

CHAPTER V.

Review of the causes which have retarded the progress of Geology—Effects of prepossessions in regard to the duration of past time—Of prejudices arising from our peculiar position as inhabitants of the land—Of those occasioned by our not seeing subterranean changes now in progress—All these causes combine to make the former course of Nature appear different from the present—Several objections to the assumption, that existing causes have produced the former changes of the earth's surface, removed by modern discoveries.

WE have seen that, during the progress of geology, there have been great fluctuations of opinion respecting the nature of the causes to which all former changes of the earth's surface are referrible. The first observers conceived that the monuments which the geologist endeavours to decipher, relate to a period when the physical constitution of the earth differed entirely from the present, and that, even after the creation of living beings, there have been causes in action distinct in kind or degree from those now forming part of the economy of nature. These views have been gradually modified, and some of them entirely abandoned in proportion as observations have been multiplied, and the signs of former mutations more skilfully interpreted. Many appearances, which for a long time were regarded as indicating mysterious and extraordinary agency, are finally recognized as the necessary result of the laws now governing the material world; and the discovery of this unlooked for conformity has induced some geologists to infer that there has never been any interruption to the same uniform order of physical events. The same assemblage of general causes, they conceive, may have been sufficient to produce, by their various combinations, the endless diversity of effects, of which the shell of the earth has preserved the memorials, and, consistently with these principles, the recurrence of analogous changes is expected by them in time to come.

Whether we coincide or not in this doctrine, we must admit that the gradual progress of opinion concerning the succession of phenomena in remote eras, resembles in a singular manner that

which accompanies the growing intelligence of every people, in regard to the economy of nature in modern times. In an early stage of advancement, when a great number of natural appearances are unintelligible, an eclipse, an earthquake, a flood, or the approach of a comet, with many other occurrences afterwards found to belong to the regular course of events, are regarded as prodigies. The same delusion prevails as to moral phenomena, and many of these are ascribed to the intervention of demons, ghosts, witches, and other immaterial and supernatural agents. By degrees, many of the enigmas of the moral and physical world are explained, and, instead of being due to extrinsic and irregular causes, they are found to depend on fixed and invariable laws. The philosopher at last becomes convinced of the undeviating uniformity of secondary causes, and, guided by his faith in this principle, he determines the probability of accounts transmitted to him of former occurrences, and often rejects the fabulous tales of former ages, on the ground of their being irreconcilable with the experience of more enlightened ages.

As a belief in want of conformity in the physical constitution of the earth, in ancient and modern times, was for a long time universally prevalent, and that too amongst men who were convinced that the order of nature is *now* uniform, and has continued so for several thousand years; every circumstance which could have influenced their minds and given an undue bias to their opinions deserves particular attention. Now the reader may easily satisfy himself, that, however undeviating the course of nature may have been from the earliest epochs, it was impossible for the first cultivators of geology to come to such a conclusion, so long as they were under a delusion as to the age of the world, and the date of the first creation of animate beings. However fantastical some theories of the sixteenth century may now appear to us,—however unworthy of men of great talent and sound judgment, we may rest assured that, if the same misconceptions now prevailed in regard to the memorials of human transactions, it would give rise to a similar train of absurdities. Let us imagine, for example, that Champollion, and the French and Tuscan literati now engaged in exploring the antiquities of Egypt, had visited that country with a firm belief that the banks of the Nile were never peopled by the human

race before the beginning of the nineteenth century, and that their faith in this dogma was as difficult to shake as the opinion of our ancestors, that the earth was never the abode of living beings until the creation of the present continents, and of the species now existing,—it is easy to perceive what extravagant systems they would frame, while under the influence of this delusion, to account for the monuments discovered in Egypt. The sight of the pyramids, obelisks, colossal statues, and ruined temples, would fill them with such astonishment, that for a time they would be as men spell-bound—wholly incapacitated to reason with sobriety. They might incline at first to refer the construction of such stupendous works to some super-human powers of a primeval world. A system might be invented resembling that so gravely advanced by Manetho, who relates that a dynasty of gods originally ruled in Egypt, of whom Vulcan, the first monarch, reigned nine thousand years. After them came Hercules and other demi-gods, who were at last succeeded by human kings. When some fanciful speculations of this kind had amused the imagination for a time, some vast repository of mummies would be discovered and would immediately undeceive those antiquaries who enjoyed an opportunity of personally examining them, but the prejudices of others at a distance, who were not eye-witnesses of the whole phenomena, would not be so easily overcome. The concurrent report of many travellers would indeed render it necessary for them to accommodate ancient theories to some of the new facts, and much wit and ingenuity would be required to modify and defend their old positions. Each new invention would violate a greater number of known analogies; for if a theory be required to embrace some false principle, it becomes more visionary in proportion as facts are multiplied, as would be the case if geometers were now required to form an astronomical system on the assumption of the immobility of the earth.

Amongst other fanciful conjectures concerning the history of Egypt, we may suppose some of the following to be started. ‘As the banks of the Nile have been so recently colonized, the curious substances called mummies could never in reality have belonged to men. They may have been generated by some *plastic virtue* residing in the interior of the earth, or they may

‘be abortions of nature produced by her incipient efforts in the
 ‘work of creation. For if deformed beings are sometimes born
 ‘even now, when the scheme of the universe is fully developed,
 ‘many more may have been “sent before their time, scarce
 ‘half made up,” when the planet itself was in the embryo state.
 ‘But if these notions appear to derogate from the perfection
 ‘of the Divine attributes, and if these mummies be in all their
 ‘parts true representations of the human form, may we not
 ‘refer them to the future rather than the past? May we not
 ‘be looking into the womb of nature, and not her grave? may
 ‘not these images be like the shades of the unborn in Virgil’s
 ‘Elysium—the archetypes of men not yet called into existence?’

These speculations, if advocated by eloquent writers, would not fail to attract many zealous votaries, for they would relieve men from the painful necessity of renouncing preconceived opinions. Incredible as such scepticism may appear, it would be rivalled by many systems of the sixteenth and seventeenth centuries, and among others by that of the learned Falloppio, who regarded the tusks of fossil elephants as earthy concretions, and the vases of Monte Testaceo, near Rome, as works of nature, and not of art. But when one generation had passed away, and another not compromised to the support of antiquated dogmas had succeeded, they would review the evidence afforded by mummies more impartially, and would no longer controvert the preliminary question, that human beings had lived in Egypt before the nineteenth century: so that when a hundred years perhaps had been lost, the industry and talents of the philosopher would be at last directed to the elucidation of points of real historical importance.

But we have adverted to one only of many prejudices with which the earlier geologists had to contend. Even when they conceded that the earth had been peopled with animate beings at an earlier period than was at first supposed, they had no conception that the quantity of time bore so great a proportion to the historical era as is now generally conceded. How fatal every error as to the quantity of time must prove to the introduction of rational views concerning the state of things in former ages, may be conceived by supposing that the annals of the civil and military transactions of a great nation were perused under the impression that they occurred in a period of one hundred

instead of two thousand years. Such a portion of history would immediately assume the air of a romance; the events would seem devoid of credibility, and inconsistent with the present course of human affairs. A crowd of incidents would follow each other in thick succession. Armies and fleets would appear to be assembled only to be destroyed, and cities built merely to fall in ruins. There would be the most violent transitions from foreign or intestine war to periods of profound peace, and the works effected during the years of disorder or tranquillity would be alike superhuman in magnitude.

He who should study the monuments of the natural world under the influence of a similar infatuation, must draw a no less exaggerated picture of the energy and violence of causes, and must experience the same insurmountable difficulty in reconciling the former and present state of nature. If we could behold in one view all the volcanic cones thrown up in Iceland, Italy, Sicily, and other parts of Europe, during the last five thousand years, and could see the lavas which have flowed during the same period; the dislocations, subsidences and elevations caused by earthquakes; the lands added to various deltas, or devoured by the sea, together with the effects of devastation by floods, and imagine that all these events had happened in one year, we must form most exalted ideas of the activity of the agents, and the suddenness of the revolutions. Were an equal amount of change to pass before our eyes in the next year, could we avoid the conclusion that some great crisis of nature was at hand? If geologists, therefore, have misinterpreted the signs of a succession of events, so as to conclude that centuries were implied where the characters imported thousands of years, and thousands of years where the language of nature signified millions, they could not, if they reasoned logically from such false premises, come to any other conclusion, than that the system of the natural world had undergone a complete revolution.

We should be warranted in ascribing the erection of the great pyramid to superhuman power, if we were convinced that it was raised in one day; and if we imagine, in the same manner, a mountain chain to have been elevated, during an equally small fraction of the time which was really occupied in upheaving it, we might then be justified in inferring, that

the subterranean movements were once far more energetic than in our own times. We know that one earthquake may raise the coast of Chili for a hundred miles to the average height of about five feet. A repetition of two thousand shocks of equal violence might produce a mountain chain one hundred miles long, and ten thousand feet high. Now, should one only of these convulsions happen in a century, it would be consistent with the order of events experienced by the Chilians from the earliest times; but if the whole of them were to occur in the next hundred years, the entire district must be depopulated, scarcely any animals or plants could survive, and the surface would be one confused heap of ruin and desolation.

One consequence of undervaluing greatly the quantity of past time is the apparent coincidence which it occasions of events necessarily disconnected, or which are so unusual, that it would be inconsistent with all calculation of chances to suppose them to happen at one and the same time. When the unlooked for association of such rare phenomena is witnessed in the present course of nature, it scarcely ever fails to excite a suspicion of the preternatural in those minds which are not firmly convinced of the uniform agency of secondary causes;—as if the death of some individual in whose fate they are interested, happens to be accompanied by the appearance of a luminous meteor, or a comet, or the shock of an earthquake. It would be only necessary to multiply such coincidences indefinitely, and the mind of every philosopher would be disturbed. Now it would be difficult to exaggerate the number of physical events, many of them most rare and unconnected in their nature, which were imagined by the Woodwardian hypothesis to have happened in the course of a few months; and numerous other examples might be found of popular geological theories, which require us to imagine that a long succession of events happened in a brief and almost momentary period.

The sources of prejudice hitherto considered may be deemed as in a great degree peculiar to the infancy of the science, but others are common to the first cultivators of geology and to ourselves, and are all singularly calculated to produce the same deception, and to strengthen our belief that the course of nature in the earlier ages differed widely from that now established. Although we cannot fully explain all these circum-

stances, without assuming some things as proved, which it will be the object of another part of this work to demonstrate, we must briefly allude to them in this place.

The first and greatest difficulty, then, consists in our habitual unconsciousness that our position as observers is essentially unfavourable, when we endeavour to estimate the magnitude of the changes now in progress. In consequence of our inattention to this subject, we are liable to the greatest mistakes in contrasting the present with former states of the globe. We inhabit about a fourth part of the surface; and that portion is almost exclusively the theatre of decay and not of reproduction. We know, indeed, that new deposits are annually formed in seas and lakes, and that every year some new igneous rocks are produced in the bowels of the earth, but we cannot watch the progress of their formation; and, as they are only present to our minds by the aid of reflection, it requires an effort both of the reason and the imagination to appreciate duly their importance. It is, therefore, not surprising that we imperfectly estimate the result of operations invisible to us; and that, when analogous results of some former epoch are presented to our inspection, we cannot recognise the analogy. He who has observed the quarrying of stone from a rock, and has seen it shipped for some distant port, and then endeavours to conceive what kind of edifice will be raised by the materials, is in the same predicament as a geologist, who, while he is confined to the land, sees the decomposition of rocks, and the transportation of matter by rivers to the sea, and then endeavours to picture to himself the new strata which Nature is building beneath the waters. Nor is his position less unfavourable when, beholding a volcanic eruption, he tries to conceive what changes the column of lava has produced, in its passage upwards, on the intersected strata; or what form the melted matter may assume at great depths on cooling down; or what may be the extent of the subterranean rivers and reservoirs of liquid matter far beneath the surface. It should, therefore, be remembered, that the task imposed on those who study the earth's history requires no ordinary share of discretion, for we are precluded from collating the corresponding parts of a system existing at two different periods. If we were inhabitants of another element—if the great ocean were our domain, instead of the narrow limits of the land, our difficulties would be considerably lessened;

while, on the other hand, there can be little doubt, although the reader may, perhaps, smile at the bare suggestion of such an idea, that an amphibious being, who should possess our faculties, would still more easily arrive at sound theoretical opinions in geology, since he might behold, on the one hand, the decomposition of rocks in the atmosphere, and the transportation of matter by running water; and, on the other, examine the deposition of sediment in the sea, and the imbedding of animal remains in new strata. He might ascertain, by direct observation, the action of a mountain torrent, as well as of a marine current; might compare the products of volcanos on the land with those poured out beneath the waters; and might mark, on the one hand, the growth of the forest, and on the other that of the coral reef. Yet, even with these advantages, he would be liable to fall into the greatest errors when endeavouring to reason on rocks of subterranean origin. He would seek in vain, within the sphere of his observation, for any direct analogy to the process of their formation, and would therefore be in danger of attributing them, wherever they are upraised to view, to some "primeval state of nature." But if we may be allowed so far to indulge the imagination, as to suppose a being, entirely confined to the nether world—some "dusky melancholy sprite," like Umbriel, who could "flit on sooty pinions to the central earth," but who was never permitted to "sully the fair face of light," and emerge into the regions of water and of air; and if this being should busy himself in investigating the structure of the globe, he might frame theories the exact converse of those usually adopted by human philosophers. He might infer that the stratified rocks, containing shells and other organic remains, were the oldest of created things, belonging to some original and nascent state of the planet. "Of these masses," he might say, "whether they consist of loose incoherent sand, soft clay, or solid rock, none have been formed in modern times. Every year some part of them are broken and shattered by earthquakes, or melted up by volcanic fire; and, when they cool down slowly from a state of fusion, they assume a crystalline form, perfectly distinct from those inexplicable rocks which are so regularly bedded, and contain stones full of curious impressions and fantastic markings. This process cannot have been carried on for an indefinite time, for in that case all the stratified rocks would long ere

this have been fused and crystallized. It is therefore probable that the whole planet once consisted of these curiously-bedded formations, at a time when the volcanic fire had not yet been brought into activity. Since that period there seems to have been a gradual development of heat, and this augmentation we may expect to continue till the whole globe shall be in a state of fluidity and incandescence.”

Such might be the system of the Gnome at the very same time that the followers of Leibnitz, reasoning on what they saw on the outer surface, would be teaching the doctrine of gradual refrigeration, and averring that the earth had begun its career as a fiery comet, and would hereafter become a frozen icy mass. The tenets of the schools of the nether and of the upper world would be directly opposed to each other, for both would partake of the prejudices inevitably resulting from the continual contemplation of one class of phenomena to the exclusion of another. Man observes the annual decomposition of crystalline and igneous rocks, and may sometimes see their conversion into stratified deposits; but he cannot witness the reconversion of the sedimentary into the crystalline by subterranean fire. He is in the habit of regarding all the sedimentary rocks as more recent than the unstratified, for the same reason that we may suppose him to fall into the opposite error if he saw the origin of the igneous class only.

It is only by becoming sensible of our natural disadvantages that we shall be roused to exertion, and prompted to seek out opportunities of discovering the operations now in progress, such as do not present themselves readily to view. We are called upon, in our researches into the state of the earth, as in our endeavours to comprehend the mechanism of the heavens, to invent means for overcoming the limited range of our vision. We are perpetually required to bring, as far as possible, within the sphere of observation, things to which the eye, unassisted by art, could never obtain access. It was not an impossible contingency that astronomers might have been placed, at some period, in a situation much resembling that in which the geologist seems to stand at present. If the Italians, for example, in the early part of the twelfth century, had discovered at Amalphi, instead of the pandects of Justinian, some ancient manuscripts filled with astronomical observations relating to a period of three thousand years, and made by some ancient geometers

who possessed optical instruments as perfect as any in modern Europe, they would probably, on consulting these memorials, have come to a conclusion that there had been a great revolution in the solar and sidereal systems. "Many primary and secondary planets," they might say, "are enumerated in these tables, which exist no longer. Their positions are assigned with such precision, that we may assure ourselves that there is nothing in their place at present but the blue ether. Where one star is visible to us, these documents represent several thousands. Some of those which are now single, consisted then of two separate bodies, often distinguished by different colours, and revolving periodically round a common centre of gravity. There is no analogy to them in the universe at present, for they were neither fixed stars nor planets, but stood in the mutual relation of sun and planet to each other. We must conclude, therefore, that there has occurred, at no distant period, a tremendous catastrophe, whereby thousands of worlds have been annihilated at once, and some heavenly bodies absorbed into the substance of others." When such doctrines had prevailed for ages, the discovery of one of the worlds, supposed to have been lost, by aid of the first rude telescope, would not dissipate the delusion, for the whole burden of proof would now be thrown on those who insisted on the stability of the system from the beginning of time, and these philosophers would be required to demonstrate the existence of *all* the worlds said to have been annihilated. Such popular prejudices would be most unfavourable to the advancement of astronomy; for, instead of persevering in the attempt to improve their instruments, and laboriously to make and record observations, the greater number would despair of verifying the continued existence of the heavenly bodies not visible to the naked eye. Instead of confessing the extent of their ignorance, and striving to remove it by bringing to light new facts, they would be engaged in the indolent employment of framing imaginary theories concerning catastrophes and mighty revolutions in the system of the universe.

For more than two centuries the shelly strata of the Subapennine hills afforded matter of speculation to the early geologists of Italy, and few of them had any suspicion that similar deposits were then forming in the neighbouring sea. They were as unconscious of the continued action of causes still pro-

ducing similar effects, as the astronomers, in the case supposed by us, of the existence of certain heavenly bodies still giving and reflecting light, and performing their movements as in the olden time. Some imagined that the strata, so rich in organic remains, instead of being due to secondary agents, had been so created in the beginning of things by the fiat of the Almighty; and others ascribed the imbedded fossil bodies to some plastic power which resided in the earth in the early ages of the world. At length Donati explored the bed of the Adriatic, and found the closest resemblance between the new deposits there forming, and those which constituted hills above a thousand feet high in various parts of the peninsula. He ascertained that certain genera of living testacea were grouped together at the bottom of the sea in precisely the same manner as were their fossil analogues in the strata of the hills, and that some species were common to the recent and fossil world. Beds of shells, moreover, in the Adriatic, were becoming incrustated with calcareous rock; and others were recently enclosed in deposits of sand and clay, precisely as fossil shells were found in the hills. This splendid discovery of the identity of modern and ancient submarine operations was not made without the aid of artificial instruments, which, like the telescope, brought phenomena into view not otherwise within the sphere of human observation.

In like manner, in the Vicentin, a great series of volcanic and marine sedimentary rocks were examined in the early part of the last century; but no geologist suspected, before the time of Arduino, that these were partly composed of ancient submarine lavas. If, when these enquiries were first made, geologists had been told that the mode of formation of such rocks might be fully elucidated by the study of processes then going on in certain parts of the Mediterranean, they would have been as incredulous as geometers would have been before the time of Newton, if any one had informed them that, by making experiments on the motion of bodies on the earth, they might discover the laws which regulated the movements of distant planets.

The establishment, from time to time, of numerous points of identification, drew at length from geologists a reluctant admission, that there was more correspondence between the physical constitution of the globe, and more uniformity in the laws re-

gulating the changes of its surface, from the most remote eras to the present, than they at first imagined. If, in this state of the science, they still despaired of reconciling every class of geological phenomena to the operations of ordinary causes, even by straining analogy to the utmost limits of credibility, we might have expected, that the balance of probability at least would now have been presumed to incline towards the identity of the causes. But, after repeated experience of the failure of attempts to speculate on different classes of geological phenomena, as belonging to a distinct order of things, each new sect persevered systematically in the principles adopted by their predecessors. They invariably began, as each new problem presented itself, whether relating to the animate or inanimate world, to assume in their theories, that the economy of nature was formerly governed by rules quite independent of those now established. Whether they endeavoured to account for the origin of certain igneous rocks, or to explain the forces which elevated hills or excavated valleys, or the causes which led to the extinction of certain races of animals, they first presupposed an original and dissimilar order of nature; and when at length they approximated, or entirely came round to an opposite opinion, it was always with the feeling, that they conceded what they were justified *à priori* in deeming improbable. In a word, the same men who, as natural philosophers, would have been greatly surprised to find any deviation from the usual course of Nature *in their own time*, were equally surprised, as geologists, not to find such deviations at every period of the past.

The Huttonians were conscious that no check could be given to the utmost licence of conjecture in speculating on the causes of geological phenomena, unless we can assume invariable constancy in the order of Nature. But when they asserted this uniformity without any limitation as to time, they were considered, by the majority of their contemporaries, to have been carried too far, especially as they applied the same principle to the laws of the organic, as well as of the inanimate world*.

* Playfair, after admitting the extinction of some species, says, "The inhabitants of the globe, then, like all other parts of it, are subject to change. It is not only the individual that perishes, but whole *species*, and even perhaps *genera*, are extinguished."—"A change in the animal kingdom seems to be a *part of the order of nature*, and is visible in instances to which human power cannot have extended."—Illustrations of the Huttonian Theory, § 413.

We shall first advert briefly to many difficulties which formerly appeared insurmountable, but which, in the last forty years, have been partially or entirely removed by the progress of science; and shall afterwards consider the objections that still remain to the doctrine of absolute uniformity.

In the first place, it was necessary for the supporters of this doctrine to take for granted incalculable periods of time, in order to explain the formation of sedimentary strata by causes now in diurnal action. The time which they required theoretically, is now granted, as it were, or has become absolutely requisite, to account for another class of phenomena brought to light by more recent investigations. It must always have been evident to unbiassed minds, that successive strata, containing, in regular order of superposition, distinct beds of shells and corals, arranged in families as they grow at the bottom of the sea, could only have been formed by slow and insensible degrees in a great lapse of ages; yet, until organic remains were minutely examined and specifically determined, it was rarely possible to prove that the series of deposits met with in one country was not formed simultaneously with that found in another. But we are now able to determine, in numerous instances, the relative dates of sedimentary rocks in distant regions, and to show, by their organic remains, that they were not of contemporary origin, but formed in succession. We often find, that where an interruption in the consecutive formation in one district is indicated by a sudden transition from one assemblage of fossil species to another, the chasm is filled up, in some other district, by other important groups of strata. The more attentively we study the European continent, the greater we find the extension of the whole series of geological formations. No sooner does the calendar appear to be completed, and the signs of a succession of physical events arranged in chronological order, than we are called upon to intercalate, as it were, some new periods of vast duration. A geologist, whose observations have been confined to England, is accustomed to consider the superior and newer groups of marine strata in our island as modern, and such they are, comparatively speaking; but when he has travelled through the Italian peninsula and in Sicily, and has seen strata of more recent origin forming mountains several

thousand feet high, and has marked a long series both of volcanic and submarine operations, all newer than any of the regular strata which enter largely into the physical structure of Great Britain, he returns with more exalted conceptions of the antiquity of some of those modern deposits, than he before entertained of the oldest of the British series. We cannot reflect on the concessions thus extorted from us, in regard to the duration of past time, without foreseeing that the period may arrive when part of the Huttonian theory will be combated on the ground of its departing too far from the assumption of uniformity in the order of nature. On a closer investigation of extinct volcanos, we find proofs that they broke out at successive eras, and that the eruptions of one group were often concluded long before others had commenced their activity. Some were burning when one class of organic beings were in existence, others came into action when different races of animals and plants existed,—it follows, therefore, that the convulsions caused by subterranean movements, which are merely another portion of the volcanic phenomena, occurred also in succession, and their effects must be divided into separate sums, and assigned to separate periods of time; and this is not all:—when we examine the volcanic products, whether they be lavas which flowed out under water or upon dry land, we find that intervals of time, often of great length, intervened between their formation, and that the effects of one eruption were not greater in amount than that which now results during ordinary volcanic convulsions. The accompanying or preceding earthquakes, therefore, may be considered to have been also successive, and to have been in like manner interrupted by intervals of time, and not to have exceeded in violence those now experienced in the ordinary course of nature. Already, therefore, may we regard the doctrine of the sudden elevation of whole continents by paroxysmal eruptions as invalidated; and there was the greatest inconsistency in the adoption of such a tenet by the Huttonians, who were anxious to reconcile former changes to the present economy of the world. It was 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 havoc and desolation over the whole earth, or even over one great region. If it could have been shown, that a certain combination of circumstances would at some future period produce a crisis in the subterranean action, we should certainly have had no right to oppose our experience for the last three thousand years as an argument against the probability of such occurrences in past ages; but it is not pretended that such a combination can be foreseen. In speculating on catastrophes by water, we may certainly anticipate great floods in future, and we may 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 six hundred feet above the level of the ocean, and is in parts twelve hundred 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 excavation of ravines as the receding cataract of Niagara is now effecting, might breach the barriers. Notwithstanding, therefore, that we have not witnessed within the last three thousand 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.

The great contrast in the aspect of the older and newer rocks, in their texture, structure, and in the derangement of the strata, appeared formerly one of the strongest grounds for presuming that the causes to which they owed their origin were perfectly dissimilar from those now in operation. But this incongruity may now be regarded as the natural result of subsequent modifications, since the difference of relative age is demonstrated to have been so immense, that, however slow and insensible the change, it must have become important in the

course of so many ages. In addition to volcanic heat, to which the Vulcanists formerly attributed too much influence, we must allow for the effect of mechanical pressure, of chemical affinity, of percolation by mineral waters, of permeation by elastic fluids, and the action, perhaps, of many other forces less understood, such as electricity and magnetism. In regard to the signs of upraising and sinking, of fracture and contortion in rocks, it is evident that newer strata cannot be shaken by earthquakes, unless the subjacent rocks are also affected; so that the contrast in the relative degree of disturbance in the more ancient and the newer strata, is one of many proofs that the convulsions have happened in different eras, and the fact confirms the uniformity of the action of subterranean forces, instead of their greater violence in the primeval ages.

The popular doctrine of universal formations, or the unlimited geographical extent of strata, distinguished by similar mineral characters, appeared for a long time to present insurmountable objections to the supposition, that the earth's crust had been formed by causes now acting. If it had merely been assumed, that rocks originating from fusion by subterranean fire presented in all parts of the 'globe a perfect correspondence in their mineral composition, the assumption would not have been extravagant; for, as the elementary substances that enter largely into the composition of rocks are few in number, they may be expected to arrange themselves invariably in the same forms, whenever the elementary particles are freely exposed to the action of chemical affinities. But when it was imagined that sedimentary mixtures, including animal and vegetable remains, and evidently formed in the beds of ancient seas, were of homogeneous nature throughout a whole hemisphere, or even farther, the dogma precluded at once all hope of recognizing the slightest analogy between the ancient and modern causes of decay and reproduction. For we know that existing rivers carry down from different mountain-chains sediment of distinct colours and composition; where the chains are near the sea, coarse sand and gravel is swept in; where they are distant, the finest mud. We know, also, that the matter introduced by springs into lakes and seas is very diversified in mineral composition; in short, contemporaneous strata now in the progress of formation are greatly varied in their

composition, and could never afford formations of homogeneous mineral ingredients co-extensive with the greater part of the earth's surface. This theory, however, is as inapplicable to the effects of those operations to which the formation of the earth's crust is due, as to the effects of existing causes. The first investigators of sedimentary rocks had never reflected on the great areas occupied by modern deltas of large rivers; still less on the much greater areas over which marine currents, preying alike on river-deltas, and continuous lines of sea-coast, might be diffusing homogeneous mixtures. They were ignorant of the vast spaces over which calcareous and other mineral springs abound upon the land and in the sea, especially in and near volcanic regions, and of the quantity of matter discharged by them. When, therefore, they ascertained the extent of the geographical distribution of certain groups of ancient strata—when they traced them continuously from one extremity of Europe to the other, and found them flanking, throughout their entire range, great mountain-chains, they were astonished at so unexpected a discovery; and, considering themselves at liberty to disregard all modern analogy, they indulged in the sweeping generalization, that the law of continuity prevailed throughout strata of contemporaneous origin over the whole planet. The difficulty of dissipating this delusion was extreme, because some rocks, formed under similar circumstances at different epochs, present the same external characters, and often the same internal composition; and all these were assumed to be contemporaneous until the contrary could be shown, which, in the absence of evidence derived from direct superposition, and in the scarcity of organic remains, was often impossible.

Innumerable other false generalizations have been derived from the same source; such, for instance, as the former universality of the ocean, now disproved by the discovery of the remains of terrestrial vegetation, contemporary with every successive race of marine animals; but we shall dwell no longer on exploded errors, but proceed at once to contend against weightier objections, which will require more attentive consideration.