspect of our earth.

These are the opinions of some of the most enlightened men who have lately written on this long controverted subject, and we may remark in general, that the more that is known of geology, the greater is the number of advocates for allowing the common reading of the Scriptures to remain, under a belief that further investigations will destroy every ground of excuse for a change in the obvious meaning of Moses.

INDIAN ASTRONOMICAL TABLES.

Since we are on the subject of the connexion between the sciences and revelation, we will end our labors by briefly citing two or three instances, in which infidelity, for a time, was allowed to triumph over the Scriptures, in such a manner as seemed to show, that either the demonstrations of the exact sciences must be false, or the writings of Moses could not be true. But the reader will see, that in these as well as in all other cases, inspiration has proved itself the test of truth.

The Hindoo, or Indian Tables, were calculated by the astronomers of India, and were supposed, by many, to substantiate, in no small degree, the pretensions of the Hindoos to the vast antiquity which they have always claimed for their nation. Here, it was said, were mathematical calculations of great abstruseness and accuracy, made by these people, thousands of years anterior to the epochs at which any European nation could trace its origin.

These tables were first published in Europe by M. Bailly, a Frenchman, who claimed a high standing in the world for learning and eloquence. But had it not been for the influence of Professor Playfair, of Edinburgh, they would have been little known, and, therefore, would have had little influence in depreciating the veracity of Moses

In a paper which this learned professsor read before the Royal Society of Edinburgh, in 1788, he declared his unqualified belief in the truth and solidity of this Hindoo production.

No professor in Europe had, at that period, attained to a higher eminence in the department of mathematics, than Playfair; and being withal a man of amiable manners, and the most eloquent of scientific writers, his open avowal of the truth of a series of mathematical calculations, designed to prove that the Christian had no foundation for his belief, could not but have produced strong emotions in the public mind. Some who had never before doubted, now began to waver; while others who had before tried to become skeptics now had sufficient excuse, as they thought, to come out downright infidels.

Professor Playfair's commentary on the Indian Astronomy was published in the Philosophical Transactions for 1790. He there says, that "it is through the medium of astronomy *alone*, that a few rays from those distant objects, (the primitive inhabitants of the earth,) can be conveyed in safety to the eye of the modern observer, so as to afford him a light, which, though scanty, is pure and unbroken, and free from the false coloring of vanity and superstition." Thus declaring, that it is through the medium of astronomy, and not through that of revelation, that we are to look for any knowledge of antiquity, "*which is pure, and free from the false coloring of vanity and superstition.*"

With respect to the tables themselves, Professor Playfair says, "that on grounds which have now been explained, the following general conclusions appear to be established. The observations on which the astronomy of India is founded, were made more than 3000 years before the Christian era, (consequently 650 years before the deluge, by the Hebrew chronology,) and, in particular, the places of the sun and moon, in the beginning of the Calyyoug, or age of misfortune, that is 3102 years before the Christian era, were determined by actual observation."

"Two other elements of this astronomy," he continues, "the equation of the sun's centre, and the obliquity of the ecliptic, when compared with those of the present time, seem to point to a period of this astronomy 1000 or 1200 years earlier, (that is 4300 years before the Christian era,) and the time necessary to have brought the arts of calculating and observing, to such perfection as they must have been, at the period spoken of, comes in support of the same conclusion."

Thus, on the authority of Professor Playfair, it was established that the Hindoo period called Caly-youg, being 3102 years before the Christian era, was the epoch at which these calculations were made; then other elements point to a period 1200 years before this, making in all 4300 before the Christian era, so that the astronomical calculations of these heathen philosophers, extended to a period nearly 300 years before the creation of the sun, and moon, and planets, according to Moses.*

All this was proved by one of the first mathematicians of the age, for Professor Playfair had made himself responsible for the truth and accuracy of the Indian calculations, as well as for the period at which they were made.

These important conclusions, solemnly announced from the mathematical chair of Edinburgh, gave them a degree of consequence and authority in the estimation of the world, proportionate to the high source whence they came.

Few persons could follow the professor through the calculations from which these demonstrations had been deduced; and fewer still, thought of making public opposition to such authority.

Thus, infidels believing their cause now settled on a foundation that could not be moved, thought and spoke of Moses and his history with the utmost contempt; while many Christians, believing that, at least, some truth had emanated from such a source, and being unable to bring any thing but the naked word of inspiration, against what were considered mathematical deductions, were happy when they could avoid all religious discussions with those who, at the onset, were ready to prove that the very foundation of their faith was wanting.

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* This estimate is founded, as above stated, on the Hebrew chronology, which gives 4004 years from the creation to the incarnation. It is, however, but fair for the reader to remember, that the Constantinopolitan chronology makes 5504 years between these events, and that Josephus makes the same period to consist of 5200 years. If we adopt either of these periods, the calculations of Playfair do not extend beyond the time of the creation.

But whether the Mosaic record remained true or false, it is certain that the demonstrations of Professor Playfair did not destroy the verity of all Scripture, since the truth of that declaration, "a kingdom divided against itself cannot stand," was confirmed and illustrated in his own case, as the event will prove. Laplace, the French astronomer, who was contemporaneous with Playfair, and on whose high attainments the professor had pronounced a splendid panegyric,—Laplace himself, the lover and patron of infidelity, was destined to become the agent by whom Moses and the prophets were delivered from obloquy and contempt; and by which it was demonstrated, that notwithstanding the existence of the Hindoo tables, and the opinion of the Edinburgh professor, the Scriptures might still be a revelation from Heaven.

"Every thing," says Laplace, "leads us to conclude that they [the Hindoo tables] are *not* of high antiquity. They have two principal epochs, which go back, one to the year 3102, and the other to 1491 years before the Christian era. These are linked together by the mean movements of the sun, moon, and planets, so that one of the epochs are *necessarily fictitious*." "In fact," he continues, "if we assume for our point of departure, the epoch 1491, and go back, by means of the Indian tables, to the year 3102, before the Christian era, we obtain a general conjunction of the sun, moon, and planets, as these tables suppose; but this conjunction differs too much from the result of our best tables to have taken place, demonstrating that the epoch to which it refers *is not grounded on observation*.

"The tables altogether, and particularly the impossibility of the conjunction which they suppose at the same epoch, prove, on the contrary, that they have been constructed, or, at least, rectified in modern times."*

"It is well known," says Baron Cuvier, "that M. Bailly, thinking that the epoch which is used as a period of departure in some of the Indian astronomical tables, had been really observed, has attempted thence to deduce a proof of the remote antiquity of this science among that people, or, at least, in that nation which bequeathed its knowledge to them. But the whole of this system, so la-

* Book v. chap. i.

boriously conceived, falls to the ground of itself, now that it is proved that this epoch was subsequently adopted on calculations made backwards, and the result of which was incorrect."*

M. Bently has discovered that the tables Tivalour, on which, particularly, the assertion of Bailly was founded, must have been calculated about 1281 after Christ, (540 years since;) and that the Surya Siddhanta, which the Brahmins regard as their most ancient and scientific treatise on astronomy, and which they pretend was revealed more than twenty millions of years ago, could not have been composed until about 760 years since.

These authorities might be considered sufficient to settle for ever the famous question of the Indian tables, which, for a time, it is known, was the strong hold of infidelity; and yet the opinion of Playfair has been so widely disseminated, and is contained in so many books still in existence, and still read, that we add one other authority, lest, in the minds of some, these should not remove every doubt.

Delambre, in his History of Astronomy, writes on this subject as follows:

"The extensive treatise on Indian Astronomy, by Bailly, has been labored with more care than any of his works. We regret only to remark too frequently in it, that spirit of system which predominates in all his productions. Instead of giving an exposition of the facts, which may enable us afterwards to consider them in every point of view, he espouses an opinion to which he makes every thing conform. He renders it available with much address, and by approximations which are often specious. Sometimes, and especially in his Indian Treatise, he intrenches himself behind imposing masses of calculations, carefully dissembling whatever may prove prejudicial to his cause, as well as the objections that might be advanced, and which he himself could not fail to perceive.

"If we be allowed to hazard a conjecture, we would say that Bailly never writes but to prop a system framed beforehand; that he glances slightly over the writings of the ancients, reading them in bad translations, and that he runs over all the calculations, in order to pick out ob-

* Cuvier's Disc. p. 145.

scure passages which may lend some countenance to his ideas."

"When we inquire why the Indians chose the remote and fictitious epoch of Caly-youg, or misfortune, we perceive, in the first place, that it was from national vanity; and in the next, that they might make all the planets start from one point, a conjunction which their method of calculation required. If we further ask, why they adopted a complicated method which employs divisions and multiplications of enormous numbers, with so many additions, subtractions, reductions, and different precepts, the answer is, that they did not wish for written tables; they wanted numbers which could be put into technical verses, even into songs, so that the calculations might be performed without writing a book. These facts, now well known, through the labors of the Asiatic Society, are alone sufficient to subvert the whole system of Bailly."

"Mr. Playfair, in the 4th volume of the Edin. Phil. Trans. has spoken of the Indian table of signs, believing it to be very ancient. Consequently he is not surprised at finding no tangents in it, which were unknown in Europe till the 16th century. But as the idea of them is very clearly expounded in the work of Albategni; and as, in the 13th century, we find tables of tangents calculated by the Arabs, we need not wonder if they should be found in the Surya-Siddhanta, whose date is now known to be more ancient. The Professor is astonished at seeing versed sines among the Indians; but his memory has betrayed him, when he asserts that the Arabs did not know them. He acknowledges that the Indians have not actually demonstrated either of the processes which they point out for these calculations. I would be tempted to believe that they were ignorant of these demonstrations; if they had known the principle, their table would have been probably a little better. Mr. Playfair has not calculated it anew, he has not even had the discernment to perceive the error of the division, 225 substituted, probably by an error of the copy, for the true divisor 235. 5."

Thus, at the touch of truth, vanished the most specious, and apparently the most solid foundation for infidelity that modern times have afforded; and thus did Moses and his history triumph over the vain pretensions of the Hindoos, combined with the demonstrations of one of the first mathematicians of Europe. And, it is not a little gratifying to the friends of the Bible, that the "*pure and unbroken light which is free from the false coloring of vanity and superstition,*" was thus freed from contempt and derision, not by the guardians of religion, but by those who were searching for truth solely in honor of the sciences, and who would (at least some of them) have rather the error had fallen against Moses, than against the Indian Astronomy.

EGYPTIAN ZODIACS.

"No sooner," says the Rev. Mr. Conybeare, "has any new discovery, whatever might have been its subject, occurred, (whether it was a fragment of Indian Chronology, or an Egyptian Zodiac, or the mechanism of the Universe, or that of living bodies, or lastly some new fact relating to the structure of the earth,) than the first aspect under which some minds have seemed anxious to view it, has been, whether it would not furnish some new weapon against Revelation."*

Recent history, especially that department which relates to the sciences, constantly affirms the truth of the above observation. In no age have the advocates for unbelief sought after new resources, with so much eagerness, as during the present. The mighty movements of the Christian world, have not only shown a determination to spread the truths of the gospel, where they are still unknown, but also to remove from herself, as far as possible, every taint of irreligion. The light of science, and a more general knowledge of the Bible, have long since thrown all the ancient systems of infidelity into oblivion. Even those which were in fashion thirty years ago are now obsolete; so that the errors and the authors against which Dr. Dwight warned his Baccalaureate in about 1800, are such as young men are in little danger from at the present day. The world is too far advanced in knowledge, to be caught by commonplace arguments against religion. All this is well known to the infidel ranks in every part of Christendom, and hence they see the necessity of looking among the higher branches of knowledge for new weapons.

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* Conybeare and Phillips' Geo. Int. p. 50.

The progress of the sciences has lately afforded these men their chief hopes, and already several high attempts have been issued from this quarter. Among these the *Systeme des Animaux sans Vertebres*, and the "*Hydrogeologie*," from one hand, and the *Expose du Systeme du Monde*, from another, stands conspicuous.

Meantime, Egypt, that country of wonders and of antiquities, of which no one could tell the origin or date, has been for a long period looked upon as a most probable source, whence some strong proof against revelation would come; and from time to time it has been asserted, that monuments had been there discovered, which, could their antiquities be known, would undoubtedly, as counter truths, go far to destroy the influence of the Bible. But the language of the Egyptians being unknown, was the excuse for not proving to the world the antiquity of these monuments, and thus doing away at once, all ground of religious prejudice and superstition among men.

It was not, however, until Egypt was occupied by the army of Napoleon, that monuments which appeared to offer any great available promise for such a purpose, were discovered, and these were the famous *Egyptian Zodiacs*, which for a time occupied the almost entire attention of all the antiquaries, and many of the learned men of Europe.

There were two of these Zodiacs, one of which occupied the place of a ceiling in a temple at Dendera, in Upper Egypt, and the other a corresponding situation in a temple at Esne, the ancient Latopolis. At the latter place indeed there were two, in different temples, one of which, however, was of a small size, and of which it is unnecessary to take further notice.

These works were supposed by many learned men, to afford the most conclusive evidence, (on what ground will be seen directly,) that no history yet known, had recorded the true epoch of the creation of man; and not a few writers exulted in the belief, that at last, reason and science had triumphed, and that now the minds of men were no longer to be held in religious bondage.

The Egyptian Zodiacs present the same figures that are employed to represent the several constellations at the present day, but are arranged in a right manner, and are engraved in wood and painted. That of Dendera is the most perfect. This temple faces the north.

Here the sign of the Lion heads the band; he is directing his course towards the north, and has his feet towards the eastern wall. The Virgin, the Balance, the Scorpion, the Archer, and the Capricorn, follow in the same line. But it is needless to describe what cannot be understood without drawings.

The force of the argument for the antiquity of this monument, consisted in the supposition, that the peculiar distribution of these figures represented the exact state, or relative positions of the constellations, with respect to each other, at the time when it was constructed, and that by astronomical calculations made backward, from the present state of the constellations, it could be ascertained at what period they were actually in the position represented by this Zodiac, and thus the period of its construction would be known.

Figures of the Zodiacs were first published by the accomplished Denon, in his work on Egypt, and it appears that the subject excited the most intense interest among learned men of Europe, and particularly of France.

"The Zodiacs," says M. Greppo,* "were immediately published, and commented upon with more or less good faith and decorum. Science struck out into systems very bold; and the spirit of infidelity, seizing upon the discovery, flattered itself with the hope of drawing from it new support."

It was said that the Zodiacs exhibited the state of the heavens at the most remote periods, and that it was possible, from present data, to show when that period was. Accordingly, calculations of great prolixity and abstruseness were instituted to prove, what before had been assumed, namely, that these monuments were constructed long before the period of Scripture chronology.

These calculations, founded on the sure basis of mathematics, were said to be conclusive beyond all controversy. But a difficulty arose, which, in the opinion of truth and sobriety, threw a doubt over all such demonstrations. This was, that the philosophers did not agree among themselves, as to the actual time when the Zodiacs were constructed, though several coincided so far as to deny in

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* "Essay on the Hieroglyphic System," by M. Greppo. Translated by J. Stuart, 1830.

the most positive manner, the veracity of Moses. Thus M. Burkard demonstrated that the temple of Esne had stood 7000 years, while M. Nouet, making his calculations from other data, afforded by the same figures, proved that this temple was built 4600 years before the Christian era, that is, about 600 years before the creation, according to the Mosaic Chronology. M. Dupuis, taking a still different view of the subject, and making his demonstrations from some peculiar data which his learning and sagacity had discovered, shows, by calculations through which few could follow him, that these temples must have stood at least 15,000 years.

"Although the sensation which the Zodaical system of infidelity produced, was at first chiefly confined to men devoted to study, there were many others, who when they understood its bearings, were ready to applaud its pretended triumphs, so that intelligent, as well as pious men, were grieved to find the common belief of all Christian societies, not unfrequently attacked in their very foundation."*

In the midst of this apparent triumph of infidelity, a circumstance happened, which gave a new excitement to the subject of the Zodiacs. This was no less than the arrival of the planisphere of Dendera at Paris.

M. Leloraine, an enterprising young traveller, in spite of many obstacles, was the means of detaching this celebrated monument from the ceiling of the temple, and of transporting it to the sea, whence it was shipped, and finally reached Paris in 1821.

M. Greppo describes the intense interest it there excited. "An object of interest," says he, "to educated men, and of vanity to those who thought themselves such, it could not remain unnoticed by the multitude; and classes of society, who knew not even the signification of the term Zodiac, rushed in crowds to behold it. In the journals, in the saloons, the Zodiac was the only topic of discussion. Have you seen the Zodiac? What do you think of the Zodiac? were questions, to which every one was seemingly compelled to give a well informed answer, or to be degraded from a place in polished society.

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* Greppo.

The learned could now examine the original instead of its representations, and thus a new impulse was given to the discussions concerning the Zodiac, and new opinions, and new publications, arose in consequence.

These discussions fermented an unbelieving spirit, even among those classes which had never before arrayed themselves against the truths of revelation. Rash and unfounded opinions were hazarded; the infidelity of Dupuis, who had made the world 15,000 years old, was spread abroad in Paris, by means of small tracts, and thus the minds of multitudes partook of the poison.

At this moment, as though an antidote to the virus of infidelity had descended from heaven, there arrived in Paris, that celebrated antiquary, Champollion, the younger, from a visit to Egypt. This young man had just before solved the great secret of the Egyptian hieroglyphics, and having examined the Zodiac before its removal from Dendera, he had there deciphered, not only the inscriptions which it contained, but also several others, inscribed on several parts of the temple itself.

Armed with this great discovery, he was enabled to reveal the truth concerning these wonderful monuments, and thus to dispel the dark cloud of skepticism, which seemed destined to spread from the French capital to all parts of the world.

The title on the Zodiac consisted of the following letters, viz.: A O T K P T P. These, with certain letters, interspersed according to the rule discovered by Champollion, form the Greek word for *Emperor*. Besides this, he discovered, in the temple of Dendera, the names, titles, and surnames of the Emperors, *Tiberius*, *Claudius*, *Nero*, and *Domitian*, and upon the portico of Esne, whose Zodiac had been judged many centuries older than that of Dendera, he read the names of *Claudius* and *Antoninus Pius*.*

Here, then, the entire substratum of the Zodiacal system of infidelity was crumbled into dust, and the fabric, which had been erected upon it with so much zeal and confidence, fell at once upon its builders, and covered them with shame and confusion.

And here, again, it may be remarked, (as was the case

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* Stuart's Greppo, p. 184.

with the Hindoo tables,) that the facts were not brought to light by those whose especial duty and interest it is to defend the truths of revelation; but by one who had gone forward of his species in the science of philology; a circumstance of great interest and consequence, in both cases, since infidelity can never claim, that, in these instances, its cause has been crushed by the undue influence of "*prejudice* or *superstition*," upon the world.

It is only necessary to state, in concluding this subject, that the Egyptian Zodiacs have no greater antiquity than the Roman domination of Egypt, which commenced one or two centuries after the Christian era; and that these signs do not, in any respect, relate to astronomy, but are connected with the idle phantasies of *judicial astrology*. The figures, therefore, which were so lately and confidently expected to revolutionize the Christian world, and reduce it to heathenism, are nothing more than what adepts in the pretended science of astronomy, call *themes of nativity*.

And now, what reader does not see especial marks of Divine Superintendence, in the circumstance, that the solution of the Egyptian hieroglyphics, (which had been a principal object among antiquaries and learned men for centuries,) should have been discovered, just at a moment to destroy one of the most specious systems of infidelity ever offered to the world?

BEDS OF LAVA AT ETNA.

"I have," says Dr. Ure, "met with persons of considerable pretensions to candor and sagacity, who, having devoured, with greedy eyes, the story told by Brydone, in his Sicilian Tour, about the canon Recupero, conceive that it justifies them in reviling the chronology and character of Moses."*

This popular book has been very extensively read in this country, and it is believed, that even at this day, the beds of lava at Etna, are often brought forward to prove that there is no truth in the Mosaic Chronology. It is for

* Geol. Int. p. 14.

this reason that we here state the circumstances as they are said to have occurred. With respect to the beds of lava, Brydone pretends to publish the opinions of the canon Recupero, who lived in the neighborhood, and who, it is stated, was a competent judge in such matters.

This man, of undoubted piety, of great simplicity of life, and well known for his hospitality, is made to say, that, in his opinion, a bed of lava requires 2000 years exposure to the weather, in order to undergo sufficient decomposition to form a soil of a certain thickness. On examination, it was found, that Etna afforded seven beds of lava, with a thickness of soil between each, equal to that which the canon had said could only have been formed in 2000 years. By this mode of calculation, it was therefore proved that the first eruption, in this series, must have been 14,000 years ago, and there would, of course, be reason to suppose, that the mountain itself might be much older than the first bed of lava.

The manner in which this attempt to raise doubts, with respect to the veracity of Moses, was received, shows with what avidity certain characters catch hold of any thing, which looks like a weapon against religion; and, also, how willing many people are to be deceived, when a lie suits them better than the truth.

This simple story, which no man of common sense would have taken as testimony in the smallest matter of science or business, was immediately brought forward and published to the world, as presenting the most positive facts, in evidence, that the Bible was not true; and although it has long since been proved, that there never existed the least foundation for such an inference, it is still employed to the ignorant as an argument against the Bible, and by some is considered as good evidence even to this day.

The truth appears to be, that what Brydone believed, or pretended to believe, was decomposed lava, was probably what geologists call volcanic tufa, or volcanic ashes, either of which might have covered the surface of the lava current, a foot or two in depth, in a few hours, instead of its requiring 2000 years, as he makes the canon to suppose.

That no estimate of time can be made from any such circumstance, is proved by observations on other beds of lava.

"Some of the lavas of Auvergne," says Daubuisson, "have maintained an entire surface, all over blistered, and bristling with asperities, whose edges and angles are still sharp, and well preserved. We might even imagine these lava streams to have just flowed from the bowels of the earth, and that they had hardly had time to cool. It is, however, probable, that these lavas have lain on the soil of Auvergne for 3000 years, exposed to the action of the elements."

On the contrary, Sir William Hamilton has shown that over the matter which buried Herculaneum, there are six streams of lava with veins of *good soil between them.* Now, Herculaneum was destroyed about 1800 years ago, which shows that veins of good soil have there been formed in 300 years, instead of 2000, as estimated by Brydone. Here we see, that in one case, no soil was formed in 3000 years, while in another, veins of some thickness were formed in one tenth of that time; which proves most clearly, that no inference can be drawn with respect to the age of the lava, from the state of its surface.

Mr. Daubeny, an experienced observer, has recently visited the famous pit at Aci Reale, on which the Scottish traveller made the canon to speculate, and of which he speaks as follows:—

"At all events, Brydone has been grossly deceived, in imagining that the seven beds of lava seen lying one above the other, near the spot, have been sufficiently decomposed into vegetable mould; the substance which really intervenes between the beds, being nothing more than a sort of ferruginous tuff, just similar to what would be produced by a shower of volcanic ashes, such as naturally precedes, or follows, an eruption of lava, mixed up with mud or consolidated by rain."*

On the same subject, Dolomieu, a distinguished mineralogist, says, "The canon Recupero deserves neither the praises which have been bestowed on his science, nor the doubts which have been raised concerning his orthodoxy. He died without any other affliction, than that which was caused to him by the work of Brydone. He could not conceive for what purpose this stranger, to whom he had rendered services, endeavored to excite sus-

* Edinburgh Phil. Jour. vol. xiii. p. 266.

picions concerning the orthodoxy of his faith. This simple man, very religious, and attached to the faith of his forefathers, was far from admitting, as an evidence against the book of Genesis, pretended facts which *are false, but from which, even if they had been true, nothing could have been concluded.* Vegetable earths between the beds of lava do not exist; and the argillaceous earths, which are sometimes found between them, may have been disposed there, by causes totally independent of the antiquity of Etna."

We are not a little surprised to find that Mr. Faber, author of that learned work, the "Three Dispensations," has so magnified the story of the lava beds at Etna, as to make out of it one of his arguments for extending the days of Genesis to periods of 6000 years. (See an Epitome of his Theory, p. 319.)

"The extension," says he, "of the six demiurgic days into six very long periods, most effectually nullifies the infidel objection, drawn from the ancient eruptions of Mount Etna."

After describing the lava beds and strata of earth between them, Mr. Faber allows the infidel the full benefit of this argument, and even more. He may, if he pleases, date an eruption 30,000 years before the creation of man. "What then," says the author, "does such a concession at all tend to disprove the Scriptural chronology of man's formation. Most assuredly not: for, if the six demiurgic days each exceed a term of six thousand years, we shall have quite time enough for the eruption, even prior to the formation of man, without there being any need to impugn the Scriptural authority of that event." Vol. i. p. 159. London, 1823.

We cannot but hope Mr. Faber has since discovered, that the ground of this argument no longer exists, and also, that there may be danger in disseminating the account, since it is possible some of his readers may believe the facts concerning the beds, without recognising the counteracting force of his arguments.