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## ORDINARY MEETING, April 5, 1875.

C. Brooke, Esq., F.R.S., V.P., in the Chair.

The Minutes of the last Meeting were read and confirmed, and the following elections were announced :—

Member :—J. Wood, Esq., Birkenhead.

Associates :—Rev. H. de la Cour de Brisay, M.A. (Oxon.), Oxford ; Rev. R. H. Gray, M.A. (Oxon.), R.D., Hon. Canon of Chester, Exam. Chaplain to Bishops of Chester and Sodor and Man ; R. S. Boddington, Esq., Markham Square ; A. Gardner, Esq., Paisley ; Lieut.-Colonel G. Hutchinson, C.S.I., Inspector-General Punjab Police ; J. Smith, Esq., Cambridge Terrace.

Also the presentation of the following Works to the Library.

"Proceedings of the Royal Geographical Society," Parts 2 and 3, Vol. XIX. *From the Society.*

"Proceedings of the Society of Biblical Archæology," Vol. III. *Ditto.*

"Science based on Religion." By Rev. J. G. M'Vicar, D.D., LL.D. *The Author.*

The following paper was then read by the Rev. T. M. Gorman, M.A., the author being unavoidably absent.

### *THE RELATION OF THE SCRIPTURE ACCOUNT OF THE DELUGE TO PHYSICAL SCIENCE.* By Professor Challis, M.A., F.R.S., F.R.A.S.

THE inquiry I have undertaken to make respecting the bearing of modern physical science, especially the science of geology, on the account given in Scripture of the Noachian Deluge, will be conducted in the following manner. I begin with assuming that the statements of Scripture relative to the natural operations which immediately caused the Deluge are descriptive of actual occurrences, as they would have appeared at the time to an unscientific observer, and on this hypothesis I shall endeavour to extract from these statements the precise

character of the phenomena. Next, by taking advantage of the physical science of the present day, I shall inquire by what natural forces such phenomena might have been produced, and how the asserted destruction of the lives of men and animals would be the necessary consequence. Lastly, taking into consideration, either individually or in classes, the facts which have been discovered in such great abundance and variety in recent times relating to the status and localization of animal remains, and to concomitant circumstances of the earth's superficial crust, I propose to account for *these facts also* by reference, as in the previous discussion, to the operation of known, or possible, physical causation. The facts will be accepted as described by Lyell, Lubbock, Evans, Boyd Dawkins, and other writers on geological questions, although I may not be able to adopt the views of these authors as respects either the *modus operandi* of the physical causes, or the *time* occupied in effecting changes of the features of the earth's superficies. Having spent a large amount of thought and mathematical research, during many years, on the laws of operation of the physical forces, I am entitled, I think, to form on these two points an independent judgment. If this second discussion should indicate that the observed phenomena may be accounted for by a deluge agreeing as to its physical causation and consequences with the inferences drawn in the first discussion from the recorded facts of the Noachian deluge, it is evident that the Biblical narrative would thereby receive much confirmation. This, I presume, will be considered to be a fair line of argument.

I. The passages in the Book of Genesis which describe the immediate natural causes of the Deluge are few in number, but very significant. "All the fountains of the great deep were broken up, and the windows (καταῤῥάκται) of heaven were opened, and the rain was upon the earth forty days and forty nights" (vii. 11, 12). These statements clearly point to *two* sources of the waters of the Deluge. The views entertained by the Hebrews respecting the causes of natural phenomena were such only as might be suggested by ordinary observation; and hence, as it seems, they supposed that any collection of waters had its proper springs or fountains, and according as the fountains were opened or closed, the waters flowed or ceased to flow. Thus in 2 Esdras iv. 7, two kinds of springs are spoken of,—"springs in the beginning of the deep," and "springs above the firmament." The above passage of Genesis expresses similarly the twofold source of the waters which produced the Deluge, and may be taken as indicating that besides a copious down-pouring of rain through, as it were, cataracts, or windows,

in the sky, continuing uninterruptedly forty days and forty nights, there was—what a mere spectator might suppose to be due to fountains breaking out at the bottom of the deep—a welling up of the waters of seas and oceans, whereby the lands encompassed by them were flooded. The narrative appears to ascribe the waters of the Deluge to the *simultaneous* operation of the two causes.

"And the waters prevailed and bare up the ark, and it was lifted up above the earth. And the waters prevailed and were increased greatly on the earth, and the ark was borne upon the face of the waters. And the waters prevailed exceedingly upon the earth; and all the high hills that were under the whole heaven were covered. Fifteen cubits upward did the waters prevail, and the mountains were covered" (vii. 17—20). These words not only describe the great extent and height of the waters of the cataclysm relatively to the land, but indicate also that it continually advanced by gradations to a maximum height. In verse 24 of the same chapter, it is said that the waters prevailed (ὑψώθη, were elevated, *Sept.*) on the earth an hundred and fifty days. During this interval of five months, which is to be reckoned from the day of Noah's entrance into the ark, the height of the waters was continually on the increase up to a certain time, which, as being the epoch of a maximum, would not be definitely marked; afterwards it continually decreased. The increase might go on *after* the cessation of the rain at the end of the forty days, and, as will presently appear, the decrease commenced *before* the end of the hundred and fifty days.

In the statements given in viii. 1 and 2 respecting the operations which produced the abatement of the waters, and caused them to return continually from the face of the earth, it is said, generally, that "God made a wind to pass over the earth, and the waters were assuaged"; and then, specifically, that "the fountains of the deep and the windows of heaven were stopped, and the rain from heaven was restrained." This cessation of the rain took place at the end of forty days, and appears to be here mentioned in connection with the stoppage of the fountains of the deep, and the assuagement of the waters by "the wind," as being a necessary antecedent condition of these operations. It may be remarked that the Hebrew word for "wind" in this passage is translated in the Septuagint by πνεῦμα, whereas the same word, employed in Exod. xiv. 21, in giving the account of the dividing of the Red Sea by "a strong east wind," is translated by ἄνεμος. Possibly the LXX. Interpreters preferred πνεῦμα in the present instance because, as the Hebrew word appears to have been used to designate generally an invisible

agency, they supposed that a current of air (ἄνεμος) might not be the agent here signified.

"And the waters returned from off the earth continually; and after the end of the hundred and fifty days the waters were abated, and the ark rested in the seventh month, on the seventeenth day of the month on the mountains of Ararat. And the waters decreased continually until the tenth month; in the tenth month, on the first day of the month, were the tops of the mountains seen" (viii. 3—5). According to this account, on the seventeenth day of the seventh month, that is, five months, or one hundred and fifty days, after Noah entered the ark, the waters had so far abated as to allow the ark to rest on the mountains of Ararat. Since the ark was 30 cubits in height, this might have happened at no long interval after the maximum height of "fifteen cubits upward" had been attained, and *before* the tops of Ararat and of other mountains were visible. "The tops of the mountains," it is said, "were seen on the first day of the tenth month," that is, seventy-four days after the resting of the ark on Ararat.

The remainder of the statements (viii. 6—14) recount that at the end of forty days, reckoned apparently from the time the tops of the mountains were seen, Noah opened the door of the ark, and sent out at intervals, first a raven, and then a dove three times, and that at the second return the dove had "in her mouth an olive-leaf plucked off." These circumstances are all consistent with the supposition that the subsidence of the waters was effected in a very *gradual* manner. The interval from the entrance into the ark to the time at which the earth's surface was sufficiently dry to allow of Noah, his family, and the animals to go out of it, appears from the dates given in the narrative to have been three hundred and seventy days.

The destruction of the lives of men and animals by the Deluge is recorded in these terms:—"And all flesh died that moved upon the earth, both of fowl, and of cattle, and of beast, and of every creeping thing that creepeth upon the earth, and every man: all in whose nostrils was the breath of life, of all that was in the dry land, died. And every living substance was destroyed which was upon the face of the ground, both man, and cattle, and the creeping things, and the fowl of the heaven; and they were destroyed from the earth: and Noah only remained alive, and they that were with him in the ark" (vii. 21–23). In the Septuagint, both in this passage and in vii. 4, the Greek for "every living substance" is πᾶν τὸ ἀνάστημα, every thing that rises up. The context shows that only substance endued with animal life is signified.

The foregoing are mainly the facts stated in the Book of Genesis, which I propose to account for by a physical theory. But before proceeding to do this, it is right to say that the theory necessarily has reference only to the *general* condition, and *kind* of action, of the physical forces concerned in producing the phenomena, and not to the precise amount of the results of their action, and that on this account it is incapable of giving quantitative determinations admitting of comparison with the specific numbers which occur in the above statement of the facts. Possibly these round numbers may be considered to mark out intervals that are approximately true as to their proportions, but not as to the actual magnitudes.

It should also be here mentioned that for the following reasons I have not thought it necessary to inquire what might have been the particular circumstances under which the lives of all the different kinds of living creatures were preserved in the ark. Much that relates to the ark is of a *miraculous* character. The very act of preparing means of safety in anticipation of a deluge could only have proceeded from divine interposition. It was by special "warning" from God that Noah built the ark; God also gave particular directions respecting its dimensions and construction; and it is added that when Noah with his family and the animals had entered into it, "the Lord shut him in" (vii. 16). On account of these avowedly miraculous circumstances, it is needless to inquire by what special means the ark and the animals within it were saved from destruction.

Moreover, I do not consider it necessary to take the terms of the biblical narrative as implying that the propagation of the different kinds of animals was continued after the Flood exclusively through those that were saved in the ark. It is true that this is distinctly affirmed relatively to the human race, because it is said of the three sons of Noah, that "of them was the whole earth overspread" (ix. 19). But it is not as expressly asserted that the offspring of all the living creatures that went out of the ark spread over the earth. It seems, therefore, allowable to interpret the account of the miraculous preservation in the ark of two of every kind, male and female, for the purpose of "keeping seed alive upon the face of all the earth" (vii. 3), as indicative of an effect which was produced by other means, also of a more extensive character and more conformable with ordinary physical operations. These means might be such that they could not be intelligibly stated without reference to physical and geographical facts which were not then cognizable by common observation, and on that account would have no place in Scripture. Possibly also the

reiteration with which it is affirmed that the continuation of every kind of animal life on the earth's surface after the Flood was owing to the intervention of the ark, may be taken to denote that this, the only means which for the time could be stated in consistent and intelligible terms, embraced symbolically all actual means of preservation. The sacred writers not unfrequently use words of universal import to denote the comprehensive character of an affirmation.

I do not think that more need be said on the miraculous element in the Scripture narrative, and shall, therefore, now proceed to discuss, in a second division of the essay, the physical causes that might have produced the phenomena of the Deluge, taking these phenomena exclusively as they have been inferred in the first division from the record in the Book of Genesis.

II. As preliminary to the main argument, reasons will be given for concluding that the interior of the earth is in a *liquid* state. By experiment it is found that when a quantity of ice in small fragments is inclosed in a vessel and violently compressed, the separate solidity of the different portions can be obliterated, and the whole be converted into a single solid mass. From this fact it may reasonably be concluded that the difference between the solid and the liquid states of the same homogeneous substance depends only on difference in the mechanical conditions of the parts constituting a very thin superficial stratum of the substance, and that the particular condition characterizing the solid state may be got rid of by *pressure*. The same effect, as is well known, may be produced on ice, and many other solid substances, by *heat*. Now in the interior of the earth both these causes operate in a very high degree, the pressure being due to the weight, increasing with the depth, of the superincumbent materials, and the heat to the increase of temperature with descent below the earth's surface, which is shown by thermometrical observations in deep mines, to take place at the rate of one degree of Fahrenheit for every 90 feet. Thus on both accounts the interior of the earth may be assumed to be in the condition of a liquid. It is true that this liquid must be supposed to be enveloped by a solid shell, the elevated parts of which are hills and mountains, and the depressed parts valleys or solid basins containing seas and oceans. But there is reason to say that the non-liquid state, whether solid or viscous, extends to a depth very small compared to the earth's diameter of 8,000 miles, and that the whole of this crust, together with the contained watery parts, constitutes comparatively a very

small portion of the earth's mass. For it would seem impossible to explain the remarkable fact that, after taking account of the above-mentioned elevations and depressions, the *mean* form of the superficies of the solid parts coincides with the form of the ocean-surface, unless that mean form were determined by the conditions of the equilibrium of a *liquid* mass constituting nearly the whole of the interior.

Adopting, for the above reasons, the hypothesis of a liquid interior of the earth, I propose, in the next place, to discuss briefly, with the view of applying the results of this discussion in the subsequent argument respecting the Deluge, the phenomena and probable causes of *volcanoes* and *earthquakes*. In treating of this subject I cannot do better than refer to what is said about it by Sir John Herschel in an excellent work entitled *Familiar Lectures on Scientific Subjects*. (Strahan, 1867.) The first lecture is on "Volcanoes and Earthquakes," the phenomena of which it gives a very intelligible account of in familiar terms, together with a theory of their causes, which, I believe, in all essential points is due to Herschel himself. It will contribute much towards elucidating my subject to quote some passages from this lecture, which I shall do by citing the numbers within brackets, placed for reference at the beginnings of the paragraphs.

In paragraph (3), speaking of the geological changes "we *see* going on," the author says, "We see everywhere, and along every coast-line, the sea warring against the land, and overcoming it; wearing and eating it down, and battering it to pieces; grinding those pieces to powder; carrying that powder away, and spreading it out over its own bottom, by the continued effect of the tides and currents." Looking at our chalk-cliffs, "what do we see? Precipices cut down to the sea-beach, constantly hammered by the waves and constantly crumbling: the beach itself made of the flints outstanding after the softer chalk has been ground down and washed away; themselves grinding one another under the same ceaseless discipline; first rounded into pebbles, then worn into sand, and then carried out farther and farther down the slope, to be replaced by fresh ones from the same source."

"The same thing is going on everywhere, round every coast." "And what the sea is doing, the rivers are helping it to do. Look at the sand-banks at the mouth of the Thames. What are they but the materials of our island carried out to sea by the stream? The Ganges carries away from the soil of India, and delivers into the sea, twice as much solid substance weekly as is contained in the great pyramid of Egypt. The Irawaddy

sweeps off from Burmah 62 cubic feet of earth in every second of time on an average." (4) The large deposits of sedimentary matter which have been ascertained by series of measurements made in quite recent times, to be going on at the mouth of the Mississippi, might be adduced as another instance of the transfer of earthy materials from one locality to another by river-agency. (See Lyell's *Antiquity of Man*, 4th ed., p. 44.)

But besides these changes which appear to be operating continuously and in comparative quietness, others are witnessed from time to time, which are specially characterized by their suddenness and violence. As to these, to adopt the language of Sir John Herschel in (6), "Let the volcano and the earthquake tell their tale. Let the earthquake tell how, within the memory of man, the whole coast-line of Chili, for 100 miles about Valparaiso, with the mighty chain of the Andes, was hoisted at one blow (in a single night, Nov. 19th, 1822) from two to seven feet above its former level, leaving the beach below the old low-water-mark high and dry." "One of the Andes upheaved on this occasion was the gigantic mass of Aconcagua, which overlooks Valparaiso, and is nearly 24,000 feet in height." On the same occasion "at least 10,000 square miles of country were estimated as having been upheaved; and the upheaval was not confined to the land, but extended far away to sea, which was proved by the soundings off Valparaiso and along the coast having been found considerably shallower than they were before the shock."

"In the year 1819, in an earthquake in India, in the district of Cutch, bordering on the Indus, a tract of country more than fifty miles long and sixteen broad was suddenly raised ten feet above its former level. The raised portion still stands up above the unraised, like a long perpendicular wall, known by the name of the Ullah Bund, or God's wall." (7).

Again, as examples of changes of level, Sir Charles Lyell adduces "the strata near Naples, in which the temple of Serapis at Pozzuoli was entombed. These upraised strata, the highest of which are about twenty-five feet above the level of the sea, form a terrace skirting the eastern shore of the Bay of Baiæ. They consist partly of clay, partly of volcanic matter, and contain fragments of sculpture, pottery, and the remains of buildings, together with great numbers of shells, retaining in part their colour, and of the same species as those now inhabiting the neighbouring sea. Their emergence can be proved to have taken place since the beginning of the sixteenth century." (*Antiquity of Man*, p. 48.)

Herschel's Lecture, before cited, contains, in the portion

devoted to the history of earthquakes and volcanoes, the following remarkable statements. In a district of Mexico, between two streams called Cuitimba and San Pedro, suddenly, on the 28th of September, 1759, a tract of ground from three to four square miles in extent, rose up in the form of a bladder, to a height of upwards of 500 feet. Flames broke forth over a surface of more than half a square league, and the ground, as if softened by heat, could be seen swelling and sinking like an agitated sea. Vast rents opened in the earth, into which the two rivers precipitated themselves, reappearing afterwards at some distance from among little volcanic cones, called hornitos, which sprang in great numbers out of an immense torrent of boiling mud, with which the whole plain became covered. "But the most astonishing part of the whole phenomena was the opening of a chasm vomiting out fire, and red-hot stones and ashes, which accumulated so as to form a range of six large mountain masses, one of which is upwards of 1,690 feet in height above the old level, and which is now known as the volcano of Jorullo" (43).

Paragraph (46) contains a description by Sir Stamford Raffles of an eruption from Mount Tomboro, in the island of Sumbawa, which gave perceptible evidences of its existence to a distance of 1,000 miles from its centre, by tremulous motions and the report of explosions. "I have seen it computed," Herschel states, "that the quantity of ashes and lava vomited forth in this awful eruption would have formed three mountains of the size of Mont Blanc" (47).

Many other instances of upheavals and eruptions that have occurred in recent times might be collected from the writings of geologists, especially those of Lyell. It will suffice for my purpose to have mentioned the foregoing. I shall now only add that earthquakes frequently produce *subsidence*, as well as elevation, of the ground, and that there are also cases of subterraneous action, which are akin to that which produces earthquakes, but do not operate in the same fitful and violent manner. For instance, the northern gulfs, and borders of the Baltic Sea, are steadily shallowing; and the whole mass of Scandinavia, including Norway, Sweden, and Lapland, is rising out of the sea at the average rate of about two feet per century" (9).

I proceed, next, to the consideration of *the nature of the forces* by which sudden and violent changes on the earth's surface might be produced, with reference, for the present, only to changes such as those above described, which are known to have taken place in comparatively recent times. Respecting the

dynamical causes of this class of phenomena, I adopt, as I have already intimated, the theory advocated by Herschel in the before-mentioned Lecture. After giving details of many extraordinary effects attributable to earthquakes and volcanoes, he goes on to say, "The origin of such an enormous power thus occasionally exerting itself will no doubt seem very marvellous —little short, indeed, of miraculous intervention; but the mystery, after all, is not quite so great as at first it seems. We are permitted to look a little way into these great secrets of Nature; not far enough, indeed, to clear up every difficulty, but quite enough to penetrate us with admiration of that wonderful system of counterbalances and compensations; that adjustment of causes and consequences, by which, throughout all nature, evils are made to work their own cure; life to spring out of death; and renovation to tread in the steps and efface the vestiges of decay" (10). He then asserts categorically that "the key to the whole matter is to be found in the central heat of the earth" (11); and before proceeding to indicate *how* this key unlocks the mystery, he requires nothing more than that there should be granted him "a sea of liquid fire, on which we are all floating, land and sea; for the bottom of the sea will not come nearly down to the lava-level, the sea being probably nowhere more than five or six miles deep, which is far enough above that level to keep its bed from becoming red-hot" (16).

It will be seen, on referring to the preliminary argument at the beginning of Division II., that the above postulate may reasonably be granted, if, as is there maintained, the quality of rigidity is destroyed in a very large proportion of the earth's interior mass, both by pressure and by heat, so that the dynamical properties of the mass become the same as those of a *perfect* liquid. In that case the transfer of ever so small a quantity of material from one position to another on the earth's surface, will *tend* to disturb the equilibrium of the floating mass. This cause of disturbance will not, however, immediately take effect, because the viscosity and rigidity of the earth's crust will act conjointly as an opposing force; but whatever be the amount of resistance this obstacle is capable of, it has a definite limit, and must, therefore, eventually yield to the constantly increasing disturbing force due to the accumulation of transported matter, both from the detritus of mountains and cliffs, and from the mud and gravel and sand conveyed by rivers. In short, the mechanical operation and its effects may be very appropriately described in the words of Herschel, contained in the following passage:— "It is impossible but that this increase of pressure in some places and relief in others must be very unequal in their

bearings. So that at some place or other this solid floating crust must be brought into a state of strain, and if there be a weak or a soft part, a crack will at last take place. When this happens, down goes the land on the heavy side and up on the light side. Now this is exactly what took place in the earthquake [see three pp. *ante*] which raised the Ullah Bund in Cutch" (18).

This view of the causes of earthquakes, and of elevations and subsidences of the land, accounts at the same time for volcanic eruptions, the volcano being a vent for the passage of heated and melted matter, which the elevatory pressure of the liquid below tends to throw up. It has with much probability been suggested that the reason volcanoes and the originating centres of earthquakes are almost universally on the borders of seas and oceans, is that at such positions the accumulation of transported matter, whether due to sub-aërial detritus, or to river-deposit at deltas, would attain its greatest amount. Further, as is much insisted upon in Herschel's lecture, the eruption of scoriæ and lava from the mouths of volcanoes, in consequence of the upward pressure of the fiery liquid below, is a kind of compensation for the downward transfer of material by detritus and river-deposit, so that upon the whole the quantity of solid matter above the ocean-level is likely to be pretty nearly constant.

These are all the points relating to the forces concerned in the phenomena of earthquakes and volcanoes, that I have thought it necessary to direct attention to. This antecedent consideration of the nature of those forces was required for my purpose, because I am about to propose a theory which attributes the *Deluge* to the operation of forces of the same kind, differing only in degree and in the superficial extent of their action. Also I regarded it as a matter of importance to show that the character of the forces I shall have to deal with has received countenance from the views of so eminent a philosopher as Herschel, although the supposed applicability of such forces to account for the circumstances recorded in Scripture relative to the Deluge is altogether an independent hypothesis, for which I alone am responsible.

The next step in Division II. of the general argument is to indicate, first, the possible origination of physical operations which might have the particular effect of producing a deluge, and then to show in what manner such operations might generate the phenomena recorded in Scripture relative to *the Noachian Deluge*. The explanations I am about to propose relative to these two points will rest on the assumption that the earth's internal heat is not a constant quantity, but susceptible of variations partaking of a sudden and violent character. I do not

profess to be able to state how such changes are produced; but that, as matter of fact, the heat of large masses is subject occasionally to abnormal augmentation, may be inferred from what is observed of certain stars, which have been seen to blaze out for a time, and then relapse into their previous degree of brightness, or to become altogether evanescent. To account for variability in the thermal conditions of the solar system, and, inclusively, of the earth's central heat, some physicists have supposed that there are different degrees of temperature in different regions of space, and that the sun, in consequence of its ascertained proper motion, passes with its attendant planets sometimes through a hot region, and at other times through a cold one. Without entering into details which would be inappropiate in this essay, I could not give the reasons which dispose me to assent to this view; and after all, since the destruction of the human race by a deluge must be looked upon as a special act of divine judgment, the truth may be that the primary physical cause was simply an effect of *miraculous interposition*. I shall therefore content myself with saying that the subjoined explanations rest on the hypothesis that the *Deluge was produced by physical causes, which primarily were due to a paroxysm of the earth's central heat*. We have, therefore, now to inquire in what manner the recorded phenomena of the Deluge might have been thus produced.

It is not difficult to infer, from known physical laws, what would be the general result of a sudden increment of the heat of the earth's central mass. The effect of an increase of considerable amount would in a short time become perceptible at the surfaces of seas and oceans, because it would be conveyed from their lowest parts by convection as well as by the slower process of conduction; whereas the visible effects of the heat on the solid parts of the envelope would be transmitted towards the surface mainly by conduction. The consequence would be that from the whole extent of water-surface a rapid *evaporation* would take place, which would load the superincumbent air with so much vapour that the ordinary state of atmospheric equilibrium would be disturbed, and air and vapour together would be compelled to flow towards the continental parts, where little or no evaporation is going on. According to what has just been said, those parts and the incumbent columns of air would for a time be nearly free from the influence of the central heat, and thus the overflow would bring air saturated with vapour into contact with colder air, in consequence of which the vapour would be condensed and fall on the continents in the form of rain. (The gene-

ration of rain by this means very much resembles the well-known process, in which vapour raised by the agency of the sun's heat from the ocean-surface in the torrid zone is conveyed by the atmosphere and deposited in the temperate zones). According to our hypothesis, the downfall of rain would continue till, by the mixture of atmospheric currents and the flowing of streams of water from the rain over the land, the temperature, so far as it depended on the access of central heat, was equalized at the earth's surface, and an equilibrium established between the temperatures of the contiguous parts of the air and ocean. The evaporation would then cease. According to the narrative in Genesis, the rain ceased at the end of forty days.

But what, under these circumstances, would be the effect produced on the earth's envelope, regarded as composed of solid and watery parts, and floating on a liquid sea? It is plain that by reason of the diminution, by the evaporation, of the weight of the waters resting on the bed of the ocean, and the increase of the weight of the continents by the accession of the deluge of rain, the previously existing conditions of equilibrium would be violated, and motion of some kind must ensue, and would continue till new conditions of equilibrium were established. It will be seen that the forces which, according to this view, produce the disturbance of equilibrium, act analogously to those which came under consideration in the foregoing theory of *volcanoes* and *earthquakes*; and from the results observed to take place under the *actual* physical conditions of these phenomena, we may infer what might be the consequences of an analogous action under the hypothetical conditions of the present theory. For instance, we may conclude analogically from facts such as those stated in pp. 73 and 74, that there might be elevations and subsidences of the earth's crust, the parts which receive an accession of weight being depressed, and those from which weight is removed being elevated. The application of this principle to our problem leads to a very remarkable result, which it will now be proper to point out.

The diminution of pressure at the bottom of the ocean, in consequence of the abstraction of fluid matter by the evaporation at the surface, will give rise to an excess of upward pressure of the liquid mass below, and on the other hand, the increment of the aggregate weight of the continents by the fall of rain will produce an excess of downward pressure. So long as the solid parts of the envelope retain their form, these two pressures only put it into a state of *strain*. But because

the strain will continually increase as the evaporation proceeds, sooner or later the envelope, according to the degree of its plasticity or rigidity, will yield, or actually be broken. In either case the bed of the ocean would rise and the continents correspondingly sink, and this movement will go on increasingly so long as the disturbing cause is operative. It might thus very well happen that the waters of seas and oceans would be caused to rise up as if from fountains situated at their bottoms, and to flow over the adjoining parts of the continents, increasing thereby the effect of the deluge of rain. This may be the explanation of the statement in Scripture that "the fountains of the great deep were broken open."

It is evident that the sinking of continents and mountains below the surface of the water would to appearance be the same as the rise of the water above them, and might by a mere spectator be described in the latter terms. We now know enough of terrestrial conditions to be sure that the mountains, if they remained fixed, could not be "covered fifteen cubits upward" by the waters of either land or sea; but our theory, if true, enables us to interpret the language of Scripture as indicating, not the absolute height of the waters, but the height *relative* to the mountains, by whatever means that relative height was produced. It is the part of physical science to ascertain such means: Scripture only states the fact as seen.

From known mechanical principles we may conclude that the sinking of continents and mountains would not stop when the operating causes—the evaporation and rain—ceased, but, by reason of the momentum acquired, would go on for a definite time, till by slow degrees the maximum depth was reached, after which there would be a return movement upwards. According to this interpretation of the Scriptural account, this upward oscillation brought the mountain-tops into view two hundred and twenty-four days after the commencement of the rain, or one hundred and eighty-four days after its cessation.

Although Scripture points only to a single downward and a single upward movement, it is known from mechanical principles that these initial oscillations would be followed by others of smaller magnitude; and we may presume that the earth's interior and crust returned to a condition of equilibrium and fixity by a succession of constantly-decreasing oscillations. The interval during which this took place would be one of comparative quietude, and may be supposed to correspond to that in which the raven and the dove were sent out of the ark, and the dove returned with a plucked olive-leaf in her mouth.

The only remaining statement in the biblical narrative which

the theory may be expected to account for is that relating to the destruction of animal life. Assuming that sufficient reasons have been given by the theory for concluding that by the combined effects of copious rain, overflow of oceans, and oscillations of the earth's crust, large tracts of the surface were for many days completely submerged, the destruction of living creatures, whether "man," or "cattle and beast," or "fowl," or "reptile" (Gen. vii. 21), frequenting those districts, would be a necessary consequence. I cannot, however, on the same grounds assert that there would be *no* localities to which animals might flee for safety; and the Scriptural account, as I have already intimated (p. 70), does not exclude means of continuing animal life after the Deluge, which at the time could not be within human cognizance. To this point I shall have to recur in the course of the third division of the subject, which I am now prepared to enter upon.

III. In this the concluding division of the essay I propose to inquire whether facts of a certain class, the evidence for which is exclusively drawn from the observations and descriptions of geologists, can be referred to the same physical causation as that which is proposed in Division II. to account theoretically for the statements relative to the Deluge which are cited and commented upon in Division I. If so, those facts may be appealed to in corroboration of the truth of the biblical record.

It will be proper, before commencing this inquiry, to introduce a few general remarks. There are two distinct processes of investigation applicable to physical questions: either it may be proposed to deduce, from the quality and circumstances of observed facts, the kind and degree of the agency to which they may be attributed, or the purpose of the inquiry may be to account for observed facts by a physical theory of causation which rests on hypotheses, the truth of which is established in proportion as the theory explains the facts. The second method is more comprehensive than the other, inasmuch as, if complete, it should be capable of accounting for the amount and the laws of action, arrived at deductively by the latter. The second method is that which I have followed in this essay; the first is the one most generally adopted in treatises on geology. It may here be remarked, that the attempts made by geologists to derive from facts of observation the character of the physical operations to which they may be due, exhibit a great diversity of views. Some, of whom Lyell may be considered the representative, are unwilling to admit the existence in geological times of any causation differing in kind, or much in degree, from what is seen to be going on at the present time; while

others allow of the occasional occurrence of violent perturbations, affecting the condition of sea and land, and originating in unknown and unobservable causes. According as the one or the other of these views is taken, the chronology of geology will be widely different. The system of Lyell demands, in fact, the concession of ages of inconceivable duration to account for the changes in the earth and its inhabitants which geology has revealed.

I here take occasion to advert to the paper by Mr. Pattison, entitled, "On the Chronology of Recent Geology" (read before the Institute on March 1, 1875), for the purpose of indicating the relation in which his treatment of that subject stands to the views maintained in the present paper. His method of discussing the chronological question is that which I have above called "deductive," as distingushed from the theoretical method which I have employed. He has, in fact, adopted the same deductive course of reasoning, and argued from the same premises, as Lyell, Dawkins, and other geologists, but, in my opinion, has, by sounder and more consistent arguments, successfully combated the principles of their calculation of long geological periods. I am able to give my assent to the conclusions Mr. Pattison has arrived at on geological chronology, both because they are remarkably accordant with those I shall come to by a different route in the sequel of this essay, and because I cannot but regard this coincidence of the results from the two processes of reasoning as confirmatory of the truth of both. I revert now to what is my special object, that of accounting for observed facts of geology by the physical theory already applied in explanation of the recorded facts of the Deluge.

It is unnecessary for my purpose to enter into details respecting the evidences that have been discovered in modern times, of habitation of the earth by man during a long interval antecedent to the earliest date of profane history, this subject having been so well discussed by Sir John Lubbock, in his *Pre-historic Times* (3rd ed. 1872). One point, however, requires to be specially noticed; namely, the marked difference, as respects the character of the evidence, between the portions of that interval which have been named "neolithic" and "palæolithic." Not only the implements of the neolithic men exhibit more art and polish than those of the palæolithic, the evidences also of habitation which they left behind, such as the Danish shell-mounds and the lake-dwellings of Switzerland, are found to be *in situ*, whereas the human remains and implements of the palæolithic age, having been discovered almost exclusively in "river-drift" and "caves,"

appear to have been transported from their original localities by the agency of currents of water. Respecting the difference in the character of the implements, there will be occasion to make some remarks subsequently; but as to the other mark of distinction between the palæolithic and neolithic ages, it may, I think, be safely assumed that the transition from the one to the other was signalized by a sudden cataclysm brought on by some violent interruption of the ordinary terrestrial conditions. When this happened we cannot gather, with any approach to certainty, from geological data; and if we might suppose the cataclysm to be identical with the Deluge of Scripture, the exact date would still be uncertain, because chronologies derived from the two authenticated forms of Scripture, the Hebrew and the Septuagint, differ as to the date of the Flood by eight centuries. If we take the earliest date assigned by Biblical chronologists, we cannot infer from geology that the interval between the supposed cataclysm and the limit of profane history is unduly lengthened; nor, if we take the latest date, that the interval is unduly shortened. It is, however, probable, when account is taken of the circumstance that the tradition of a deluge was handed down to historic times among the ancient Greeks, and generally in the East, that neither date would be very far wrong. On these grounds I make the hypothesis that the separation of the neolithic age from the palæolithic, as indicated by geological phenomena, was caused by a cataclysm identical with the Deluge of Scripture, and shall next proceed to substantiate this view by arguments.

One of the first lessons in geology that I learnt by attending the lectures of the late Professor Sedgwick was, that parts of the Jura chain of mountains were capped by *tertiary* strata, and that, consequently, they were raised up subsequently to the deposition of those strata; how much later it is not possible to say. These mountains flank the Alps, with a deep intervening valley, and might apparently have been pushed aside by the elevation of the Alpine range at a still later date. In short there is reason, from geological facts, to conclude that the elevation of mountain-ranges generally is to be regarded as the most recent of large geological changes. The following extract from a Lecture by Professor Owen on extinct animals, published in the *Standard* of August 3, 1874, is adduced in confirmation of this assertion.

"In the north of India, during the progress of the Jumna canal works, sandstone was being blasted in the foot hills of the Himalaya mountains at a point 1,000 feet above the present Indian Ocean. A fossil elephant was dug out. Every bit of

the original ivory and bony substance had passed away particle by particle, and had been replaced by particles of stone. There was no doubt that the whole Himalayan chain—the highest in the world, had been raised since that old elephant had lived; because at greater heights than this Indian quarry, not only fossil elephants, but hippopotami,—which required lakes and rivers to live in—had been found; also fossil giraffes. Similar evidence had been procured in regard to the Alps, the Pyrenees, and the Andes, all of which had been upheaved at what, in the history of geological changes, was a comparatively recent period."

This account of the condition in which the fossilized elephant was found is very remarkable and instructive, as seeming to prove that this animal was suddenly enveloped by matter in the state of hot lava flowing from the mountain.

In a Manual of Geology by the Rev. T. G. Bonney, published by the Society for Promoting Christian Knowledge, the opinion is expressed that "mountain-ranges have been raised like gigantic billows, two of the largest, the Alps and Himalayas, being *comparatively modern*" (p. 41).

If for the reasons above given we may conclude that the upheavals of the principal mountain-ranges were of so recent a date that they might be contemporaneous with the Deluge of Scripture, and be referable to the same physical causation, it will be necessary to inquire whether the forces to which, according to our theory, the Deluge may be attributed, were adequate to the production of these effects also. The original and remote cause of the Deluge, we have argued, was an abnormal increment of the earth's central heat; the immediate cause, a disturbance of the equilibrium of the earth's crust by the abstraction of water from the sea by evaporation, and the descent of the same on the land in the form of rain. To give some means of estimating the weight of water which might be thus taken up from the oceans and deposited on the continents, it may be stated that every inch of rain falling upon an acre of ground is in measure 22,622 gallons, which is equivalent in weight to one hundred tons very nearly, and that in instances of rain-falls which occurred at Geneva, Perth, and Naples, the rates were found by measurement to be respectively two inches, one inch and three-fifths, and one inch and four-fifths, in an hour (Report of Transactions of Sections of the British Association, 1840, p. 44). Taking the rate of two inches per hour, the weight of the rain-fall in one hour on the area of England and Wales, which is known to be about 37⅓ millions of acres, would amount to very little short of seventy-five hundred millions of tons.

Now supposing the mean rate of descent of the rain in the Deluge to have been only one inch per hour, which is proved by the observations just mentioned to be possible, we may judge by the result of the foregoing calculation how enormous would be the weight of the water transferred from one locality to another by rain falling at this rate on the continents and islands generally, and continuing without ceasing forty days and forty nights. This transfer of weight would put the earth's crust into a state of *strain*, and tend continually to *deform* it, at the same time that plasticity would probably be communicated to it by the great quantity of heat which, as is known from the theory of the mechanical equivalence of heat, would be developed by such mechanical conditions. When the effect of the simultaneous flow of the seas over the land (the cause of which has already been indicated) is also taken into account, it may well be supposed that the operation of the two causes would eventually produce *ruptures* at certain parts of the crust. Through the cracks thus opened the interior liquid would be ejected with great momentum, according to the resistance overcome, and by this means the ejected matter might be made to form mountain-ridges. The force of ejection would be greatly increased by the development of heat which would accompany the movements produced by this perturbing action. From the same cause the parts of the crust distant from the places of rupture might be put into a plastic, or semi-liquid state, and be susceptible of undulatory movements. When the pent-up energies have exhausted themselves in producing new conditions of equilibrium of the floating crust, the developed heat will be quickly dissipated; and supposing the primary cause of the disturbance to decline at the same time, or to be withdrawn, the solid parts will resume their proper rigidity, and the final result will be seen in that surface-contour which, in addition to the more prominent features of peaks and mountain-ridges, exhibits the minor inequalities of hills and dales and terraces, partaking very much (so, at least, it seems to me) of the characteristic forms of *waves* and *breakers*.

Since, according to the foregoing argument, the hypothetical forces which accounted for the phenomena of the Deluge, as described in Genesis, account also for upheavals of mountain-chains and concomitant circumstances relative to the earth's surface, and since geological facts show that these upheavals took place at a comparatively recent date, not inconsistent with that assigned by Scripture chronology to the Deluge, the truth of the theory, and the reality of the phenomena it explains, may be considered to receive confirmation. The Deluge and

the elevation of mountain-chains would thus appear to be related and simultaneous events, the epoch of which might be taken to be the end of the quaternary period, or that which Lyell calls Pleistocene.

In recent discussions respecting the "Antiquity of Man," much stress has been laid on a supposed "Glacial Period," the existence of which has been inferred mainly from the evidences of ancient glacier action and moraines which have been discovered in various districts of islands and continents. These phenomena give plain proof that the action of the glaciers must have gone on through long ages; and if the whole period through which it lasted was subsequent to the first existence of man on the earth, his antiquity will extend backwards to an extremely remote epoch. But as to this question, the theory I am expounding gives the following very different answer.

By considering the character of the forces to which the theory ascribes the disturbance of the earth's envelope, it will be seen that the action is as much downwards as upwards; and hence we may perceive a reason why, simultaneously with any elevation of large masses, as mountain-chains, there must be corresponding depressions, and probably such that the quantity of matter above the ocean-level would not be greatly altered by the disturbance. The fact might, therefore, be, that those localities which give evidence of the prior existence of glaciers and moraines (as, for instance, districts of North Wales) were formerly much elevated above their present mean level, and at that time, as the Alps do now, generated glaciers and moraines. The process might have gone on for ages, till, by the catastrophe of the Deluge and the accompanying convulsions, the glaciers were brought to a lower level, and were thus caused to disappear, after which there would only remain the evidences of their existence, which are visible at the present day.

Lyell, in his *Students' Elements of Geology*, p. 159, makes the following statement:—"In Europe several quadrupeds of living, as well as extinct species, were common to pre-glacial and post-glacial times. In like manner there is reason to suppose that in North America much of the ancient mammalian fauna, together with nearly all the invertebrata, lived through the ages of intense cold." These assertions, which are hardly reconcilable with the views entertained by the advocates of long-period geological chronology respecting the duration and effects of the glacial period, are quite consistent with the foregoing inferences from the present theory, which do not allow of a glacial period which could have any influence on the extinction of species of animals. The evidence for such a period

has been drawn from phenomena which, according to the view I take, belong to *depressed* mountainous heights, and consequently do not prove the *general* prevalence of intense cold at any period, but only the prevalence of cold at those heights *before* the mountains were depressed. It seems that the localities which have furnished this evidence are districts of limited area, but widely dispersed over the earth's surface; as, in fact, might be expected, if their origin be such as we have supposed. I do not think that there are causes of a *cosmical* order which could account for the prevalence, during a long period, of a great degree of cold. In short, I am not prepared to admit the existence of a glacial period which had any effect on the succession of mammalian fauna, or bears in any way on the question of the antiquity of man.

It has been urged that as there is geological evidence (which I fully admit) that man was contemporary with the Mammoth, and as the Mammoth has long been an extinct species, the antiquity of man must be correspondingly great, because species do not become extinct except by a long course of time. The theory I am maintaining meets this argument in the following manner. It has already been remarked that it is not a necessary consequence of the physical circumstances of the Deluge which have been deduced from the theory that all animal existence on the face of the earth would thereby be destroyed. There might be large areas which would be completely submerged, in the course of the vertical oscillations, during an interval sufficient to cause the destruction of all animals resident upon them; but at the same time, in conformity with a usual law of oscillations, there might be *nodal* spaces free enough from oscillations and inundation to allow of their proper inhabitants remaining alive upon them, and others from other quarters fleeing to them for safety. Under these circumstances there would probably be survivors from a certain number, but not from *all* the different species existing before the catastrophe. The fauna of different continents do not comprise the same classes of individuals, and it is known that the area of habitation by a particular species is in many instances of limited extent. "Mr. Boyd Dawkins has shown that out of forty-eight species [of mammalian fauna] living in the Post-Glacial, or River-Drift period, only thirty-one were able to live on into the Pre-historic or Surface Stone period." (Evans's *Ancient Stone Implements*, p. 618.) It might, therefore, have happened that certain species, by the submergence of the parts on which they lived, became wholly extinct. This would be an event of the same kind as that recorded in Scripture respecting the destruction of the human

race by the Flood, and might, if established on geological grounds, be adduced in corroboration of that particular in the Biblical narrative. According to this argument, the Mammoth species may be supposed to have become extinct by the Deluge, and from its contemporaneity with man, its comparatively recent sojourn on the earth ought to be inferred rather than man's antiquity.

Geologists have acknowledged that it is difficult to account for the fact that remains of animals have been found in localities far removed from their usual places of habitation, and where they could not actually have lived: for instance, bones of hippopotami have been dug up in districts where there are no lakes or rivers, and in northern latitudes far above the present limits of their habitation; and remains of the reindeer have been met with in abundance in spots much more southward than any they ever reach now. Lyell proposes to account for these circumstances by a theory of the migratory habits of the animals. (*Antiquity of Man*, pp. 208, 209.) It has occurred to me, that such a transfer from their usual localities might have resulted from the impulses of the vast waves of inundation that must have swept over the earth's surface at the time of the Deluge, which would be likely to transport animal remains in various directions to spots more or less distant.

With respect to the upper-level gravels and low-level gravels on the borders of the Somme, both containing flint implements, it has been thought that the interval between the deposition of the two gravels is to be measured by the time required for excavating the valleys to their present depth by river-action. It is, however, stated that neither the gravels nor the implements at the two elevations exhibit any considerable differences, and it has even been a matter of discussion among geologists which of the gravels is the most ancient. (See Lyell, *Antiq. of Man*, pp. 176, 177.) This being the case, the theory I have adopted leads to the supposition that the difference of level was caused by a local upheaval occurring at the Deluge epoch, when the features of the earth's surface were in so many respects undergoing change. The same kind of local disturbance seems to account for *caves* being situated at an elevation considerably above the position they must have at first occupied, and perhaps, even for their formation and interior shape, inasmuch as "engulfed rivers" have occasionally been found in them. The slow process of river-erosion would certainly not account for such facts as these.

The transport of Alpine boulders, or erratics, to a distance of fifty miles across the valley of Switzerland, "one of the

widest and deepest in the world," is an astonishing and perplexing fact, to account for which, Lyell (*ib.*, p. 340) conceives that "they might have been transferred by floating ice to the Jura, at the time when the greater part of that chain, and the whole of the Swiss valley to the south was under the sea." The detachment and descent of these large boulders at the epoch of the elevation of the Alps, or rather when the mass was in course of elevation and passing from the liquid to the rigid state, is not difficult to conceive of; but I should be disposed to ascribe their transport to the action of waves and currents while the Deluge was subsiding, when, as Lyell supposes, the Jura chain and Swiss valley had not yet been raised above the level of the water. I remember that Hopkins, an accomplished mathematician and geologist, was accustomed to attribute an enormous power of transferring boulders to the agency of currents of water.

The circumstance that *marine* shells have been found in *caves,* and in some instances in caves not near the sea, seems to require explanation. In a cave at Mentone, fifty-four marine and eleven terrestrial species were collected; and again, from the cave of Bruniquel were obtained "two classes of shells, one characteristic of the Atlantic and the other of the Mediterranean." (Lyell, *ib.*, pp. 142 and 144.) Lyell inclines to the opinion that these shells "imply that the natives of Aveyron had easy access to both sea-coasts, from whence they returned to mingle the shells of the Atlantic and Mediterranean in their cave-dwellings." Might not the overflow of the ocean on adjoining lands, which, according to the theory I have advanced, took place at the Deluge, account for marine shells being found in caves, and in particular, for Atlantic and Mediterranean shells being found together in the cave of Bruniquel, which is situated about midway between the seas?

The *contents* of caves give evidence by their character that they were driven by running water into openings and passages leading to the cavernous interiors, inasmuch as they consist for the most part of loose materials,—gravel, sand, and bones of animals,—which might be borne by streams, or torrents, along the valleys and channels of rivers. The caves generally have an upper opening into which the currents and the materials carried by them would enter, as well as a lower aperture usually on the face of a cliff or hill. The stalagmite floor would be formed by droppings when the immediate action of the water had ceased. The hypothesis of a deluge which accounts for the caves receiving their contents in this manner, also gives a reasonable explanation of the great variety of the animal

remains, and the dismembered and disorderly state in which they are almost always found. The encroaching flood might drive many animals of different kinds to the same spot, a common calamity producing strange companionship, and after the waters had overwhelmed them, and exposure to the elements had decayed the soft parts of the carcasses, the bones might be carried by the currents of the retiring deluge along river-channels into the sea, or into any receptacles, such as caves, that might be suitably situated for receiving them. Lyell states that "from one fissure, called Bosco's Den, no less than one thousand antlers of the reindeer were extracted," and it was estimated that "several hundred more still remained in the bone-earth of the same rent." "Among the other bones, which were not numerous, were those of the cave-bear, wolf, fox, ox, stag, and field-mouse." (*Antiq. of Man*, p. 110.) It would seem that in this instance the collection of animals overwhelmed by the flood consisted principally of a herd of reindeer.

The supposition which has been made that the animals whose bones are found in caves were brought there by hyænas is wholly untenable, considering the number, size, and variety of the remains, and that the bones of hyænas themselves are mixed up indiscriminately with the rest. It is true, however, that subsequently to the palæolithic age the caves were invaded and their contents disturbed by hyænas, the bones having evidently been gnawed and broken by these animals for the sake of food, and in some instances *outside* the cave. (*See* Lubbock, *Pre-historic Times*, p. 21.) The bones appear also to have been cut and broken by aboriginal hunters of the neolithic period, indications having been found that the caves were resorted to in that age both for habitation and for burial.

Many other instances of the explanation of geological facts by the proposed dynamical theory might be adduced in confirmation of its truth. These will suffice for the inferences I propose to draw finally relative to the explanation on the principles of physical science of the Biblical account of the Deluge. At present I shall only remark that these theoretical explanations do not agree with those of geologists who have treated the same questions deductively, chiefly in respect to the effects of long periods of glacier-action, and of erosion by seas and rivers, and inferences thereon depending as to the antiquity of man. The divergence of the explanations evidently arises from the comprehension by the theory, within a brief space of time, of violent agencies and their results, whilst the other view attributes results to slow action extending over unlimited ages. There are, however, certain points of agree-

ment between inferences by the two methods as to the *character* of the immediate causes of geological phenomena, which, as contributing to the completeness of my argument, I shall now point out.

"The Glacial epoch, though for the most part anterior to the valley-drifts and cave-deposits of the Palæolithic age, was still so closely connected with that period that we cannot easily draw a line of demarcation between them." (Lyell, *Principles of Geology*, vol. i. p. 192, 11th ed.) "There were also great changes in the form of the earth's crust, many movements of upheaval and subsidence, and many conversions of sea into land, and land into sea, during the Glacial epoch." (*Ibid.*, p. 196.) These statements are reconcilable with our theory if it be understood that the Glacial period was synchronous with the interval during which the localities which show marks of glacier-action were much more elevated than they are at present, and that it extended to the epoch of the oscillatory movements (mentioned in the above extract), which issued in bringing those localities to their present level. The period of the valley-drifts and deposits was closely connected with this Glacial period as constituting the termination of it, for which reason also no definite line of demarcation can be drawn between them.

"In Wales the rocks had been exposed to glacial polishing and friction before they sank." "The evidence of the sojourn of the Welsh mountains beneath the waters of the sea is not deficient in that complete demonstration which the presence of marine shells affords." (*Antiq. of Man*, p. 313.) Such submergence might be produced by the first oscillatory movement, which, according to the theory, would be *downward*. Marine shells have been discovered "in North Wales, in drift elevated more than 1,300 feet above the level of the sea." (*Ibid.*, p. 313.)

"Professor Ramsay infers, from the position of the stratified drifts of the Glacial period in North Wales, that the full extent of the vertical movement which brought about first the submergence, and then the re-emergence of the land, exceeded 2,000 feet." (*Principles of Geology*, vol. i. p. 193.)

Referring to geological observations made by Professor Geikie in Scotland, Lyell speaks of them as "requiring for their explanation several oscillations of level and successive submergences and re-elevations of the land." (*Antiq. of Man*, p. 295.)

"There can be no doubt that the physical geography of Europe has changed wonderfully since the bones of men and mammoths, hyænas and rhinoceroses, were washed pell-mell into the cave of Engis." (Huxley, *Man's Place in Nature*, p. 120.)

As I conceive, the great change was effected *then*, and Nature's operations have gone on since in comparative quietness.

Murchison arrived at the conclusion that the fossil mammalia at Folkstone were destroyed "by violent oscillations of the land, and were swept by currents of water from their feeding-places into the hollows where we now find them." (*Quart. Journ. Geol. Soc.*, vol. vii. p. 386.) Hopkins, in reviewing the question of the Drift, agrees with Murchison in supposing that the Wealden area has been traversed by waves of translation, and in attributing to such agencies much of the drift phenomena. (*Ibid.* vol. viii. p. li.) See in the *Philosophical Transactions*, vol. 154, pp. 250 and 286, the views of Mr. Prestwich, who does not admit purely cataclysmic action.

These instances may be enough to show that geologists have been led by observation and discussion of facts, apart from any *à priori* dynamical theory, to conclusions agreeing in very important points with results derivable from the theory which I have proposed in this essay. That theory may consequently be considered to be capable of embracing in its explanations the classes of facts from which those conclusions of the geologists were deduced, and on that account to be entitled to additional confidence.

Before concluding, it will be right to advert to an argument which might be drawn from geological facts against certain statements in the book of Genesis, indirectly connected with the account of the Deluge. According to our theory, palæolithic men were contemporaries of the antediluvians. Now, it is stated in Gen. ii. 17—21, that the descendants of Cain in the *sixth* generation had arrived at a degree of civilization and art of which there is no trace in the palæolithic race, so far as may be judged from their implements and mode of life with which geology has made us acquainted, which prove, in fact, that they were mere savages; on the other hand it is to be said that this character of the inhabitants of the parts which geologists have scrutinized may be owing to the distance of those parts from the centres of aggregation and civilization of the antediluvians, which centres may all have been submerged, in fulfilment of the declared purpose of the Deluge, and possibly may have remained submerged, like the sunken forests near the coast of Norfolk. Ethnological considerations seem to point to the conclusion that the earth was repeopled by Noah and his sons, no other designations of the large divisions of the human family having been so generally accepted by ethnologists as those derived from Shem, Ham, and Japhet. This family must have handed down to post-

diluvians the knowledge of art and the skill they had attained to before the Flood, which they gave proof of in the building of an ark; for otherwise the science and civilization which eastern nations were in possession of at no long interval after the Flood can hardly be accounted for. It is true that we learn from geology that the neolithic postdiluvians were also savages, who gained their livelihood for the most part by hunting; but their implements exhibit a much higher amount of art and polish than those of their palæolithic predecessors (in consequence, it may be, of the influence of advancement in knowledge and art in the new centres of civilization), and, in fact, admit of favourable comparison with implements that have been used in this nineteenth century in islands of the Pacific by *our* contemporaries. For these reasons it cannot be affirmed that the revelations of geology respecting the degree and the stages of art among the Palæolithic and Neolithic races are contradictory to the statements in Gen. ii. 17—21.

From the whole preceding argument, I draw the following conclusion. Since it has been shown in Division III. of the argument, that many geological facts and phenomena indicative of the violent action, *at a certain epoch*, of a widely extended cataclysm, may be accounted for by a dynamical theory of physical causation, which, at the same time, as shown in Division II., explains the recorded facts of the Noachian Deluge, being, in fact, suggested by them, it is reasonable to conclude that the cataclysm of geology and the Deluge of Scripture are identical events (only *one* such having befallen the human race), and that so far as the reality of the former is established by physical science, the reality of the other may be inclusively inferred. Also, it follows, as a corollary from the general argument, that geological science does not actually point either to a deluge-epoch, or an antiquity of man, that can be shown to be inconsistent with historical statements in the book of Genesis.*

* Before this paper appears in the Journal I beg permission to add in a note, that on reconsideration of the arguments in Section III., from which I infer that the largest of existing mountain-ranges were elevated at the epoch of the Deluge, I have come to the conclusion that the contemporaneous changes in the contours and positions of continents and islands, caused by the disruption of the earth's crust and its floating on the interior liquid mass, might have been of much greater intensity and extent than, at first, I ventured to surmise, and might account for the occurrence, within a comparatively brief interval, of phenomena which have been supposed to extend over periods of incalculable length. For instance, the discovery of remains of arctic fauna in temperate regions, and the reverse phenomenon, might be explained by a transfer of the floating *habitats* of the animals from one position to another on the earth's surface; and the existence in caves (as in Kent's cavern) of

The CHAIRMAN.—I am sure that all will join with me in conveying the thanks of the Institute to Professor Challis for his very valuable paper, and to the Rev. T. M. Gorman for having so kindly read it.

The HON. SECRETARY.—Letters have been received from various members, who are unable to be present here to-night, expressing their approval of Professor Challis's paper; and one from General Boileau, F.R.S., commends it as a really satisfactory paper upon the subject.

Rev. H. ST. JOHN READE.—Allow me to preface my remarks by relating an anecdote. Not long ago, a schoolmaster of my acquaintance was about to give a lesson on Genesis vii. and viii. He consulted Smith's Dictionary of the Bible, and, being struck with the arguments in favour of a partial deluge, and not seeing its inconsistency with an orthodox belief in the inspiration of the Bible, he laid before his pupils both theories—the universal theory and the partial theory,—and, without pledging himself to either, stated the principal arguments for each. One of the boys wrote home to his father to say that he had been told by one of the masters that the Deluge was not universal. His father wrote to one of the governors to say that the boy had been taught that the Bible had not been inspired; and the council recommended the master to resign his position at the end of the term. That schoolmaster was not myself, but I was his friend, and I am still a schoolmaster, and my boys are taught the elements of science and read manua of geology. I come to this Society to learn how best to teach scientific knowledge in conjunction with Bible History; and I feel sure that the reason why so many parish clergymen have become members is, that they may not denounce as false in the church what they admit to be true in the lecture-room; and I for one shall welcome any hints upon this point. The education of the young is a most important matter in every respect, and this is the question which touches it most nearly in the present day. As things are now, we rest the whole moral teaching of our boys on Bible History; and it is absolutely necessary to find a plain, straightforward interpretation of the Scripture narratives, which shall leave those narratives manifestly consistent with the ultimate standards of what is right and true—with the demonstrable conclusions of science, no less than with the good of mankind in general and with the best aspirations of honest hearts. If this cannot be done, we must alter our system altogether. If you puzzle a boy about the plain meaning of a familiar Scripture narrative, he will puzzle himself about the meaning of a plain Scripture precept. When his faith in the narrative totters, his faith in morality will totter also.

Rev. GEORGE HENSLOW.—In any remarks I may make I do not propose to enter upon any consideration of the subject of inspiration; but to deal with the fact of the Deluge as recorded in Genesis, as being such as falls

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two layers, separated but in succession, containing animal remains of the same classes, and in large proportion *of the same species*, might be due to the earth's surface being swept over by successive waves of the Deluge consequent upon repeated oscillations of the crust (*see* p. 79).

within the scope of our endeavours to explain it by a purely physical interpretation. With regard to the origin of the account in Genesis, I believe Mr. George Smith's remarkable discoveries in the libraries of the Assyrian kings may throw some light upon it. I will argue on the subject apart from the question of inspiration; for the object of the paper now before us is to introduce physical causes—at least, in part—to account for what we read in the Biblical narrative. It is a curious fact that geologists seem now inclined to adopt somewhat more extensively, the theory of fire instead of that of water, as a mechanical agent, though it is scarcely probable that we shall have the old battle fought over again between the Plutonists and Neptunists. There are the theories of Mr. Belt, however, and of Mr. Croll and others, concerning the glacial epoch; while the first of these endeavours to account, also, for the Deluge by means of melting ice. Thus we have two exactly opposite causes suggested to account for the same phenomenon; and it is for those who take either side to accept the theory which accords best with their own views. With regard to the primary or fundamental cause of the Deluge, Professor Challis proposes to begin with what—so far as I understand it—the facts do not warrant; and that is, an increased heat in the centre of the earth. If he introduces such a physical cause, the question may be asked, Where are you to stop? or where are you to bring in miraculous agency, and where do you limit purely physical causes? He looks to physical causes as far as he can, and beyond that to miraculous agencies; but why should he assume the latter just because at a certain point the causes cannot be explained, but which, by aid of more extended knowledge, would probably prove to be purely natural as well. He ought to show why some causes are physical and others miraculous. Now, granting his supposition, we may observe that the results due to his supposed igneous cause are quite as easily explained by aid of the phenomena of the glacial epoch as well. He compares the earth to a sort of bubble. The central heat causes the upheaval of the sea-bottom, which in turn upheaves the water, and then the evaporation resulting from increased heat, produces torrents of rain. But regarding the same phenomenon from the glacial point of view, the exposure of a certain area of the sea-bottom is accounted for in a totally different way, even to its being *thrust up*, though not by the expansive force of heat from below. Similarly with regard to rain: there is strong evidence of a great "pluvial period"—referred to by Mr. Tylor the other day—subsequent to the glacial period, when the vapour, instead of condensing as snow to increase the ice-caps, came down as rain. Thus we have two phenomena—the exposure of a certain portion of the now submarine area (by the removal of a large body of water by evaporation and its subsequent condensation as ice at the polar regions), as well as a great pluvial period, and both arrived at from totally opposite sources. Professor Challis alludes to the origin of mountains as caused by molten matter bursting through and forming their substance; whereas it is well known that it is only volcanoes that are constructed of ejected matter, and that, too, without any upheaval of their

underlying strata whatever. A volcano is nothing more than matter ejected through a crack. That process of formation cannot be applied to mountain-ranges, which are not at all like volcanoes. They are due to the secular refrigeration of the earth's surface. The superficial crust, by shrinking, must yield along the weakest lines, and so becomes crumpled. It is these crumplings (so to say) which produce mountain-ranges. With regard to the separation of the Palæolithic and Neolithic periods by a certain cataclysm, I do not think the evidence is at present sufficient to warrant it, though there may be some, to a slight extent, which might countenance it. Thus, when we consider the enormous range of the Mammoth (*Elephas primigenius*) througout Siberia, Northern America, and Europe as far south as Rome, and find that it had become extinct in the Neolithic period, it does look as if they had been swept off by some wide-spreading cause, and which probably was the sinking of the land throughout the whole of these northern areas. In Kent's cavern, at Torquay, there is a fact of some importance bearing upon this; namely, a broken-up mass of gravel with remains of animals intermediate between the earliest deposit containing bears, with excessively rude flint implements, and later deposits with less rude weapons, though *still* of the Palæolithic age, not without bone implements, including an exquisite needle, and delicately constructed weapons,* while the associated flint implements are made from "flakes," and are not merely the flintstone itself which was used, as in the earlier and lowest deposit of the cave. Now this breaking up of older materials between the different deposits seems to point to some violent physical action, which may have, as it were, separated the times; but still we must not forget the whole of the period is palæolithic as represented in Kent's cavern. With regard to Mr. Belt's theory, I do not think Professor Challis does justice to the glacial epoch, and what was then accomplished in nature; whereas many modern geologists lay great stress upon the forces which were in activity at that important period. There is abundant evidence of ice having extended southwards to the 50th parallel of latitude in America, and to about the 40th in Europe; but Mr. Belt says he discovered proof of glacial action in tropical America down to 2,000 feet above the level of the sea. It is imagined by some that that was the time when the earth's orbit was at its greatest eccentricity, and that "glacial periods" alternated at each pole; but Mr. Belt combats that view, and thinks that they existed contemporaneously; so that there was, as now, though to a less degree, an enormous accumulation of ice at both poles simultaneously; and the cause he suggests, and which appears to be the one most generally favoured by geologists, viz., a greater inclination of the earth's axis to the ecliptic. If now, as is probable, the earth's crust be somewhat elastic, the stupendous pressure at the poles would cause the equatorial region to rise, so that there

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* See Mr. Whitley's letter at the commencement of discussion on Mr. Pattison's paper, controverting some of these statements in regard to the implements.—Ed.

would be two causes conjointly conspiring to account for the Polynesian continent, and an extension of Central America (eastward), beyond the West Indian isles; perhaps thus realizing the famed Atlantic isle. A subsequent change in the inclination of the axis, on the melting of the ice-caps taking place, there would be a tendency to restore the equilibrium as it was at first; the equatorial region would sink, and the sea would rise; and as the centre of gravity shifted under these circumstances, the sea would overflow many low-lying countries; so that there would be local effects of inundation at different places, more or less, *all over the world.* In support of this theory, Mr. Belt alludes to Easter Island, in the south-east Pacific Ocean, a small island, but in which are gigantic idols quite out of keeping with the extent of land and the existing population, but which, if forming the summit of a hill, or low mountain overlooking a vastly extended plain, then their position and character is comprehensible. Every nation has some account of a deluge, and Mr. Belt's theory seems, at all events, to be in harmony with the facts of a universal inundation. You will therefore see that in the glacial phenomena there are results just the same as Professor Challis has deduced from an assumed increase in subterranean heat; but the advantages of the glacial theory are that you have evidence of an enormous abstraction of water from the sea, and then a subsequent return, and which could not be effected without great disturbance in the distribution of land and sea. A very good account of these theories will be found in the address of the President of the Geological Association for the present year.

Rev. W. B. GALLOWAY.—I am very glad to have heard Mr. Henslow's remarks, and to have received from him the information, that a change in the earth's axis is now regarded as a probable cause of the Deluge by some geologists, because I brought it forward myself some time ago, and some points referred to to-night appear to me to require an allusion to some of the particulars which I then brought forward. In the Book of Job there is a cause assigned for the shaking of the wicked out of the earth, and that cause is a change in the earth's axis. The passage in Job runs: "Hast thou commanded the morning since thy days, and caused the day-spring to know his place, that it might take hold of the ends of the earth, that the wicked might be shaken out of it?" Now the sunrise or day-spring being caused to know its place, and to take hold of the ends of the earth, indicates a change of its place and annual range; and a change of the place and range of sunrise must be due to a change of the earth's axis. It must necessarily be so; the inclination of the sphere to the ecliptic being the cause of varying of the place of sunrise, sometimes to the north and sometimes to the south; and the increased range of its varying to points much further to the north, and further to the south of due east, so as, in a manner, to "take hold of the ends of the earth," being a necessary effect of the increased obliquity of the earth's axis. That remarkable passage we can place in connection with the Gentile tradition. We know that Pythagoras in his travels picked up many truths from patriarchal tradition, which he

transmitted, and among the rest, the theory of the earth's rotation; and Anaxagoras says that at first the apparent revolution of the starry sphere was without the inclination which it subsequently received, and that that inclination which it now has was given to it afterwards. That is a most distinct statement of a change of axis. Now I am prepared to demonstrate that that change of axis must have produced a universal deluge, and the glacial drift, and what, in a sounder state of geology, was called the diluvial formation. The present glacial theory was unknown in Buckland's day; and that we should be expected, on the assumed evidence of a new theory, to set aside the records forwarded to us from a remote antiquity seems really too much. This glacial theory has been pressed to a degree which it would be almost impossible to credit, if it were not written, and if we could not refer to chapter and page. It is supposed by Mr. Geikie, who has published a learned work on the great ice age, that in Connecticut—and he quotes Professor Dana, a professor of geology and natural history—the thickness of the ice overspreading the continent measured from 6,000 to 8,000 feet. Mr. Geikie introduces a picture of the great Antarctic ice-barrier from Sir James Ross's Antarctic expedition, and gives that as an illustration of the state of Scotland in the glacial age; but that great ice-barrier was limited to 1,000 feet thick, while in Connecticut the thickness is estimated, as I have said, at from 6,000 to 8,000 feet; in Scotland, from 2,500 to 3,000 feet; and in Switzerland, at 3,000 feet. Are we to understand that those who believe in a universal deluge are to be considered credulous, while those who receive these monstrous hypotheses, one of which is that boulders from the Alps were borne to the Jura upon a great continuous glacier which filled that whole wide and deep valley of Switzerland, are to be deemed not credulous but scientific? With regard to some of the particulars in this paper, I rejoice much that Professor Challis has come forward to support the Scriptural record: but that internal heat, which he does not account for, would be accounted for by a change of axis. We find from the calculations of Professor Hansteen that the north magnetic pole is about 18½ degrees from the geographical pole. The inclination of the moon's orbit to the ecliptic is 5 degrees, or thereabouts; while the plane of the earth's equator inclines to the ecliptic about 23½ degrees. If you deduct the 5 degrees of the moon's inclination from the 23½ degrees of the earth's inclination, the remainder, 18½ degrees, is the distance of the magnetic from the geographical pole—the old axis from the new; and you may thus come to some indication of a time when the moon's orbit was in agreement with the plane of the earth's equator. Upon that theory which represents the moon to have been originally an outlying portion of an extended attenuated condition of the earth itself, it is reasonable to suppose that she did originally move in the plane of the earth's equator, or very near it; and if so, the moon is a "faithful witness in heaven" of the fact that the earth's axis has shifted 18½ degrees. The facts of terrestrial magnetism, from which that great astronomer, Dr. Halley, deduced the conclusion that there is a nucleus

of the earth not revolving exactly with the earth itself, but revolving differently, bear the same evidence to a divergence of 18½ degrees. Putting these facts together, there is a basis on which calculations may be arrived at, establishing the fact that there has taken place a change of the equator of the earth. It is very singular that Sir Charles Lyell has shown that the island of Jamaica bears fossil evidence of having had at one time the same temperature with Vienna. How was it possible that these two places could have nearly the same temperature, unless the equator lay differently then from now? If that be the case, I undertake to demonstrate from it the fact of a universal deluge. I hope, if it is considered desirable, an opportunity may be given to me to lay my views at greater length before this Institute. I ought to have mentioned that the change of axis, acting in its effects, principally at the poles, would have caused a rush of water round the world which would be more violent in the more northerly than in the equatorial regions; and the atmosphere would have been affected in a similar manner: the drift formation demonstrates that to have been actually the case. Professor Geikie gives a detailed account of the boulder-formation of Scotland, where, sometimes for 100 feet in depth, the stratum is full of stones and boulders mixed together with clay, as he expresses it, "pell-mell, higgledy-piggledy"—so thick and dense that, in railway operations, the navvies have no greater difficulty than in dealing with that formation. How was that great mass mixed up? Without water it would have been clearly impossible; and that it could have been done in the course of millions of ages by slow deposit is also impossible, because it is not stratified, but is mixed up altogether. It must have been stirred about, and swept along violently, by a tremendous force, and deposited by being allowed to settle all at one time.

Dr. Coleman.—I cannot agree with Mr. Henslow, who appears to suggest that we may, in our discussion, argue the question apart from inspiration. I hold by the old system, that the Book of Genesis is inspired, and we must teach that boldly; and if there appears to be any inconsistency between science and Revelation, we must wait until the same God who revealed the Book of Genesis shows the consistency of the two.

Rev. T. M. Gorman.—A small work on the *Principles of Chemistry*, published in 1721, attempts to account for certain geological phenomena by the hypothesis of a primeval ocean. In one part I find the author saying—"At this day (in Sweden) the timbers and ribs of vessels and galleys have been discovered in places which are now forty or fifty yards above the level of the sea; and that hooks, rings, and hawsers, with many other indications of a port, and of inhabitants, have been found even on the mountains. And it is certain," he continues, "that the Baltic is still gradually subsiding towards the north, at a rate of four or five yards in depth in less than seventy years. So that in many localities, within the last hundred years, the plough has supplanted the oar, and the sower has taken the place of the fisherman. I myself," he proceeds to say, "have seen the marine spots, and have heard old men conversing about them. In Lapland, at the extremity

of the Gulf of Bothnia, within a century, towns have undergone a spontaneous removal from the shore, and are now some thousand paces distant from the original site of their port. And similar things have happened to other places on the same coast. And this may serve to prove that all these circumstances were not occasioned by the universal deluge, but that for a long time afterwards, the northern countries especially lay under a deep ocean, and that as the sea gradually subsided towards the north, they emerged and formed a habitable land. Should this view be established by the future discoveries of scientific men, it will furnish a reason for thinking, although not for positively asserting, (1), that even the horizontal pressure is liable to change, which follows if, according to the allowed opinion, the seas be depressed towards the north, and elevated towards the equator; (2) and, consequently, that the distances of the latitudes vary between the poles; (3), that certain countries in the far north, agreeably to the notion of modern, as well as to the accounts of ancient authors, may once have been islands, which, in process of time, as the sea subsided, united into a continent or contiguous land. Besides these, there are many other things which I shall not venture to publish until I am strengthened by still more numerous proofs, and enabled to proceed on a firmer foundation."

Mr. P. V. Smith.—As a member of the same University as Professor Challis, I would venture to say one or two words in his defence in reference to two charges which have been made against him. First, as to his mixing up miraculous and physical causes. I think the mixture he has suggested is no greater than the mixture necessarily involved by the other hypothesis: I mean, that of the alteration of the earth's axis. Those who adopt that hypothesis must assume that there was some extraordinary physical cause which produced the change in the position of the earth's axis. In what respect then is there less of a mixture of the miraculous and the physical in this hypothesis, than in Professor Challis' idea that an abnormal increase of the earth's internal heat was the immediate cause of the Deluge? He would of course attribute that increase to some extraordinary or miraculous occurrence. His mode of argument and his language appear to me to be fully borne out by the descriptions we have of miracles in the Scriptures. Take that of the crossing of the Red Sea by the Israelites. We all recognize that to have been a miracle; and yet the Scriptures say, that a strong east wind divided the waters. I do not pretend to say which theory of the Deluge is to be accepted—whether that held by Professor Challis, or that of a change in the earth's axis. I would only say that the attack which has been made on Professor Challis on the ground of his importing a physical cause, appears to me to be unfounded. I would also suggest a defence of Professor Challis in reference to the other charge which might be brought against him—that of not understanding the Scriptural narrative in the way in which we understand it as regards the animals being saved by means of the ark alone, and all the rest being destroyed. It appears to me that we find a justification of Professor Challis' view in the same part of Scripture as that to which I

have already referred. In the account of the plagues of Egypt, we are first told that in the plague of the murrain all the cattle of Egypt died, and then we are told that afterwards the cattle were destroyed by the succeeding plague of hail, which also destroyed every herb of the field. Subsequently we read that the locusts ate up all the herbs and green things which the hail had left. It is evident that these expressions must be taken together, and so taken, they explain what the writers of the books of Scripture understood and meant by the expressions "all" and "every." We gather that they used these expressions in a comprehensive, and not in a universal sense; and that is exactly what Professor Challis has suggested with respect to the preservation of the animals in the ark.

[Mr. CHARLESWORTH having disagreed with the Paper, and objected that the large amount of rain that must have fallen to cause the Deluge would have destroyed the fish in the seas, who could not exist in fresh water,]

The HON. SECRETARY.—Mr. Charlesworth cannot have noticed that his objection is one most satisfactorily answered in the Paper. Professor Challis speaks of the sea coming up on the land by reason of its subsidence, a phenomenon which is going on even in our own day. I find in America Professor Dawson, in his annual address for 1874, before the Natural History Society of Montreal, gives an account of the rapid subsidence of the eastern coast, and the rise of the western coast of the northern continent of America. In the Baltic we find somewhat similar changes going on, and Dr. Beke mentioned, after his last trip, that he had noticed that the whole land of the Gulf of Akaba was rising, and the sea-shore showed a recent elevation of 40 feet. These changes are now gradual, but is there reason to doubt that in earlier times such changes may not have been catastrophic? Indeed, Professor Challis mentions some in our day—referable to volcanic action, and I may, perhaps, be permitted to add to the instances he gives by mentioning that in Iceland the Skapta Jökul, in 1783, in forty days threw out a mass of lava which, if conical, would have covered London, and reached to a height of 13,000 feet; again, Mouna Loa, a few years ago, in ten minutes, threw out a pile of lava 3 miles long, 1 broad, and 20 to 30 feet deep. It is somewhat interesting to note the disturbing influences of atmospheric changes in the case of earthquakes. Milner states that "It is a well-established result of home and foreign observation, that earthquakes are preceded and accompanied by barometrical depression, indicating the diminished pressure of the atmosphere. Hence the occurrence of the greater number in the winter months, when the average height of the barometer is always the lowest, and is also subject to greater fluctuation than in the opposite season of the year. It may, therefore, be considered as highly probable that, while the causes of earthquakes are still shrouded in mystery, they are intimately connected in their occurrence with atmospheric vicissitudes. When the barometer is at 31 inches, the atmosphere presses on the surface of Great Britain with a weight = 291,793,239,406 tons;

when it sinks to 27 inches there is a diminution of weight on the same area = 37,648,938,386 tons; being about 427,231 tons to the square mile. Hence it may well be the case that, when the subterranean forces have acquired such strength as nearly to rupture the confining strata, any considerable diminution in the pressure of the atmosphere may bring on the crisis of actual disengagement." As regards the rate of the descent of rain at the Deluge, I have nothing to add to Professor Challis' statements, but may mention a remarkable fact in regard to the possible rate of its descent even in our own day, which was referred to at a recent (1875) meeting of the Geological Society by Professor Duncan, who stated that "on the Khasia hills there is a rainfall of about 600 inches annually; and this, falling upon ground which does not readily absorb moisture, has cleared away all surface deposits, and even excavated coombs in the granite."

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## THE REV. PROFESSOR CHALLIS' REPLY.

Professsor CHALLIS, who was not present at the meeting, having received a copy of the printed account of the discussion of his paper, requested that the following reply to some of the remarks made by the speakers might be added to the discussion :—

Mr. Henslow appears to have misunderstood the view I take of the physical operations by which the Deluge was produced. It is true that I consider the primary disturbing cause to have been an abnormal increment of the temperature of the interior of the earth; but the accession of heat is not supposed to "cause upheaval of the sea-bottom," nor to have any other immediate effect than that of generating excessive evaporation at the surface of the sea, in consequence of which there would be a downfall of "torrents of rain" on the land. For reasons which I adduced, it is not improbable that the amount of water which by this means would be transferred from sea to land might have the effect of disturbing the equilibrium of the earth's crust, which, adopting Sir John Herschel's view, I suppose to be resting on a molten sea. Hence, vertical oscillations of the crust, accompanied by transverse movements and occasional ruptures, might be the result, producing eventually the configuration of islands and continents, and the superficial irregularities, which we witness at the present day. I make no objection to the speculations mentioned by Mr. Henslow, according to which results like these might have followed from a change of the inclination of the earth's axis, and the consequent mechanical action of "an enormous accumulation of ice at the poles." But failing to see how such views could conduct to an explanation of the particular phenomena of the Noachian Deluge, *as described in Scripture*, and having found that these phenomena might be intelligibly accounted for by the supposition of an abnormal increment of terrestrial temperature, I had no alternative, considering the purpose of the paper, but

to adopt that hypothesis. And as the same authority that furnishes the record of the phenomena also plainly intimates that the Deluge had a miraculous character, it seemed not unreasonable to assume that the increment of temperature which accounts for the phenomena was *extraordinary*, and due to miraculous agency. In an analogous manner, as was appropriately remarked by Mr. P. V. Smith, the waters of the Red Sea were miraculously divided by the physical action of a "strong east wind." I can conceive of no *ordinary* physical agency whereby a change of the earth's temperature, so sudden and effective as that required to satisfy the conditions of the Deluge, could have been produced.

For the reasons above alleged, I am unable to assent to the view taken by Mr. Galloway, that the internal heat which my theory postulates "would be accounted for by a change of axis."

The facts stated in the passages which Mr. Gorman has quoted from a work on the Principles of Chemistry, published in 1721, are all in favour of the supposition that the earth's crust, as resting on a liquid mass, is susceptible of various conditions of equilibrium.

The remarks made by Mr. P. V. Smith relative to my being charged with mixing up miraculous and physical causes, and taking universal expressions in Scripture in a comprehensive sense, agree so exactly with the views I entertain on these points, that I have no occasion to add anything to what he has said.

The objection raised by Mr. Charlesworth having been met by the remarks of the Hon. Secretary, it only remains for me to take notice of the reference made by Dr. Coleman to the bearing of scientific arguments, relative to Scriptural statements, upon the "Inspiration" of Scripture. On the supposition that Scripture is inspired, it is a necessary consequence that there can be no real inconsistency between the statements it contains and the ascertained truths of physical science; that is, between God's Word and knowledge of His works. It is legitimate, therefore, on that supposition, to bring the results of modern physical science to bear on the interpretation of the Scriptural accounts of natural facts, such as those in the Book of Genesis relating to the Creation and the Deluge. In proportion as the stated facts may in this way be reasonably explained, confirmation is given to the hypothesis of inspiration. Such have been the character and the object of the arguments contained in the present paper, and in another ("On the Metaphysics of Scripture") which I have since communicated to this Society. In the latter, the question as to where natural agency ends and miraculous agency begins is particularly dwelt upon.