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ON THE PAST AND PRESENT RELATIONS OF GEOLOGICAL SCIENCE TO THE SACRED SCRIPTURES.

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IT seems too like presumption for an "outsider" in Geology to undertake such a subject as this. We are reminded of a young man who had been trained in the country as a cartwright, and came to town seeking employment as a joiner. He was asked if he had ever made a window, and replied that he had not, but that he had made a harrow, which he said "was very like it." We fear that the present paper will be only too like the writer's former "harrow," to pass well for the window which is required. It will lack symmetry, and its joints will admit, all too freely, the "cold winds of criticism." And yet the glorious sun, whose radiance is truth, may condescend to shine through it.

Geology is literally the "word of the earth." Not a word which the earth speaks, but the word which is spoken or written concerning the earth.

A word is a symbol of thought. It is only in so far as geology expresses *thought* regarding the earth, that it is anything. It is not the structure of the globe itself—nor is it the absolute truth regarding that structure—neither is it the expression of that truth. It is only the expression of that *imperfect thought* by which the structure of the earth is represented in the minds of men. He who is aware of this, will guard against the idea that Geology is any part of that supreme knowledge to which all other thought must ultimately bow.

When we take up Geological Science in this view, it lays itself out to us in three great divisions. There is that thought in which what are called the *facts* of the science are represented, then that representing the true *inferences* drawn from the comparison of these facts, and, last, the conjectural ideas that are allowed to represent themselves, but do not represent any other reality. If we wish to illustrate the first of these divisions of thought by an example, we may take up

a piece of rock, composed, we shall say, of sandstone, which has just been broken from the solid bed in the side of a hill. In that piece of rock, and as it lay in the mass of the mountain, you see the form of a shell. The words which express the thought of that fact form a part of that which is fundamental in geology. Apart from this kind of thought there is nothing real in the science.

In that which is called a *fact* of this character, you have three things; first, the material rock with its shell-form; then the thought representative of that object in the mind; and third, the words which express that thought. The piece of rock is the same to all who see it; the thought representing it in one mind is probably, so far, unlike the thought of it in every other; and the words expressive of such thought are both varied and changeable. Yet, from the nature of the rocky fact itself, there is at least a possibility of such repeated observation as issues in the all but perfect agreement of informed minds, as to the thing itself. It is the expression of thought regarding such facts, about which the truly scientific mind is ever most careful.

But to proceed to another example. You are on the sea-shore; and observing a portion of the sand which the tide has left exposed, you see that true shells, as they have been left by the molluscs that dwelt in them, are imbedded in that sand exactly as the form you have seen is imbedded in the rock. As yet we assume that you do not reason on the *relations* of those objects—you only observe them as they lie. Your thoughts represent little more than that which has reached you through your senses, sufficiently cogitated to present the objects to your mind. We shall suppose that you go on observing objects of this character, you are treasuring that kind of thought, out of which all geological science must be formed.

But there is, as we have said, a second and very different description of geological thought. You bring together the form of a shell which you have observed in the rock, and a real shell which you observed in the sand; comparing them, you perceive that, in many respects, they are not alike. They are indeed similar, but also strikingly dissimilar, and you begin to *reason* or to *infer*, that is, to form certain thoughts which represent relations of objects rather than the objects themselves. You then leave the thoughts representative of the mere facts for totally different thoughts, and enter a region in which difficulties and dangers greatly increase. It is then that you begin to realize what Steno, one of the ablest of geologists, wrote about two centuries ago. He says, addressing

the Grand Duke of Tuscany,—"Most Serene Duke, it often befalls travellers in unknown countries, that, hastening through a mountainous tract unto a town standing on the top of a hill, they think it hard by, as soon as they come in sight of it; the manifold turnings and windings of the ways thereto retard their hopes unto a trouble. For [at first] they have only a view of the nearest tops, but they cannot guess what is hidden by the interposition of those high places; whether they be lower hills or deep valleys, or plain fields, because with their flattering hopes they measure the distances of places by the eagerness of their desires." It is not the sight of the hill-tops, nor even that of the town beyond them, that gives the traveller difficulty and the danger of error, but the effort to *infer*, or to form the thought which will truly represent the unseen distances between. "So," says this learned Dane, "Having once or twice seen those grounds out of which are digged up *shells* and other such-like things cast up by the sea, and found that those earths were the sediments of a turbid sea, and that everywhere we might estimate the number of times how often the sea had been troubled here and there, I hastily not only imagined by myself, but confidently affirmed to others, that the whole business [of accounting for them] would be an inquiry and work but of a very short time."* There was no difficulty to Steno as to the facts; but when he undertook to produce the true thoughts which would represent the relations of those facts, he found himself encountering the real labour of science.

And yet it is not in the field of patient inference from facts that either great difficulty or danger may be said to lie. If we are satisfied to accept the certain thought which fairly compared facts gradually give us, and to wait patiently for the increase of such true light, we may learn an incalculable amount of relative truth. Much that cannot be seen will be as real to us, and even far more powerful and precious in its influence over us, than anything that is seen. For example, we may observe how a shellfish lives and dies in the bed of the sea at the present time, leaving its shell in the sand, and observe also the form of a similar shell imbedded in a rock, which is now high above the level of the sea. We may note that this shell-form is so imbedded as to indicate that the creature to which the shell belonged lived and died in the very sand of which that rock is composed, just as the modern one lived and died under the present waters of the ocean. We

* I quote from an interesting old volume entitled "*The Prodromus to a Dissertation concerning Solids contained within Solids, &c.*. By Nicolaus Steno. Englished by H. O. 1671;" pp. 1 to 4.

have now got a great amount of relative thought, and we may go on till we believe, without difficulty and without danger of error, that the sea at one time flowed over the rock in which this shell-form lies imbedded. So long as the facts are duly observed, and the inferential thoughts derived from their comparison are manifestly related to the facts, and beyond reasonable doubt, so long we are gathering real science in its two great branches of trustworthy instruction.

But, as we have indicated, there is a third kind of geological thought, which is of a value very different from that of the other two. This consists of speculation, which, so far as discovery has gone, has no realities to represent. The universe of waking dreams, to which this introduces us, consists of all the possibilities of falsehood as well as of all those of truth. It is the region from which, we humbly think, true science warns us away. That which *is, and so may be known*, as distinguished from that which *is not, but may be conceived*, is the proper object of science. It is very important, when we would trace the relations of geological science to the Sacred Scriptures, to consider whether we mean the relations of our first two divisions of thought, or the relations of that so-called Geology, which is chiefly composed of conjecture. Because of the extremely speculative tendencies of scientific men, it has become painfully necessary that we should sift most carefully that which is presented, even by the highest authorities, as geological science; so that we may be able to distinguish between truth which is the logical result of real discovery, and doctrine held as above all price, but which may be abandoned to-morrow by those who are to-day its most earnest advocates. Because of the fond partiality, too, with which favourite hypotheses are almost worshipped, and on account of which every opposing idea is disliked, it is needful that we take up, and examine with great care, views that have been scouted by scientific leaders and their followers as worthless.

Almost all truth has been thus treated for a time by the rulers of public opinion during whose reign it has been discovered. To those who have not yet attended to the evidence from which it really springs, and who are more in love with speculation than with real science, every new truth will appear conjectural, it may be even preposterous; while conjecture, which has no evidence whatever to support it, may seem highly reasonable, only because it happens to accord with some preconceived notion.

It is in connection with this part of our subject that we come upon the phrase "negative evidence." At first sight one would naturally imagine that this means really "evidence."

But it means nothing of the kind. Such evidence as could, with any degree of propriety, be called "negative," must be such as would nullify some apparently positive evidence opposed to it. That to which we are geologically introduced has no such effect. The "negative evidence" of popular geology is only that to which we are told the Irishman appealed, when, on being confronted with a witness who saw him commit the crime laid to his charge, said he could bring a dozen who *did not* see him do it! For example, what were called the "oldest rocks" were termed *azoic*, because it was held that no relics of life had been found in them. And, as it was held also that no relics of life had yet been found beneath them, it was concluded that *there was no life on the surface of the globe when they were formed*. The support of this great doctrine was "negative evidence." In other words, it was not known that there were no relics of life in such rocks—there was no evidence of such a negative; on the contrary, very worthy testimony had been borne to the effect that such relics had been found—still less was it known that there never had been such relics of life in these old rocks; there is now, at least, pretty strong evidence that such relics existed, though they have been obliterated in the alterations of the strata in which they were inclosed. It was only generally unknown whether or not there were such relics of life in these rocks, or under them. We need scarcely say that all conclusions built on ignorance, under the name of "evidence," are utterly unworthy of science.

We have only too strong reason to dwell on this conjectural aspect of the fashionable geology of our day. It is not as if only details, here and there, were turning out false, while grand principles remain evidently sound. If we do not err greatly, the speculative geological mind is escaping out of one great mistake in *principle*, and that only by leaping into another as great, because its leaders are careless as to the true nature of their reasoning. When their evidence is not "negative," or, in plain words, not *nothing*, it is so utterly inadequate as to leave the ideas supposed to be proved by it, as purely conjectural as if they were altogether matters of fancy. For example, look at the measurement of time believed to be required for the upheaval of land. "*Two feet and a half in a century*" is a scale of upheaval adopted for the whole world during all time! Why? Only because there is apparently some reason to think that the coast of Norway, taking the north and south of that coast together, and striking the average, is rising at that two-and-a-half-feet rate! The observation of this mere scrap of the earth's surface, and that during a very brief period, is taken as if it furnished a sufficient standard for measuring the

rate of upheaval over all portions of the surface of the globe, during all ages! Such is a grand instance of conjectural chronology as given by one of the greatest of geologists.*

As another instance, I take the following from the same high authority; in this case, an estimate of time required for the growth of strata. A mass of rock, sixty feet thick, is described as composed of layers so thin, that "thirty are sometimes contained in the thickness of an inch." Observe the "*sometimes;*" for we notice in the same description, that there are "occasionally" layers of flint, carbonaceous matter and marl, each, as it seems from the statement, "about an inch thick." We have no means given of estimating the "sometimes," nor the "occasionally," that are manifestly of so much importance in the case. Between the layers, of which thirty occupy an inch, there are marks of plants that have been flattened and carbonized, and "sometimes myriads of small *Paludinæ* and other fresh-water shells." Here again we observe the "*sometimes.*" For these thin leaves are spoken of as each "a page of history representing a certain period of the past." And we are evidently expected to draw the inference that these rocks that have grown in ancient lake-bottoms, were formed "with extreme slowness." We are also told that masses of the same sort of rock, two hundred feet thick, are found in the neighbouring hills.† Well, how shall we calculate? Say that we give each bed of shells a year to grow, and forget the "sometimes," and the "occasionally" also. One inch of rock gives thirty years; a foot of rock, 360 years; sixty feet, 21,600 years; 200 feet, 72,000 years! Here, then, is a magnificent idea. But what if a bed of such very small snail-shells should not take a month to grow? What, if some of the flattened plants might be floated and laid on the surface of the lake-bottom every day? What, if the heat at noon and the cold at night, affecting the muddy water, might account for the layers? Each of them would then represent but a day, and thirty of them only a month. What if the "sometimes," in which the snail-shells occur, should be very few times, and the "occasionally," which qualifies the occurrence of layers an inch in thickness, should be really very often. How do our 72,000 years dwindle down into a very brief period indeed! If we take for example any pond into which muddy streams are flowing, it is surely anything but according to experience and observation among those who should clean such places out, that they take ages to

* Lyell's *Antiquity of Man*, edition 1863, pp. 58, 178. Sir Charles advances this two-and-a-half-feet scale in exceedingly cautious language, but argues upon it as if it might be fairly assumed.

† Lyell's *Elements of Geology*, edition 1865, page 229.

silt up. The slightest change in the inflowing water, or in the temperature of the pond itself, causes a change in the character of the silt, and, consequently, a layer in the mass forming in the bottom. As to larger bodies of water, Page says that the clayey mud of the great Chinese rivers is estimated as borne down at the rate of *two million cubic feet in an hour!* The Ganges alone carries 700,000 cubic feet every hour into the Bay of Bengal! * Must such work take tens of thousands of years to deposit sixty feet of muddy strata? In the face of the most common facts, it is surely anything but scientific to magnify duration into measureless vastness, when looking at a rock which has been formed by such means.

So much for the three great divisions of what is generally understood to be geology. It seems well that we should have the true nature of that which passes as the science clearly before us, ere we attempt to trace its relations in any direction.

Sacred Scripture is the Word of God. It is a word which He speaks, rather than one spoken concerning Him. It is the expression of thoughts which He desires to communicate to men. It is, we think, really an expression of a portion of His own thoughts, although that expression is necessarily cast in the mould of human language, and these thoughts are necessarily made to take a form such as allows them to enter the human mind. When thus viewed, the Sacred Scriptures present us with several divisions of very important matter for consideration.

First of all, we think it necessary to note a very important distinction between what is called "the Book of Nature," and the written revelation contained in the Bible. The created universe is, no doubt, in a certain sense, an expression of divine thought, and as such, it is a "Book" which may, and ought to be "read;" but it is not such an expression as that which takes the form of human language, and comes near, in that language, with the treasures of the divine heart, to the human soul, as man comes near in speech, and opens his heart to his fellow-creature. If, for example, we observe attentively what a man does, we may generally so far learn what that man thinks and feels. If we note what he does to us, we may generally so far learn his state of heart towards us. Man's works are, in this sense, an expression of his thoughts which may be read. So far, we may speak of his doings as the Book of his deeds; and we may also thus far speak of the "Book" of God in nature. But this is very different from

* Page's *Advanced Textbook of Geology*, edition 1856, page 31.

that which takes place when any one either speaks to us himself, or sends another, for the purpose of telling us the very thoughts and feelings of his own mind. In the former case, we indirectly learn something regarding the mind of the person whose deeds we observe,—we may, so to speak, *guess* correctly his feelings and designs; but, in the latter case, we are not left to guess at all. We are directly told the thoughts and feelings, as well as the true intentions of his heart. He who, in any proper sense, believes in the divine authorship of the Bible, sees in it an expression of God's own thoughts, and that by Himself, as really addressing Himself to mankind.

This view is greatly strengthened, when we remember that portions of the Sacred Scriptures consist of God's own statements of such doings of His as could not, in the nature of the case, be otherwise known to man. The account of the creation is plainly of this character. It could not be gathered from any other source than God's own testimony. Man seeks in vain for it in the so-called "Book of Nature." He finds it in the plain testimony of the inspired teacher, who is made to communicate God's own thoughts of it to mankind. We see in it the teaching of the Creator himself as to His work—not the teaching of the work, but of Him by whom the work was performed.

But there are other distinctions of great moment to be noticed. We must not confound the noblest productions of men as authors, with this Word of God. To take, therefore, another illustrative example. If we open a book which has been written by one of ourselves in the ordinary way, we gather merely the thoughts of the man who has originally written the book. If we open the book of Genesis, we gather not merely thoughts which passed through the mind of Moses, but the thoughts of God, which He passed through the mind of the Hebrew, that they might be communicated to us. No modification of the idea of inspiration, which allows any fragment of that idea to remain in the mind, can dispense with this view of the divine origin of those thoughts that are embodied and expressed in the Sacred Scriptures. These Scriptures must be accepted as God's expression of His thoughts, as truly as man's scripture is his expression of his own thoughts, or we are not regarded as possessing any true Word of God in the Bible. What is called "the inspiration of the poet," is no more "inspiration," such as that of Sacred Scripture, than is ordinary thought of the dullest kind. Both are only the thoughts of human beings. But the inspiration of the Bible is really God's personally passing His thoughts through human

minds, so as to cause them to be expressed in human language to men.

I am careful to make this part of our subject clear, because the entire importance of all true defence of the Bible hinges on the idea of a real inspiration of the thoughts communicated in that record by the Infinite One. The relation of science to Milton's "Paradise Lost," for example, is a matter of little or no moment; and if the Books of Moses had no other inspiration than those of Milton, and others of like genius, the relation of science to them would be equally unimportant. It is the belief that God spake by Moses, and meant that the words which Moses wrote should express His own divine thoughts, and this belief alone, which gives the relation of Science to Scripture its intense interest. "*Thus saith the Lord,*" are words that express the grand peculiarity of Sacred Scripture, and they can have no meaning short of that to which we are now directing attention.

There is, however, another aspect of this matter which requires to be carefully considered here. If thought is to pass from the Divine to the human mind, that thought will be affected both in form and degree, because of the nature of the mind which it enters. It must be evident, at a glance, to any one, that the infinite conceptions of God cannot be comprehended in the extremely limited intelligence of man. So must it be evident that the absolute harmony which appears to the Omniscient, because of His omniscience, cannot be made to appear to those who can, in the nature of the case, see only a few fragments of the vast whole. This is true even in the communication of truth from a largely informed to a little informed mind among men. If any one who has mastered a great subject is desirous to communicate some portion of his thoughts to another who is as yet very ignorant not only of that subject but of things in general, he must present only a portion of those thoughts, and that such a portion as cannot represent the loftiness and harmony of that which delights his own mind. While, then, the believer in the divine inspiration of the Sacred Scriptures, regards them as the expression of God's thoughts, he does not imagine that these Scriptures were ever intended to express all God's thoughts on any subject, or to represent the harmony of truth as it is seen in the Infinite Mind. He means only that the thoughts, so far as expressed, are God's own thoughts, and hence infallibly true.

But if these thoughts are affected by the nature of the mind which they enter, they are still more affected as they pass from one human mind to another. We all know how seldom anything is told twice over in exactly the same shade of meaning, and

how necessary it is, if we would secure the truth, to have it as far as possible at first hand. This makes it necessary ever to distinguish between the teachings of the inspired writers and all *interpretations* of those teachings. Not that we would undervalue interpretation. When a mind full of vast and varied knowledge, reads a portion of the Sacred Scriptures, the divine thought which rises in that mind will be far more full than that which rises in the mind that has but little information. Consequently, the well-informed will often be able to help the ill-informed to more lofty and expanded views of divine things, or of things divinely spoken of, than could otherwise be reached by the less favoured among men. So the mind which is free from error, to a great extent, will be capable of far more truthful thought in reading the divine record, than that mind which has imbibed a great deal of false idea. There will be less mixture in the views suggested by revelation in the one mind, than in those which rise in the reading of it by the other. The man, therefore, who is comparatively free from misleading preconceptions, must often be of great use to the man who is not so. Hence the value of his interpretations. But if these same interpretations are allowed to take the place which can only be properly occupied by the sacred Word itself, it is not difficult to see that there must be great risk of evil. In so far as the interpreter enables the reader to see the meaning of the divine text more fully for himself, he proves of use and value; but the moment the person to whom the interpretation is given is turned from thinking of the word of God, as addressed to his own mind, away to the thoughts of an uninspired interpreter, even if he is not led into error, he is led into a false position, in which he loses the peculiar influence which truth has on the mind when it is seen to come from God Himself.

Here, then, it seems well to glance at Scripture interpretation, as that has been affected by geological theories. The desire to accommodate men of science, and to accept their conjectures as established discoveries of truth, rather than to face the unpleasant consequences of sifting their statements so as to show the visionary character of their most cherished theories, has had a powerful and, we think, a disastrous effect, on the exposition of the Bible. It is not an easy matter for those who have the duties and responsibilities of active ministerial life resting fairly on their hearts, to find time to cultivate much acquaintance with geology. If they are earnest, they are likely to be swallowed up with what they deem more urgent work, so as to excuse themselves from that labour which alone can enable them to judge for themselves on so complicated a

subject. If they are not earnest, then they avoid the toil on other grounds. If they see in some degree the momentous character of the agreement of popular science with religious belief, and so turn their hearts to do something in the way of promoting that agreement, they are tempted to study rather the things that make for peace than those by which a really solid edification may be secured in the public mind. They too readily accept the decisions of the great leaders of science, and set to work to make the ideas given forth in Scripture harmonize with these decisions. Hence the almost incalculable amount of utterly groundless thought that has been made to overlie the clear ideas of God put before us in the Sacred Scriptures. It is not possible to see the relations of geological science to the Sacred Word, without some knowledge of the effect which has been thus produced on its interpretation.

We have illustrations of this in the productions of some of the most noble minds. One of the first of these, a truly representative man of an important class, may be quoted as an example. Dr. John Pye Smith, of Homerton College, was not only a man of the most earnest religion, but also of the most intensely scientific spirit. In his masterly book, "On the Relations between the Holy Scriptures and some parts of Geological Science," he shows that he felt himself forced to give a new and startling interpretation to the teaching of the Bible, by what he thought were the irresistible conclusions of geology. It is most instructive to observe where the centre of this fancied compulsion lay. He imagines one opposing his views, and says, "If, for example, the objector could say to us, 'You have arrived at no term. You cannot show us the indications of a cessation of the materials which you say have been deposited, and which form the portion through which you have passed. The series may be repeated, possibly again and again; or there may be another series of entirely different composition, such as precipitates from suspension in water, or products of chemical action, or results of igneous fusion, and so on indefinitely. Unless you had penetrated through all these, you can draw no conclusion on which dependence can be placed.'" How does the good man reply to this supposed objector? He says,—"But the objector cannot say this. He would be guilty of a false assumption. The true state of the facts is the very contrary to what he supposes. We are acquainted certainly, I might almost say perfectly, with the character and succession of the deposited substances, which, laid upon each other, compose the crust of our globe; and we know the totally different constitution of the materials which lie underneath. We see demonstrated

with satisfactory clearness the distinct character and the opposite mode of production of these two classes of mineral formations. We have all the evidence that can reasonably be desired, of the previous condition of those underlying rocks, their ancient, and, at a depth not great, their present liquidity by heat; their boiling up; their extrusion, both in the melted state and in different degrees of advancement towards being cooled and hardened; their being driven upward through the overlying formations of deposited layers; their sometimes insinuating themselves between the previously contiguous surfaces of those deposits; their filling long furrows of outbursts, and their being laid bare in many cases to open daylight. It is therefore no presumption to affirm that we do know, with the clearness of sensible evidence, the constituent formations of the crust of the earth, their modes of production, their relations to each other, and the fact of their enveloping a mass of materials similar in composition to the lowest rocks, and which we have much reason to think are, at certain depths, still in a state of constant fusion."* What does the editor of the *Geological Magazine* for 1865 say to this "certain" and almost "perfect" knowledge? His words are: "Many a range of so-called primeval granite, gneiss, and slate, lapping the one over the other successively for hundreds of thousands of feet, or of upright 'primary schistus' miles across, will exhibit to the geologist of to-day only many-times-repeated folds of an altered set of strata; nor will their furthest change, or granitic form, be taken either for primeval or intrusive granite: and whilst the latter may still be found, the former, or the hypothetical granite of a cooling globe, becomes a myth."† Sir Charles Lyell expresses the same truth still more decidedly. In the first volume of his "Principles," which has just been issued, he says, "The progress of geological investigation gradually dissipated the idea, at first universally entertained, that the granite or crystalline foundations of the earth's crust were of older date than all the fossiliferous strata. It has now been demonstrated that this opinion is so far from the truth that it is difficult to point to a mass of volcanic or plutonic rock which is more ancient than the oldest known organic remains."‡ So the all but perfect knowledge of the excellent man who felt, in view of it, that our Scriptural cosmogony must be all recast, was only a perfect delusion! Are we not taught by this that great minds are not only gigantic in their grasp of

* Dr. J. Pye Smith's *Scripture and Geology*, edition 1843, pp. 44 to 46.
† *Geological Magazine* for January, 1865, page 2.
‡ Lyell's *Principles of Geology*, edition 1867, *in loco*.

truth, but equally gigantic in their grasp of error? Are we not warned against that grand popular mistake which leads thousands to accept as true that which has no other evidence in their thoughts than the fact that great men believe it? And do we not see how important it ever must be to keep the Sacred testimony itself most carefully in view?

We do not think it necessary on our part in this paper to give any interpretation of what the Sacred Scriptures teach on geological subjects. Our present duty is not to interpret, but to state and illustrate relations which are not essentially dependent on any peculiar interpretation of Bible teaching. If we do not greatly err (and are not led on in our error by all we can learn as we go on with the study of our great subject), the Bible will turn out in the end to be its own best interpreter. The account of the creation and the flood, as given by Moses will, we think, prove to be only the plain truth, as the scientific world will be compelled to admit it at last.

From what we have said thus far, it will appear that there are various fields of thought in which we might attempt to trace the relations of geological science to the Sacred Scriptures. These relations exist in the absolute truth as that stands in the Divine Mind. The thought of this leads us to raise our eye to that ocean on the shores of which we can only gather fragments of the wealth that lies hid in its waters. It is beyond measure cheering to the Christian to remember that endless time remains for the exploration of this expanse of thought. It is because he finds that he gathers most precious treasures cast up by this vast sea on Bible ground, that he so loves the Bible. But relations between geological science and the Sacred Scriptures exist also in that field of thought in which we meet with the true facts and sound inferences of geology, on the one hand, and the actual teachings of the Bible on the other. This is our true field of safe investigation. If we could only keep within its enclosures, all would go well. But neither have theologians nor geologists been as yet confined to such ground. As we have seen, the influence of great names—the power of great talents—the vanity which makes us proud of that which is knowledge in appearance only—the worship, we may say, of magnificent delusions, even after their delusive nature is exposed—in a word, the deceivableness of our common humanity, seems to have swept us into a turbid stream of thought in which it is extremely difficult to say whether the teachings of the geologist or the interpretations of the expositor are most to be distrusted.

In the way of reviewing the actual facts and such conclusions of true reasoning in geology as have been derived from the

comparison of those facts, we are disposed to regard the history of this science as naturally divided into certain great epochs, or stages of development. It will suit our purpose of making the past and present relations of the science somewhat clear, if we glance at the progress made during each of these great epochs. With this plan in mind, we go back to the earliest thoughts recorded on the subject, and run rapidly down the stream till we reach the present state of affairs.

Ever since man was on the earth, the more prominent facts of geology must have been patent to his observation, and they must, we think, have so far arrested his attention, and exercised his reason. When, therefore, we trace back the literature of the science, and light upon the first written thoughts that indicate observation and reasoning on the subject, it would not be wise to conclude that men never thought geologically till the authors of that literature lived among them. Those who did write so much as six or seven hundred years before the commencement of the Christian era, constantly refer to others who had written before them, and to ideas on the subject that had generally prevailed. We are disposed to select two of the prominent names of antiquity, as representative of all the rest. These are Herodotus among the Greeks, and Pliny among the Romans. In the works of both of these authors, we think we see that which may be very respectfully regarded as worthy geological observation and not unworthy reasoning on the important facts that had been observed.

We turn for our earliest historical notes to the pages of Herodotus. This masterly Greek had evidently thought geologically, and so far correctly. Speaking of the account which the Egyptians gave of their peculiar country, he tells us that, in the time of Menes, "no part of the land that now exists below Lake Myris was then above water."* Herodotus says that "they seemed to me to give a good account of this region. For it is evident to a man of common understanding, who has not heard it before, but sees it, that the part of Egypt which the Greeks frequent with their shipping, is land acquired by the Egyptians, and a gift from the river; and the parts above the lake, during a three days' passage, of which, however, they said nothing, are of the same description." Then he speaks of the sea-bottom, a day's sail from land, as mud in eleven fathoms, and evidently "an alluvial deposit." He says again, "The space between the above-mentioned mountains [the Arabian and Libyan], that are situated beyond Memphis, seems to me to have been formerly a bay of the

* Herod., Eut. ii. 5 and 12.

sea." He goes on to establish this idea by a reference to other rivers, and especially by a description of the Arabian Gulf, into which, he says, if the Nile were turned, it would fill it up within twenty thousand, or even within ten thousand years. Herodotus gives a number of other reasons for his belief that the sea once flowed over the space now occupied by Egypt; among which is the fact that "shells are found on the mountains." He says, "that a saline humour forms on the surface, so as even to corrode the pyramids, and that this mountain, which is above Memphis, is the only one in Egypt which abounds in sand; add to which that Egypt in its soil is neither like Arabia or its confines, nor Libya, nor Syria (Syrians occupy the sea-coast of Arabia), but is black and crumbling, as if it were mud and alluvial deposit, brought down by the river from Ethiopia, whereas we know that the earth of Libya is reddish and somewhat more sandy; and that of Arabia and Syria is more clayey and flinty." It is very clear, we think, from these true ideas of this author regarding the basin of the Nile, that he was accustomed to a certain extent to follow out his observations of the surface of the earth, in true geological reasoning.

But we pass from the Greeks to the Romans, to give the ideas of another truly representative man. So far as the collection of facts and correct reasoning on these are concerned, Pliny is our best ancient writer on geology. This does not arise from his own observation of the structure of the earth, so much as from the wonderful acquaintance which he displays with the works of other authors. Herodotus was a traveller, and observed with his own eyes the facts which he narrated. Pliny gathered sheaves of information from the labours of all reapers in the field of knowledge.

It is in connection with earthquakes that this author gives us his best geology. Speaking of these, he says that "the earth is shaken in various ways, and wonderful effects are produced; in one place the walls of cities are thrown down, and in others swallowed up by a deep cleft; sometimes great masses of earth are heaped up, and rivers forced out, sometimes even flame and hot springs, and at others the course of rivers is turned." "There is no doubt," he says, "that earthquakes are felt by persons on shipboard, as they are struck by a sudden motion of the waves, without these being raised by any gust of wind." Then he notes the important truth that "inundations of the sea take place at the same time with earthquakes; the water being impregnated with the same spirit, and received into the bosom of the earth which subsides." "The same cause produces an increase of the land;

the vapour when it cannot burst out forcibly lifting up the surface. For the land is not produced merely by what is brought down by rivers, as the islands called Echinades are formed by the river Achelous, and the greater part of Egypt by the Nile, where, according to Homer, it was a day and a night's journey from the island of Pharos; but in some cases by the receding of the sea, as, according to the same author, was the case with the Circean Isles." Then again he says, "Land is sometimes formed in a different manner, rising suddenly out of the sea, as if nature was compensating earth for its losses, restoring at one place what she has swallowed up at another."* He gives abundant instances of islands so formed. Then he shows that lands are separated by the sea, and islands formed, by this means; while islands are added to the mainland by the elevation of their channels. All this is unexceptionable geology. It reads like some modern treatise on the principles of the science. Like everything of that early time, it was mixed up with fabulous statements, just as nearly all modern geology is mixed up with conjectural notions equally fabulous; but, so far as it goes, it indicates a very large and successful observation of the changes that affect the earth's surface.

The great amount of attention now drawn to recent formations, lends peculiar interest to the observations and reasonings of these ancient writers. There seems to be no good ground for believing that they had thought of penetrating to the secret depths of earlier strata, so as to classify the rocks; but we ourselves have been brought up from the depths to the surface by the most important controversies of our time. Hence the peculiar relish with which one now reads the records of thought so ancient, and traces the formation and character of that thought, so very much like the ideas which occupy the minds of the men of our own day.

If we endeavour to sum up the knowledge of the ancient philosophers, so far as their geology is concerned, I think we should regard them as having observed, to a great extent successfully, the characteristic changes of the surface of the globe—the degradation of higher strata—the consequent formation of alluvial land—the upheaval of the bed of the sea, and of mountain-ranges—the vast alterations connected with the phenomena of earthquakes—as well as the aqueous and igneous agencies and forces by which these effects are so far accounted for. If we compare their collections of minute facts with the collections and classifications of these accu-

* Pliny, ii. 82, 86, and 87.

mulated at the present day, the advance of science since their time has been immense, but if we fairly compare their philosophy of the earth with that reasoning as to the causes of terrestrial changes which prevails in even the highest quarters now, I am not sure that progress can be reported as of so great a measure. Fire and water unitedly filled up their thoughts of causation, so far as the surface of the earth was concerned, and these two well-known agencies seem to occupy the same space in the thoughts of modern philosophers. The forces that produce fire, and give water its power to dissolve, and which must be considered before many of the greatest facts in the earth's history can be explained, are nearly, if not quite, as much unknown to the moderns as they were to the ancients. Perhaps here the comparatively superficial thinker will remember Newton and "gravitation." The more careful thinker will remember Faraday, who says that force is "matter." "Gravitation," he says, "is a property of matter depending on a certain force, and it is this force which constitutes matter."* He will ask whether either Newton or Faraday really knew what gravitation is. He will find it very difficult to think that they did so. He will deeply ponder the manner in which the most favoured of the moderns reason on the effects of forces; exaggerating the least, and forgetting the greatest. And he will be constrained to give the ancients credit for a very great amount of geological science—that is, when that which they knew is weighed against that which is known at the present hour. There is a dangerous vanity which feeds on imaginary progress in knowledge, and needs often to be made aware of the fanciful character of that on which it thrives. I am persuaded that few things are more salutary in the way of restraining this vanity than an honest and patient comparison of what even the heathen thinker knew with the actual science mastered by the most civilized and enlightened among ourselves.

When we leave the period of observation and reasoning represented by such men as Herodotus and Pliny, and endeavour to find some tufts of truth on which to place our feet as we pass through the morass of stagnant and phosphorescent thought which followed that time, we feel greatly at a loss. For nearly fifteen hundred years rational inquiry stood as still as if progress had ceased to be a feature in humanity. It is,

* Faraday's *Researches*, vol. ii. p. 293. In this remarkable utterance gravitation is not a force but a property of a force. It is a property of matter, but then that is constituted by, or, in plainer words, *is* a certain force. So gravitation is a property of a force depending on a certain force, which force is just force!

however, remarkable that with the revival of intellectual activity generally, we have a very decided revival of geological inquiry. When Leonardo da Vinci pictured the fossil shells of Italian rocks so beautifully, and contended that they had once been real shells, there must have been a somewhat deep and wide interest awakened in connection with fossil remains. This was at the close of the fifteenth century. When Fracastoro wrote, about the year 1517, on the petrifactions that were brought to light at Verona, some degree of fundamental geology had found its way into the more intelligent minds. But it is not till more than a century after that we have much of a really scientific character in the form of geological literature. Then, it is clear, that true thought on the earth's structure had begun to spread widely. There is a rather interesting evidence of this in a production from which we have already quoted. It is a translation of Steno's work on "Solids contained in Solids," which was published in London in 1671. In the address of the "Interpreter" to the reader, he says that the treatise "giveth very fair hopes, that by a due weighing of the particulars therein laid down, the sagacious inquirers into nature may be much assisted to penetrate into the true knowledge of one of the great masses of the world, the earth, and therein to find out not only the constitution of the whole, but also the several changes and the various productions made in the parts thereof." Steno, as we have already indicated, was a learned Dane, living, at the time when he wrote this treatise, under the Grand Duke of Tuscany, but about to leave for his native land. The treatise itself is constructed as a mere sketch of a much larger work which had been contemplated. It was published as a sort of apology for so full and noble a discussion of the deeply interesting theme as might have been worthy of the acceptance of the prince. Thought on such subjects had ripened to a very great extent before the date of this publication.

We consequently find a very considerable amount of sound and excellent geology in the treatise of Steno. He writes on what he calls "the much controverted question about marine bodies found at a great distance from the sea," and says that the question itself "is ancient, delightful, and of use." He complains that modern writers had rendered the subject more difficult and doubtful by departing from the solutions of the ancients. He says, "The ancients were exercised by one only difficulty, which was, how *marine* bodies came to be left in places remote from the sea." The discussion in Steno's time was as to the origin of these marine bodies—some ascribing them to the sea, others to the earth—while many held that

some had been produced by the earth and others by the sea. He says, "Only some make mention of inundations, and I know not what immemorial course of ages; though they do that overly, and as 'twere by the by." Steno himself gives as good an account of the matter as could be desired. Speaking of "cockles," he says, "Where the penetrating force of juices hath dissolved the substance of the shell, the same juices being either drunk up by the earth, have left the spaces of shells void (which I call aërial shells), or being altered by new adventitious matter, have, according to the variety of that matter, filled up the spaces of the shells, either with crystal, or marble, or stone. Whence comes that very pretty marble, called *Nepheri*, which is nothing else but a sediment of the sea full of all sorts of shells, where the substance of the shells being wasted, a stony substance is come in the place thereof."

But Steno wrote not only of objects found in the rocky beds of the earth, but of the beds, or strata, themselves. In a notable passage on this part of the subject, he says: "At the time that any bed was formed, there was another body under the same bed, which did hinder the further descent of that dusty [muddy?] matter." Again, "At what time there was formed one of the upper beds, the lower bed had attained a solid consistency." So he reasons as to the succession and superposition of strata. Then he says, "'Tis certain that when any bed was formed, its inferior surface and that of its sides did answer to the inferior body and of the bodies lateral, but the superior surface was, as far as possible, parallel to the horizon. So that all the beds, except the lowest, were contained in two planes, parallel to the horizon. Hence it follows that beds, either *perpendicular* to the horizon, or inclined to it, have been at another time parallel to the same." He then speaks of the "beds" changing their places, "first, by a violent excussion of the beds upwards." "The other is by the falling down of the upper beds, when the lower matter or foundation being thrown down, the upper bodies begin to crack; whence, according to the variety of cavities and crevices, there follows a various situation of the broken beds." So he says, "This changed situation of beds affords an easy explanation of many things else difficult enough to give an account of."* The formation of strata, the inclosure of fossils, the change of the position of strata, the forces at work in producing these effects, the conditions necessary to the operation of these forces, and the consequent result in the external form of the earth, as

* Steno, pp. 42, 43, and 99.

affected by the lofty mountains and deep seas, were known in a very remarkable measure by this intelligent thinker.

An author like Steno, who could write such geology above two hundred years ago, is worthy of respect; and we may quote him at some length on the relation of geology to Sacred Scripture. He had come to the conclusion that "Etruria," which he had surveyed with some attention, had had *six* different "*faces*" or states of the surface, and he conjectured that this had been the case with the earth as a whole. So he says:—"But lest there should be apprehended any danger in the novelty, I shall, in short, lay down the agreement of *Nature* with *Scripture*, reciting withal the chief difficulties that may be raised about each face of the earth. As to the first face, Scripture and science agree in this, that all was covered with water; but how it began to be thus, and when, and how long this continued so, Nature is silent, Scripture is not." Then he says: "Of the second face of the earth, which was plain and dry, Nature is likewise silent when and how it began, but the Scripture is not so; meantime, that there was once such a face of the earth, Nature affirms and Scripture confirms, forasmuch that it teacheth that waters arising from one spring did water the whole earth." So he writes as to the whole appearance of this world spoken of by Scripture and seen in Nature. He says: "How great the height of the sea hath been, where Scripture determines it, Nature contradicts it not; forasmuch, I. There are certain marks of sea extant in places which are many hundred feet high above the surface of the sea; II. It cannot be denied that all the solids of the earth were in the beginning of things covered with an aqueous fluid, as they may have been covered with it again, in regard that the change of natural things is indeed continual, but there is no annihilation." This passage gives us a very fair view of geology in its relation to Scripture as it stood at this time, though we have given but a small portion of what Steno says on this relation, and its perfect harmony. He was, as we learn from his treatise, evidently a man of great ability and of a truly scientific spirit—worthy of being taken as the representative of the most advanced opinions of his time on the great subject we have in hand.

Thus far it will be seen, that we have little in what may be called geological science that could seriously come into conflict with anything that occurs in the Sacred Scriptures. Those ideas of a vast duration through which changes have been following one another in the earth's structure, ideas which have played so important a part in some recent controversies;

these had been mooted only, as Steno says, "overly and by the by." They had not taken the form of conclusions of science to which the cultivated intellect was expected to bow. Geology, though "descriptive," and so far philosophical, had not become sufficiently "systematic" to give even apparent solidity to speculations in reference to the time required for the world's upbuilding, or in reference to the manner of that great work. A most spirited controvery had arisen as to "pre-Adamite" men, but the discussion was not geological in any degree. It was founded on an exposition of the fifth chapter to the Romans, and not on deposits in the earth.* The foundation, however, was broadly laid, on which in later days a geological argument was to be raised in favour of these "pre-Adamites," and also in favour of vast ages through which such beings had lived on the earth.

It was about 1759 that the element of time fairly took its place in geological science. Whewell says that at that date Arduino deduced from original observations, the distinction of rocks into *primary*, *secondary*, and *tertiary*, and that the relations of positions and fossils were from this period inseparably associated with opinions concerning succession in time.†

It is at this point, therefore, in the history of geology, that we meet with these formidable elements of which so much advantage has been taken, against the more ordinary views of Sacred Scripture. It was now that geological science in almost every one of its branches began to give system and great additional force to the reasonings of those who studied the structure of the earth. In giving a brief sketch of what may be regarded as a grand advance in geological inquiry about this time, we shall follow other and more competent judges in giving the names of Werner, Smith, and Cuvier, as the representative men.

Werner's great distinction lay in his mineralogy. The ordinary inquirer, who thinks with any degree of care, will see the importance of this in all that concerns the true knowledge of the earth's structure. If any one takes his stand opposite a cutting which has been made—say for railway purposes—through a large and varied mass of rock, he sees layer above layer of the stony substance, each layer, perhaps, differing in its composition from every other. No inference is more certainly true than that all these layers have not been

* The chief promoter of the Pre-Adamite idea at this time was Peyrere, in whose Latin work on the subject the curious may see the best that could be said in its favour.

† Whewell's *History of the Inductive Sciences*, edition 1857, vol. iii. p. 413.

originally formed and transformed in the same way. The sandstone has not been formed as the coal has been, nor has the ironstone been formed in the same manner as either of the other two, nor has the limestone been composed of the same materials, or in exactly the same way, as any of the other three. The conditions of mineral formation must have been different, and even greatly different, in order to the composition of the strata exposed to view. If the observer has the opportunity of watching the sinking of the shaft of a deep mine, he will find a variety in the character of the layers passed through, corresponding somewhat with the thickness of the penetrated mass. Every layer will indicate by its mineral character that a peculiar state of things prevailed at the time and place of its original formation, or at that of its transformation afterwards. It was, as we have said, the great distinction of Werner to apply this truth to the study of geology. His classification of rocks depended on their outward characters. It was not their chemical distinctions, but such as could be detected by the eye or hand, that formed the bases of his ideas of them. Jamieson, his great Scottish follower, says that chemical science was not then in such a state as to warrant dependence on its decisions. He says, when speaking of his tour through the Scottish Isles: "The chemical characters which form even the foundation of many mineralogical systems, I have seldom employed; from a conviction that the chemical part of mineralogy, notwithstanding the late improvements in the art of analysis, is still to be considered as imperfect."—(*See* Preface, page viii, Jamieson's *Mineralogy of the Scottish Isles.*)—It was Werner's immensely superior acuteness in distinguishing one mineral from another by the eye, or hand, or smell, that made him great as a pioneer of advanced science, and enabled him to bring a grand truth to bear upon the earth's structure. Although his theory of the origin of rocks cannot be said to have been at all established, his views of their character will be found to be far nearer the truth than those of the men who have all but despised them. He was the great champion of the aqueous theory as to the formation of almost all strata.

Hutton opposed this view, with a popularity which shows painfully how error may triumph. When this great geologist was searching the rocks of the Grampian range, and lighted on what he took for veins of injected granite, his joy was unbounded. The scientific world may be said to have gone after him in the belief of an internal molten state of the globe, only to find that it had been misled by a false idea. Yet the varied composition of the rocks to which Werner had effec-

tually drawn attention, remained as a momentous truth in established science.

But the name of William Smith represents an advance in the knowledge of the earth, of greater importance than that of Werner. This was characterized chiefly, though far from exclusively, by true doctrine as to the superposition of the strata.* It was not so much the varied character of the rocks, nor the varied character of the fossils which they contained (though both of these were known to this thinker), as the order in which they had been laid on one another, which first influenced his thinking on the structure of the globe. It was clear and certain enough that sandstone and coal had not been laid down in the same circumstances in their original beds; but this could not tell whether the actual sandstone or the coal in a particular series of rocks, had been first formed. When, however, it was noted that the coal had from the first lain beneath the sandstone, it was sure enough that the coal had been first laid down; and so on through all the varied strata of the earth. A field of vast dimensions was thus opened for inquiring minds, and the work of many generations was cut out for them. Men imagined ere long that they had lighted on the nethermost rocks—the true foundations of the everlasting hills—and that they could trace the whole of the wonderful building of the globe all the way from the centre up to the grassy turf that crowned it! But a great deal more has yet to be learned ere that can be done.

Then came that most important of all advances, which is represented by the name of Cuvier. It was his great task to mark off the physiological distinctions that separated the kinds of creatures that lived on dry land and in the ocean, when the various strata of the earth were laid down.† The difference between stone and stone was something, the position of rock above rock was something more; but the genera and species imbedded in one set of strata, shown to be so thoroughly different from those imbedded in another set, proved a far more important affair than either of the other two. The trees on land and the shell-fish in the ocean, compared with the fossil wood and rocky forms and casts of ancient mollusca, brought wonderful results to the minds of men. Yet, if we consider calmly the true extent of those results, so far as they constitute real science, they seem to us to amount to little, if anything, more than the placing of an

* Whewell's *Hist.*, vol. iii. p. 424. "In 1792 he [Smith] 'had considered how he could best represent the order of superposition—continuity of course—and general eastern declinations of the strata.'"

† Whewell, vol. iii. p. 418.

instrument in scientific hands, by which important work may be done in the course, perhaps, of centuries.

There were now, however, three great general ideas established in scientific minds. Certain rocks, deep in the earth's crust, or high on the sides of lofty mountains, were seen to have been formed in the same manner as similar rocks are now in the course of formation in the bed of the sea. The masses of sandstone that lie buried so many fathoms down, or have been raised so many thousands of feet high, were once sand-beds washed by the waves that now wash the sandbanks over which they flow. It was not yet within reach to tell how the rocks were formed on which the sand was first laid down; and it is not yet, we think, within reach of science to tell this secret. The limestone could be traced to its formation by the living creatures, and otherwise from the ocean, and it could be seen in course of deposition on that ocean's bed. How the first bed was formed in which the shell-fish lived, or on which the ooze was first thrown down itself, was and is the grand mystery. But the discovery of the truth, that deeply hid masses had been formed at one time on the surface, and that masses now high up the mountains, had been formed in the depths of the ocean, was the opening of a vast field of thought for men. Then there was the order of superposition, teaching that difference in age is irresistibly evident from difference of place in that order. That which is now forming on the surface, must, as to its formation, be new; that over which it is forming, must, as to its formation, be older. Strata laid conformably on each other, show that they were formed during one series of changes, while those on whose edges they have been laid down, have been formed during a very different series; and so on, as far as men can make out the actual facts of the order of deposition. But the grandest of all the teachings of these discoveries, was found in the order which seemed to be disclosed by the fossil contents of the strata. Man was on the surface, but no trace of his existence could be found, except on that surface. Creatures approaching man in his material structure, were found in the relics of their existence some way down, but only a short way; and just as the search descended, the class of being discovered was "low" in the scale of life. Not that it was less perfect in its kind. As Sir Roderick Murchison says: "When first created, the Onchus of the uppermost Silurian rocks was a fish of the highest and most composite order; and it exhibits no symptoms whatever of transition from a lower to a higher grade of the family." Only it was a fish and not a reptile. This truly eminent geologist, speaking of one of the great objects he had in view in

his vast labours, says: "I am, indeed, led to hope that my readers will adhere to the views which, with many contemporaries, I entertain of the succession of life. For he who looks to a beginning, and traces therefrom a rise in the scale of being, until the period is reached when man appeared upon the earth, must acknowledge in such works repeated manifestations of design, and unanswerable proofs of the superintendence of a *Creator*."* This was and is felt to be a point of great moment, though we must confess that it is one of those points which, to say the least, are very far from being fully established. Some modification of Sir Roderick's idea may prove true, but not that idea, we think, as it appeared to him when he wrote the words we have quoted. Yet enough had become certain to convince men that there has been only a limited line of life on earth. So far as mineral character and the superposition of rocks were concerned, it appears as if there may have been an indefinite series of changes going on; but what is regarded as the irresistibly evident progress of life, from things of the most humble to beings of the most exalted character, seems to shut up the inquirer to a belief in the limited character of the creation.

We have now before us the three great parallel lines along which all geological science, properly so called, has been travelling: the varied mineral character of strata, the varied order of their deposition, and the changing character of the fossils which they contain. If we trace the progress of the science up to the present hour, we find only a development in detail of these three great branches of truth, and that development rendering it continually more evident that the present state of the earth's surface is the result of a series of material changes, as to the nature of which men are yet only beginning to see as through a glass *very* darkly. But from this point, I think we pass naturally over into the dreamland of conjectural geology.†

When we come to consider the speculative divisions of geological science, we find ourselves at once in a region where men are in conflict equally with all true reason, as with the Sacred Scriptures,—a region in which, however, they stand on ground of the most unstable character. It was because of their unwise love for pure fancy in the garb of Philosophy, that the

* *Siluria*, pp. 239, 483.

† Probably the careful reader will think that we have already passed into that region. The succession of life on the earth, which has been thought so fully established as a truth in science, is not unlikely to share the fate of some other great but too hasty generalizations.

ancients were so completely led away from the true paths of knowledge. Whewell strikingly describes their failure, and its cause, in his admirable *History of the Inductive Sciences.* "Yet," says he, "we are not to think slightingly of those early speculators. They were men of extraordinary acuteness, invention and range of thought; and, above all, they had the merit of first completely unfolding the speculative faculty; of starting in that keen and vigorous chase of knowledge by which all the subsequent culture and improvement of man's intellectual stores have been occasioned. The sages of early Greece form the heroic age of science. Like the first navigators, in their own mythology, they boldly ventured their untried bark in a distant and arduous voyage, urged on by the hopes of a supernatural success; and though they missed the imaginary golden prize which they sought, they unlocked the gates of distant regions and opened the seas to the keels of the thousands of adventurers who, in succeeding times, sailed to and fro, to the indefinite increase of the treasures of mankind."* We can enter with all our hearts into this well-merited eulogium; but it is more difficult to praise the speculative ambition of an age which has the failure of the Greeks so fully before its eyes, and yet follows in that very track in which they reached only failure, and misled the inquirers of succeeding centuries.

When Herodotus proceeds to account for the overflow of the Nile, he furnishes us with a very good example of early speculation. He says: "During the winter months, the sun, being driven by storms from his former course, retires to the upper parts of Libya; this in few words comprehends the whole matter, for it is natural that the country which this god is nearest to, and over which he is, should be most in want of water, and that the native river-streams should be dried up. But, to explain my meaning more at length, the case is this: the sun passing over the upper parts of Libya, produces the following effect: as the air in these regions is always serene, and the soil is always hot, since there are no cold winds passing over, he produces the same effect as he usually does in the summer when he passes through the middle of the firmament; for he attracts the water to himself, and having attracted it, throws it back upon the higher regions."† It is not necessary to quote the whole passage. That to which I direct attention is the purely conjectural character of the explanation of the historian, coupled with the show of science, which caused his words to pass for the language of truth.

* Whewell's *Hist.*, vol. i. p. 48. † Herod., Eut. ii. 24, 25.

We have equally striking illustrations of the conjecture into which scientific minds are ready to fall in the literature of later times. Steno, who has given us so much excellent geology, gives us also a good specimen of speculation in his explanation of the general deluge. "If it shall be said that in the earth the centre of gravity is not always the same with the centre of the *figure*, but that now and then it recedes from the one or the other side, according as the subterranean cavities are grown in divers places, it is easy to render a reason why the fluid which in the beginning of things covered all, left certain places dry and returned to them again. With the same ease may be explained the *general deluge*, if we place about the fire in the middle of the earth, a sphere of waters, or at least certain receptacles of them, whence without the motion of the centre, the pouring forth of the included water may be deduced." So he goes on at great length to account for the Deluge by means of conjectural reasoning, which is assuredly every whit as scientific as the best of the speculations of the present day.

When we come to the geological speculations of modern science, we find them arranging themselves along the three lines of thought to which we have already referred. Where reason and true science stand waiting for light, imagination kindles the torch of fancy, and passes on. Werner worthily represents those who pass down to the beginnings of the earth's strata, and see old Chaos amid his watery desolations, commencing the work of uprearing the present order of things. It is not a little interesting to find, as we have already said, recent discoveries lending so much countenance to Werner's ideas. Sir W. E. Logan's descriptions of the Laurentian rocks of Canada go very far in this direction. He has not only described the limestone formations interstratified with gneiss and granite, but he says, "Interstratified with the Laurentian limestones there are beds of conglomerate, the pebbles of which are themselves rolled fragments of still older laminated sand-rock, and the formation of these beds [that is of the beds of sand-rock from which these pebbles came] leads us still further into the past." Speaking of these limestones still, he says, "Of these calcareous masses, it has been ascertained that three, at least, belong to the lower Laurentian. But as we do not yet know with certainty either the base or the summit of the series, these three may be conformably followed by many more."* All, therefore,

* *Quarterly Journal of the Geological Society*, February 1st, 1865, pp. 46, 47

that we can say from these discoveries is, that the lowest rocks yet known to popular geology are sedimentary. If by the leadings of the highest note in the world, we go down to those sand-rocks seen in the pebbles of Laurentian conglomerate, and ask for the character of the rocks on which their sand was first laid down, we have no reply. We are not told that the foundation is granitic, nor are we told that it is not so. Our conscious ignorance here is, perhaps, our surest knowledge. We know that we do not know—that is all.

Hutton represents that host of speculators who still go down to the centre of the earth, and see all on fire. Because veins of superincumbent rock were full of granite that looked as if it had been melted and injected from below, he imagined, as we have seen, that the conclusion was irresistibly established that the basis of all the strata of the earth's crust was cooled lava, or molten rock cooled down and crystallized under great superincumbent pressure. It is most instructive to see how the very best authorities were led astray by this unfounded notion. As an illustration of this, though the author is one who discourages conjecture (at least in words), we find in Page's *Advanced Text-Book* (1856) the statement that the variable temperature of the crust of the earth descends to from sixty to ninety feet, "but at this limit it is stationary." Then he says, "that downwards from this invariable stratum, the temperature increases at the ratio of one degree for every fifty or fifty-five feet, and at this rate a temperature would soon be reached sufficient to keep in fusion the most refractory rock substances" !* At the depth of twenty-five miles, his estimate is 2,400° Fahrenheit! This is surely hot enough for the most fiery philosopher. To give another instance. Whewell says, in the second edition of his admirable history, regarding Hutton's theory, (which, however, he admits was "premature,") "that many of its boldest hypotheses and generalizations have become a part of the general creed of geologists; and its publication is, perhaps, the greatest event which has yet occurred in the progress of Physical Geology." † These words were published in 1857; and in 1865 the very foundations of Hutton's theory were seen by all informed men to be false. Playfair, Dr. Hutton's great illustrator, says, "The power of the same subterranean heat which consolidated and mineralized the strata at the bottom of the sea, has since raised them up to the height at which they are now placed, and has given them the various inclinations to the horizon which they are found actually to possess." ‡ This is just what the very best

* Page's *Advanced Text-Book*, p. 15. † Whewell's *Hist.*, vol. iii. p. 505.
‡ Playfair's *Illustrations*, edition 1802, p. 55.

authorities now tell us is utterly untrue in both its halves. We shall see this fully as we proceed. What then was the advantage derived from Dr. Hutton's speculations? Physical Geology has had the benefit of being effectually misled for half a century. No matter for congratulation, certainly. This remarkable delusion did not spread, because no one opposed it. Far abler geologists than Dr. Hutton gave facts and arguments to the world more than sufficient to show the fallacy of his notions, but they were all despised as mere Neptunian prejudices. One cannot but regret that it should have been so. It is true that we are profited by being even painfully convinced of our folly, and so far good may come out of these grand mistakes when their spell has been broken; but surely it would be better if we were sufficiently careful of the grounds of our belief to secure that we should not be misguided, generation after generation, by these magnificent fancies. As matters stand, we see only the groundless nature of those grand ideas by means of which so many have been led to think that the teachings of Scripture are overthrown.

As we proceed with the review of theories, we see how one series of errors issues in another. When it was thought to be a truth, established by the mineral character of the rocky strata, that the earth was a globe of molten matter cooled down till a solid crust surrounded the still molten centre, it was natural that men should seek for a "beginning" to the history of such a globe, in something from which a fiery mass might come. Astronomy teaches that our world is one of multitudes that whirl in space; and so in searching among those other orbs it might be hoped, that men would find some analogies to guide them in conjecturing the real origin of the earth. A great astronomer had already given the fancied cue to the wished-for mystery. In looking among the myriad stars, we descry certain bright clouds that could not at first sight, or even by the aid of very powerful telescopes, be regarded as crowds of distant globes. So far as even Sir Wm. Herschel could judge with the aid of his vastly improved speculum, these *nebulæ* were composed of "star-dust," or luminous matter in a gaseous state, and in process of concentration. The nebula seen in the constellation of Orion was one of the most persistent of these clouds. It can be seen by the naked eye, and yet the most powerful telescope that could be constructed then, failed to show that it consisted of separate stars. The irresolvability of this nebula seemed to teach that it was not so much distance which gave it a nebulous appearance, as its gaseous constitution. In the winter between

1844 and 1845, the Earl of Rosse brought his "three-feet mirror" to bear upon it, but could not see the vestige of a star. "The Nebular Hypothesis" was strong then. The immense weight of Hutton's influence, combined with that of Herschel and Laplace, bore on the scientific mind, and made the conviction apparently as irresistible as the nebula was irresolvable. Men felt as if they must believe that here was the primary state of a world—a cloud of luminous matter circling round a centre, and in process of cooling down into a solid globe like our own.* But Lord Rosse at length constructed his telescope with a six-feet speculum. Professor Nichol tells us the result, in language of intense eloquence. He was present the first time the "mighty tube" was directed to the mysterious nebula in Orion. The instrument was still imperfect, and no stars were seen. At length, however, Lord Rosse wrote, under date March 19th, 1846, telling him that with only half the magnifying power the speculum bore, he "could plainly see that all about the trapezium is a mass of stars; the rest of the nebula also abounding with stars, and exhibiting the characteristics of resolvability strongly marked." "And thus," says Dr. Nichol, "doubt and speculation on this great subject vanished for ever!" Then he says, "Yes! the Infinite we had built up after the fashion of what had become familiar, was yet, with all its greatness, only IDOLA, and could fill neither Space nor Time."† It required, as we have seen, a few years longer to demonstrate the mythical character of the "fundamental granite of a cooling globe;" but now these "brilliant" notions are safely registered in the record of dreams. It should never be forgotten that the most confident unbelief in the Sacred Scriptures perhaps ever entertained, had its foundations in these purely imaginary notions of great minds. So had the most laboriously framed but misleading interpretations of the Mosaic narrative, the force of their imagined necessity in those now abandoned theories.

It is not, however, in what may be regarded as isolated hypotheses that we notice the most signal failures in speculative geology. In its grandest generalizations there are astonishing defects. For example, when we are told that the crust of the earth is known to the depth of "perhaps ten miles,"‡ and inquire into the grounds of the statement, we are introduced into a field of astonishing reasoning. The deepest

* It is a puzzling question why philosophers did not regard these nebulæ as worlds going to smoke, rather than consolidating into globes like our own.

† Nichol's *System of the World*, ed. 1846, pp. 53 to 56.

‡ Lyell's *Elements of Geology*, page 2.

mine of which I have seen any record, is only about a twenty-second part of ten miles. Twenty-two such shafts end to end with each other, would be required to pierce the earth's surface to that depth. Then if we take the estimated thicknesses of the strata that have been classified, that proves far too much. Those formations which are now placed below the Silurian, are described as fifteen miles in thickness in themselves alone! Were we to go by the estimated thicknesses of the rocks, and to imagine that at one time they all lay one over the other at any one point on the globe, we must conclude that we know something like a hundred miles down, instead of ten! Then suppose that we take a mountain and let it even be 20,000 feet high, that is, nearly four miles, who shall tell us what is in the interior of that mountain on a level with the plains at its feet? We are told that "it may appear inconceivable to a beginner, how mountains several thousand feet high, can have become filled with fossils from top to bottom;" but our difficulty is not with the conception, but with the entire absence of proof that there are any such mountains on earth. We may be perfectly satisfied that the surface of the mountain, even to its summit, is formed of sedimentary strata and contains fossils; but this is only a surface matter of comparatively a few feet, while we are seeking for some scientific grounds on which to found the belief that geologists know the crust of the planet to a vertical depth of ten miles! But we have the "dip" and bend of strata going down from the surface and coming back to it again. Say we take a Laurentian rock that rises to the surface, at a certain point, and consequently, if we trace it back from that point, it "dips" away towards the earth's centre at a certain angle. We pass along in the direction of this "dip" till we at last believe that we meet with this same rock rising to the surface again, we shall say at a similar angle to that at which it went down. Working on this angle, and on the distance between the two points at which the rock rises to the surface, we draw a "section" of the crust of the earth which accords with these data. We have a magnificent bend in the bosom of which to "fill in" any amount of newer formations, and at the point at which the bend is the deepest, we have a great deal more, we suspect, than ten miles! Our difficulty here again is, not that we have not proved enough, but that we have proved a great deal too much! We begin to be deeply thoughtful on the problem, as to whether, if geologists had known the crust of our globe to half the distance we have reached, they could ever have fallen into those mistakes as to its character which have

turned out to be so enormous. Their real knowledge amounts simply to this. At the time when certain creatures lived under the sea in a certain place, certain rocks were formed at the sea-bottom; certain rocks were formed after these, inasmuch as they were laid above them; and during the period of this newer formation, certain other creatures lived above where those older rocks *now* lie. We do not know that the older rocks continued to lie exactly where they were formed, when the newer rocks were being formed above them. We know that certain rocks dip at a certain angle and rise to the surface at a certain angle too,—sometimes the same as that at which they dip;—but we do not know that they form always such a curve as may be drawn in following this angle of dip and rise. The variations of position and contortion are innumerable, and our ignorance of the unseen depths is perfect.

But the ignorance which, so far as we can see, prevails as to the depths, is clearly traceable among geological ideas of the surface. We may give, in passing, a notable instance of the evidence that it is so. One of the most influential theories in that class which has been used against ordinary scriptural ideas, is that usually called the *glacial*. It is given as the true account of the formations embraced in the "boulder clay," which means so much in geology. It is thus briefly but clearly stated by Page.—He says: "After the deposition of the lower tertiaries, it would seem that the latitudes of Britain and the North of Europe underwent a vast revolution as to climate, and that some new arrangement of sea and land took place at the same period. At all events, the large mammalia of the earlier tertiaries disappeared, and the land was submerged to the depth of several thousand feet, for we now find water-worn boulders on the tops of our highest hills, or at all events, at an altitude of from 1,800 to 2,000 feet. A cold period ensued, and icebergs laden with boulders and gravel from other regions, passed over these latitudes, and dropped their boulders on the then submerged lands."* This immense ocean then gave place; and upheaved land with masses of ice pressing down the mountain-sides, and laying similar loads of boulders and clay at the sea-bottom, to be raised by fresh elevations, gave existence and character to the boulder-formations of the present surface. He says, "It is thus that we find granite and gneiss boulders from the Scottish Highlands now spread on the plains of Fife and Midlothian, and blocks from the hills of Cumberland spread over the moors of

* Page's *Advanced Text-Book*, pp. 233, 235.

Yorkshire." But this dream of a vast ocean with its burdens of ice and stone has been most successfully supplanted by one (if it also be a dream) which shows the north of Europe, and especially the regions spoken of above, all covered by a mass of snow like that now covering Iceland, which travels over even the tops of high mountains, and across valleys, carrying with it similar boulders to those advanced in proof of the submergence of the land, even to the thousands of feet spoken of. Especially by Mr. T. F. Jamieson, of Aberdeen, we are shown the folly of the fashionable faith in an ocean flowing over mountains now 2,000 feet above the sea-level, and the reasonableness of the mass of superincumbent snow, such as is still creeping over the inequalities of the northern surface, carrying with it all that is required to account for the boulder formations.*

Other ice-theories are contending with this of Mr. Jamieson for the mastery over the upheavals and subsidences of the ocean-bed. Among these, the most important is that which is founded on the fancied displacement of the centre of gravity in the globe by means of an immense accumulation of snow at the Pole. A grand difficulty in the way of this is the fact of open sea at the Pole now, though such masses as those which cover Iceland lie on Polar lands. But even if this displacement theory could be accepted fully, it would not at all change the relation of the boulder formations to the ice-covering. It might account for a submergence of northern regions to the extent of 300 or 400 feet, but could say nothing as to those facts which call for one of more than 3,500 feet, if an ice-bearing sea were to be maintained instead of snow. This dissolving view of an immense frozen ocean, with all its accessory ideas, is disappearing, like those of the central fires and the nebulæ of space.

If we pass from these glacial affairs, and examine into what is known as to the formation and transformation of the rocks, we find that the same absence of true thought characterizes the present condition of this science which is seen in the matters we have thus reviewed. The mineral constitution of the strata, as enabling men to say how they were formed or transformed, is a cardinal affair in geology. Let us take up the popular notions of "trap" rocks, as a striking example of the light which prevails in this direction.

Looking into the *Geological Magazine* of July 2nd, 1866, we find, in a brief notice of an excursion of the Bath Naturalists'

* *Quarterly Journal of the Geological Society*, vol. xviii. p. 164.

Field Club, that on the 15th of May, "whilst passing along the Ridgeway, several indications of trap were noticed." One of these rocks was pointed out, coming to the surface "in the form of a boss; thus giving evidence of a mighty volcanic movement, which took place at a remote period, the limestone, before horizontal, being then upheaved by this great protruding mass, and thrown off on either side with considerable force; the lava at the same time bursting forth wherever a vent could be found." Such are popular ideas of trap rocks. In the same number of the *Magazine* (and, indeed, in the page facing that from which I have quoted) we find that the Warwickshire Field Club, on the 16th of May, had been examining "interesting sections of the lower coal-measures, with intrusive trap," and that they had some interesting discussion, on finding this once molten rock "in connection with coal shales," which in some cases remained little changed, though "in close proximity" with the igneous rock. Let us fairly fancy a melted mass of stone at its white heat flowing over a bed of combustible shale, and this same shale remaining "little changed"! In the same number of the *Magazine* still, we find that a paper was read to the Glasgow Geological Society on trap rocks near Bowling, on the Clyde. The writer, speaking of Auchentorlie Glen, says, "A little way up, on the left-hand side, there is a cave-like recess under the trap, partly filled with water, which has been formed by the scooping out of a bed of coal and shale which crops out near the level of the stream. The trap is here seen resting on the coal, which dips to the south-west at an angle of twenty-six degrees, and is almost two and a half feet in thickness. It is considerably burnt in its upper part, but some of it gives off a little flame. Between the coal and the trap there is a thin bed of clay-shale, and another bed of shale underlies the coal." Here then is a problem. Let us imagine a furnace large and hot enough to send out a stream of slag sufficient to form a mass like that which lies on this bed of coal. This stream, at its white heat, flows over this thin clay and combustible coal, yet the clay is not altered, and the coal is only "considerably burnt," and not even changed enough to prevent its "giving off a little flame"! Can anybody that ever saw molten slag coming in contact with shale and coal, conceive of such a miracle in nature as this? It would be just as easy to believe that geologists are trap rocks themselves, as to believe that coal could lie under a stream of molten lava of size enough to form the Bowling hills, and yet be only "considerably burnt." Yet Professor Ramsay himself, in his inaugural address to the Geological Section of the British Association, refers to the car-

boniferous system of Scotland as one in which "igneous rocks are rife;" the igneous rocks being this very trap which could lay itself so harmlessly at a white heat on clay-shale and ordinary coal, without even taking the colour or the smoke out of them!

The facts to which we call attention are just such as Kirwan, for example, published as early as 1799. He tells us that at Borrowstounness, in Scotland, a stratum of trap or whin is the immediate roof of a seam of coal, and at Hillhouse, near Linlithgow, a thin seam of coal is found beneath a stratum of columnar basalt. At Bathgate hills, strata of coal and basalt alternate with each other. His authority is John Williams, of whom Sir Charles Lyell says that he gave "the best account of the coal strata." Kirwan gives an instance from Hessia, in which a bed of coal six to ninety feet thick lies under a "mass of trap or basalt 600 feet high." He says that "when the coal is some fathoms thick, it forms a stratum that, next to the basalt, is the best and most bituminous."* Jamieson, in 1800, published the results of his personal observation of the geology of the Islands of Scotland. Speaking of the island of Canna, he says that there the people who had worked the coal told him that it was from six to eight inches thick, and inclosed in whin rock. At Portree, in Skye, he "observed a stratum of coal one to two feet wide, resting on basalt, and covered by a similar mass sixteen to twenty feet high." At another part he saw coal only a few inches thick, "covered by a stratum of basalt thirty feet high." In keeping with these observations, Kirwan quotes Bruckenman, who "found mussel-shells, ammonites, and corallites in the basalt of pretended extinct volcanoes of France," and says "Doctor Richardson lately discovered, and showed me shells in the basalt of Ballycastle."† Such testimonies might be multiplied to a very great extent; and the wonder is how the facts testified escape the notice and fail to be quoted, at least for refutation or explana-

* See Kirwan's *Geological Essays*, edition 1799, pp. 247 to 252, and 310 to 311. The passage in Williams is worthy of quotation; he says, "Strata of basaltine rocks are very common in many coal-fields in Scotland. There are several thick beds of this stone betwixt the different seams of coal at Borrowstounness, and one of them is the immediate roof of a seam of coal in that ground; and there is a thin seam of coal below a beautiful bed of columnar basaltes at Hillhouse lime-quarry, a mile south of Linlithgow. In the Bathgate Hills, south of Linlithgow, there are several strata of coal and several strata of basaltes blended together, *stratum super stratum*. These instances may suffice as a proof that strata of basaltes are sometimes the immediate roof and pavement of strata of coal." (*The Natural History of the Mineral Kingdom*. By John Williams, F. R. S. A. Posthumous edition, 1810.)

† *Mineralogy of the Scottish Isles, &c.* By Robert Jamieson, F. R. A. S., &c. Vol. ii. pp. 38, 57, 87, 88 (edition 1800).

tion, by those who uphold so strenuously that the trap formations of the carboniferous period of Scotland are the lavas of submarine volcanoes.

If it were necessary to give the authority of a living geologist for the truthfulness of our ideas regarding these so-called igneous rocks, Mr. Geikie might be referred to. He read a paper before the Geological Society on the 6th of last June, and wrote also an article which appears in the December number of the *Geological Magazine* (1866); in both of which he shows that sandstones and clay, as well as limestones, can be seen passing into trap and granite in Ayrshire; and that without either rising from their beds or being overheated in them.* Speaking of sandstones, he says that they "have become changed in places into a rock of variable composition, which is sometimes quartzless syenite, sometimes minette or mica-trap," and goes on to show how crystalline structure is fully reached. "At last," he says, "I am therefore forced to conclude that the crystalline rocks, described above, have resulted from the alteration, *in situ*, of certain bedded deposits." It is interesting to see the effect of this conclusion, as to sandstone passing into trap and granite, in connection with these rocks passing into each other. Sir Charles Lyell says, "It would be easy to multiply examples to prove that the granite and trap rocks pass into each other, and are merely different forms which the same elements have assumed according to the different circumstances in which they have consolidated from a state of fusion."—(*Principles*, vol. iii. p. 362, ed. 1833.) Now, sandstone and even clay, passing into trap and granite, must be classed among the fused rocks too, or the whole "fused" theory of trap and granite must be given up. If the positive statements as to the origin of trap rocks, which so abound in our popular geology, taken along with what we have thus stated, do not prove ignorance of fundamental truth in the science, nothing can be proved.

When we would account for geological belief as to the origin of certain strata—belief that is so palpably false—we have only to mark the oblivion which prevails as to some of the grandest discoveries of kindred sciences. Our great leading geologists

* Mr. Geikie says, near the commencement of his paper in the magazine, "The rocks referred to below are *Diorite*, *Minette*, and *Granite*, all of which, with one exception, are admitted by most geologists to have *generally* had an igneous origin—that is to say, they have not only been in a state of fusion, but have also at various periods forced themselves among pre-existing strata." The exception is *Granite* evidently. Mr. Geikie lets the fused theory down *gently*, but he lets it down effectually.

seem to us to have failed truly to study the subject of *force*. This cannot but prove a defect of great influence, and such as might be expected to produce results of the most disastrous character to the science. In these rocks, observed by Mr. Geikie in the very process of change from sedimentary sand and mud into what were imagined to be fused masses slowly cooled down and crystallized under pressure, but which are now seen to be simply changed masses becoming trap and granite before the observer's eyes, the very chief of geologists seem not to have even the ghost of an idea as to the power which is effecting the change. Take, for example, a piece of the undoubtedly aqueous rock before it has become changed, and a piece of the trap into which it has been changed;—here are two "facts," and what is the relation of the one to the other? The one kind of rock has passed into the other;—but how has the change been effected? Geology cannot tell. Why so? Because a force is at work which has been ignored. It has been thought of only by "heretics"!

In explaining the present mineral constitution of the varied strata, there are still, as we have said, only two great agencies recognized in any adequate degree. These are fire and water. *Igneous* and *aqueous* influences are the only ones that are allowed prominently to occupy the mind, while the best writers describe what is believed to be the origin of rocks as they now appear in the earth. The wearing down of strata, with the consequent formation of sedimentary beds by means of water, and the alteration of these sedimentary strata, by heat, under great pressure, seem to have filled the scientific mind, as if almost no other forces existed in nature. Playfair speaks decisively on this point. He says, "In Dr. Hutton's system water is first employed to deposit and arrange, and then fire to consolidate, mineralize, and lastly to elevate the strata; but with respect to the unstratified or crystallized substances, the action of fire only is recognized."* Hutton has been followed with wonderful docility by most of our popular geologists. Hence fire and water are still the only great acknowledged forces. Chemical changes, so far as they are aqueous, that is, so far as they occur through water, are recognized. The electrical force, which is surely more than equal to heat, on the one hand, and to all aqueous forces on the other—more than equal indeed to both combined—seems lost sight of. I should think that it will readily be admitted that the altering power of the electric current is greater than that of either heat or

* Playfair's *Illustrations*, p. 131.

chemical affinity, so far as that is found in igneous or aqueous agencies. It is more powerful than pressure, or heat under pressure, or hydraulic force, or anything else yet known in material changes. Yet this most inscrutable of all forces seems scarcely thought of in relation to the transformation of rocks. Must not speculations on the effects of force, which leave out of calculatiou the most powerful force of all that is known in physics, be radically defective and misleading? Is it not this neglect which leads geologists so often into the gross error of imagining that even stagnation itself will issue in the most magnificent changes, if it is only allowed sufficient *time?*

But the same defect is visible in the utterly inadequate accounts given of the positions of strata. The only upheaving force thought of is *heat,* and the only degrading force is *water.* In upheaval, water in the form of steam is thought of so far, but that only as it is, like the rocks themselves, affected by heat. Hydraulic force seems scarcely thought of, nor is that force fully considered, whatever it is, which makes water the parent of fire. Take a ship-load of burnt limestone, and let into the hold only a small portion of water, the result is fire, and a resistless rending and destruction of the vessel. So far as volcanic fires are concerned, there seems enough in this "chemical affinity," as it is called, to account for them, were it not for the associated earthquake. The shock of that seems to us to travel much too far to be accounted for by anything but electricity. The force which shakes the solid crust of the globe throughout an area of two hundred miles in breadth, and as much as fifteen hundred miles in length, cannot, I humbly think, be referred on any reasonable principle, either to the agency of fire or to that of chemical change. No development of force has any likeness to that required for such an effect, but such as we see in electricity. That strata should be rent and changed in mineral constitution, by a force that can affect the globe in this way, seems at least like reason, and it does not call for the *time* so anxiously prayed for by the fashion of the present geological day.

But there is a more important defect to notice in relation to the positions of strata. We naturally inquire where the subsiding masses that are said to sink down into or through the earth's "crust" are "stowed away." And how are the spaces out of which Alps and Andes, and even continents rise, so filled up as to support such burdens? The conglomerate which lies below the Laurentian limestone contains, as we

have seen, pebbles of sand-rock which must have come from older strata than that conglomerate itself. But we have no sign as to the nature of that rock on which the older strata were laid down. In popular geology, with its vertical upheavals, we have no provision for anything below, that could sustain the now raised sea-bed on which these pebbles were strewed. Heat is only a state of matter analogous to motion, and to have the heat we must have something to be heated; but as at present taught, we lack this actual substrate which is so indispensable. The truth is, we are worse off than Archimedes when he would have moved the world: we have neither fulcrum nor lever! Then we are taught to believe in masses equally great, that sink down without our getting any idea of unoccupied space below. Even molten matter requires space, but the molten character of the inner centre is now seen to be a "myth;" and how to account for the subsidence of vast continents is as difficult, if not more difficult, than to account for their upheaval. There is one among some other curious exceptions to this vertical rule which we have noticed in Sir Charles Lyell's explanation of the position of a mass of gneiss 1,000 feet thick and 15,000 feet long, which he found in the Alps "not only resting upon, but also again covered by strata containing oolitic fossils."* He supposes "great solid wedges of intrusive gneiss to have been forced in laterally between strata," to which he found them to be in many sections unconformable. This is a great step out of the usual road of movement. It is amusing to see how happy many great minds are in their enjoyment of vertical motion alone. Their sea-beds sink to nowhere, and their mountains and continents rise from nowhere; but they themselves are not troubled with the incongruity in the dream! Is it not possible that there may be a horizontal motion of the earth's surface? May not the travelling of Icelandic snows bear some analogy to the changing position of the masses of the earth's surface? It is surely more philosophical to speculate with the greatest of all natural forces and the only possible direction of motion in view, than to leave them out of sight, imagining vast effects without adequate causes, risings without lever or fulcrum, sinkings without empty space below, and when difficulty is hinted, merely to pray for *time!* But like all else that is really fundamental in popular geology, this vertical upheaval

* Lyell's *Elements of Geology*, edition 1866, p. 752. This whole passage in one of Sir Charles's latest editions is strikingly indicative of confusion of idea as to the nature and position of the strata on which he is remarking; however unpardonable it may be in us to think so.

and subsidence is passing from the scientific mind. It too is doomed.

The latest ideas of upheaval and subsidence entertained in what may be called "head-quarters" in this science, are stated by Professor Ramsay, in his address already quoted. He says, "There, in the Alps, we find areas half as large as an English county, in which a whole series of formations has been turned upside down. But by what means were masses of strata many thousands of feet thick bent and contorted, and raised into the air, so as to produce such results, and thus affording matter for the elements to work upon? Not by igneous or other pressure and upheaval from below; for that would *stretch* instead of *crumpling* the strata in the manner in which we find them, in great mountain chains like the Alps, or in less disturbed groups like those of the Highlands, Wales, and Cumberland, which are only fragments of older mountain-ranges; but perhaps, as some have supposed, from the radiation from the earth of heat into space, producing gradually a marked shrinkage of the earth's hardened crust."* Again, he speaks of the formation of mountain-chains by "direct igneous action operating from below," as an old-fashioned idea which he wonders to see produced in memoirs of even well-informed writers now, and thus he leads on to the new theory of a "shrinkage of the earth's hardened crust." He does not say how this *shrinkage* and *crumpling* were produced. He only speaks of the radiation of heat as that which "some have supposed;" and in regard to the formation of gneiss and granite, he says frankly, as to how they were produced, he "cannot tell;" only he imagines that somehow the means must have been heat! This launches the hypothesis of a shrinking crust on the sea of willing speculation; but by "the law of continuity," which has so ruled the race of theories from the beginning till now, ought we not to expect that "*shrinkage*" will, perhaps, by the time the British Association meets again, have given place to a successor? Surely when we recollect that the lowest stratum yet discovered in the formation of the globe is one from water, which gives no sign whatever of *shrinkage*, it requires a very bold stroke of fancy to imagine that such a thing is to account for the mighty disturbance evident even in the Alps themselves. Who, then, can contemplate the real state of speculative geology, as we are thus finding it in its very foundations, without seeing that its great leaders are completely adrift, and that without either chart or compass by which to steer? We have been kindly told, not to be afraid of the effect which this science may have

* *Geological Magazine* for November 1st, 1866, p. 510.

on religion. We hope it is understood that our fear has never arisen from its truthfulness. But false speculations are to be feared.

It may be the highest presumption in us to allow the thought to enter our minds, yet we cannot help thinking that the bewilderment of our geological guides may be in a great measure traced to one fallacy. They seem to think that it is impossible that a stratum of rock could have been formed anywhere else on the earth's surface than where it now lies. Although we have seen that a whole formation, half as large as an English county, has been turned literally upside down, it seems, according to current ideas, that this remarkable revolution *must have* taken place on the spot above which the strata of this formation were originally deposited. Upheaval and subsidence being the only recognized movements of the earth's surface, the transportation of such masses from one latitude or longitude to another, is not to be thought of! It is, however, extremely difficult for one who looks at the subject from a common-sense point of view, to imagine the mass of rock forming half an English county turned over, so that it would lie upside down over the same portion of terrestrial surface on which it lay before; but if such a mass might change its place, so that its latitude or longitude, or both, should no longer be the same as they were, it is hard to see how the British Isles themselves might not also change their place. But such change of place at once introduces the idea of a change of climate, and that again a change of the plants and animals inhabiting the transported region. Alterations of climate have been generally accounted for by referring to changes in the atmosphere arising from new directions of the oceanic currents, or changes of sea into land, or of land into sea. But such changes could never account adequately for the plants and animals of a tropical climate that are found embedded in the rocks even of England itself. Winds passing over burning deserts, and the Gulf Stream passing more directly northward, might modify the climate greatly; but with the relation of the sun and surface, as it stands, they could never account for the fossils that are found in the North now. The case is very different with the view to which I am now calling attention. For example, when we have satisfactory evidence that a climate like that of Egypt once affected the life of England, and that a change from Egyptian heat to our present climate has extinguished certain species that now live only in the Nile, or in rivers of distant lands, we are free to ask whether this change is the result of an alteration in the atmosphere of England, considered in its rela-

tion to the terrestrial surface only, or of an altered position of England in relation to the sun. I am aware that I am suggesting a "heresy" for which Mr. Evan Hopkins is responsible now for some twenty years; but surely the fact that an idea has been condemned as "heretical" can be no drawback to it among truly scientific men.* The idea is forced upon us, not by the weight of any name, unless it be that of Professor Ramsay. His facts and his bewilderment, when meditating among those old Alps, seem to urge us to accept the idea. His observed *crumpling* cannot be explained by his suggested *shrinkage*—of that we are sure. It can be explained by a lateral motion of the earth's unequal surface—of that we are as sure. How could *shrinkage* lay half an English county flat on its back? A force sufficiently powerful, pushing the mass along among other masses, might accomplish such an overturn. That force whose shiverings shake the solid globe at once over even 1,500 miles, when at its steady, earnest work, is more than enough to lay England itself, if not upside down, at least on a new and distant bed in the course of years. We do not say that this view is infallibly right, nor can we say that it is wrong; but we certainly think that the progress of Descriptive Geology shuts us up to some doctrine of lateral movement in the surface of the globe, if we would allow our physical principles to keep pace with discovery. Its rejection by geologists, combined with the necessity for some such explanatory force, is another powerful proof that the science we have in hand is loose in an extreme degree in its fundamental principles. As it now stands, no one can say what its doctrine as to the real character of strata, or as to their superposition, may be to-morrow. It is, in these essential principles, in a state of perfect indecision, and ready, like a vane in the wind, to turn itself to any current that may blow.

But it is equally clear that a thoroughly unsettled state of mind prevails among speculative geologists as to organic remains. We have already seen how important are the discoveries that men have thought they had made in this direction. Sir Roderick Murchison especially lays great stress on the idea of successive creations in the peopling of the globe, and those who take very different views from his are almost equally interested in progression. It is clear, however, that discovery of great importance is threatening the science in the direction of its doctrine as to these organic remains. The writer of the

* See *Geology and Terrestrial Magnetism*, by Evan Hopkins, C.E., F.G.S. third edition, 1865; a book worthy of earnest study.

first article in the *Geological Magazine* for 1865, from which I have already quoted, in asking the question, "Have we got back to the first of earth's created beings?" and replying "That is not for us to say," concludes his remarks with these words: "Judging from analogy, then, the Eozoön rock of Canada was the foraminiferous formation in one part of an ocean which elsewhere may have borne manifold and higher species, and buried them in sands and muds, that have since lost all form and feature by the metamorphism of age and pressure, or which were altogether shorn away by wave and weather when the old ocean-bed was lifted up."* Nothing can be more evident than that language such as this expresses bewilderment in fundamental thought, such as prepares men for any change. The theory of progression, as it has been called, is sick and ready to die. That is, not merely Darwin's notion of the transmutation of species, but the theory of a gradual evolution of higher forms, either by creations or transmutations. The grand, general idea, that the production of man formed the last step in an inconceivably long chain of development, which rose from a low first link fastened on somewhere to a piece of "fundamental granite," is expiring! If "manifold and higher species" might live in the ocean at the time of the Eozoön, why might not manifold and higher species live also on land? And if higher species, why not the highest? Here we ask our guide, if he knows the road beyond? and he replies, "No, gentlemen, we are off the track. I see no path either behind or ahead!" Such is Geological Science in one of its grandest features at the present hour. Pressed to speak as to even the way to light, it can tell us simply nothing. So we must think for ourselves.

If, then, we give up the merely vertical movement of upheaval and subsidence, with latitude maintained, and believe that since half an English county could be turned over like a turf on its grassy side, any number of such formations could be pushed along from tropical to temperate and thence to arctic positions on the great globe, we have, at least, *one line of thought* marked off, by which changes of climate, and all consequent changes of species, may ultimately be accounted for. We have also that in view, of which the sickly theory of progression, as it has been held by geologists, may be allowed to die, and the doctrine of creation, as taught us through Moses, may be seen in its proper scientific light.

As a fuller illustration of what we mean, we must direct

* *Geological Magazine*, January, 1865, p. 3.

the most earnest attention to some of the very thoroughly ascertained facts of geology. We observe that Sir Charles Lyell says: "Mr. [now Dr.] Bowerbank, in a valuable publication on the fossil fruits and seeds of the island of Sheppey, near London, has described no less than thirteen fruits of palms of the recent type *Nipa*, now only found in the Molucca and Philippine Islands, and in Bengal." He says also, that "the teeth and bones of crocodiles and turtles" are found here, with other relics of an unquestionably tropical character. Here then fairly occurs the question as to whether all these undoubtedly tropical productions and living creatures grew in the present latitude of London; or have the relics of a truly tropical situation been transported northward by the removal of the strata in which they were entombed? Certain minor causes might, perhaps, account adequately for a milder climate prevailing in England, or in its latitude, than even that which is produced by the Gulf-stream now. But it is impossible, apart from the vertical rays of a tropical sun, to account for the richest results of a tropical clime; and the very richest are entombed in the London clay. Is it not evident that this clay was formed within the tropics, and that somehow it has been removed, until it lies in our northern latitude? And is it not this removal alone that can account for the difference between its climatal character and that of the beds of sediment now forming in the Thames? But if such is the account to be given of changes in climate, we must recast our ideas of the extinction of species, and alter our views of what is called geological time. The shutting off of the warm waters of the great Atlantic current from our shores might bring a glacial period over Britain; but as we know, the letting on of those waters would not give us the heat of Bengal. No raising or sinking of the surface, which could be conceived, could give us the effects of the direct radiance of a tropical sun without those rays themselves. But the removal of the abodes of tropical creatures from under tropical skies is abundantly sufficient to account for their extinction or emigration from the portion of the earth's surface so removed; and it requires only, that we should be able to form some true idea of the time consumed in this removal, in order to our coming somewhat near the date of the extinctions and emigrations which the records of the rocks disclose.

It is at this point that we are, as it were, compelled to look into current astronomy, where that science has been called in to account for changes on the surface of the earth. And here, too, we must distinguish between practical and physical science. Because astronomers predict, to the fraction of a

second, when an eclipse will occur, if it should be thousands of years hence, it is taken for granted that all they teach must be true! But while a child may look to the dial of a time-piece, and tell us to a second when the pointer will cover a certain mark, not one among ten thousand of grown men can go behind the dial, and explain how the causes operate by which the hands or pointers are moved. So may a very poor thinker calculate the time of a transit, or an eclipse, while the loftiest intellect becomes bewildered, and is lost in trying to prove even the existence of those forces on the reality of which the fundamental doctrines of physical astronomy depend. The noblest minds are overtaxed when honestly attempting to tell us whether there is such a thing as centrifugal force, and what it really is, which is called "gravitation." No one has gone behind the scenes, and seen how the highest authorities in astronomy are situated, without seeing that the physics of this science are as unsettled and uncertain as those of geology itself. But we gladly look into its teachings notwithstanding.

Mr. Croll, of the Glasgow Andersonian University, has presented the world of science with the best phase of one of the most interesting of all theories from this quarter.* Sir Charles Lyell has given Mr. Croll great credit for his labours in this matter, as one who has pointed out a *real cause* hitherto neglected in the calculations of geologists; and although we cannot accept the conclusions at which he arrives, we must acknowledge our admiration of this writer. His idea, in essence, may be briefly stated. Our globe in being carried round the sun, as modern astronomy teaches, has a path which is not a circle, but an ellipse. This, of itself, causes the earth to be nearer the sun in certain parts of its orbit, and farther away in others. But this elliptical path of the earth does not always maintain the same relation to the sun as a centre; it changes continually, and in the course of time, the aggregate of change is very considerable. At one time, the earth, at its nearest approach to the sun, is vastly nearer, and, at its farthest departure, vastly farther from that source of heat than it is at other times. The difference, as it is calculated by astronomers, is expressed in millions of miles. This element alone, however, would not give us any reason which could account for a change of temperature on the surface of the globe, because the motion of the earth being quickened in proportion to the nearness of its path to the sun, the amount of heat which it receives is the same when it is nearest as when

* See the *Reader* for October 14th and December 2nd and 9th, 1864; also *Philosophical Magazine*, 1866, pp. 26, 27, 28, and 30.

it is farthest from the solar centre. But there is another element which combines with what is called the eccentricity of the orbit. Winter and summer are not caused by our being farther from the sun in the one than in the other; but by that motion of the earth which shortens, or, as we may say of polar regions, blots out the winter's day, and lengthens the day of summer. In polar latitudes, the sun shines on the surface of the globe during the whole twenty-four hours of the summer's day, and is not seen at all in winter. It is on the effect of this, which arises from the turning away of the polar surface from the sun, that Mr. Croll chiefly depends for the proof of his theory. The radiations of heat must be excessive from the polar surface, when it is dark and at its greatest distance from the sun—when, too, because of its slow motion, its winter is at the longest. This loss of heat (as Mr. Croll argues) will not be compensated by the sun's nearness in summer; for the shortness of that season, from the swiftness of the earth's motion, in proportion to the length of the winter, will prevent all that would otherwise make the summer warm. Put, then, these two things together—let the northern winter occur when the earth is farthest from the sun, and, consequently, the summer when it is nearest—the winter will then be excessively severe, and the short summer, not even usually warm. This, Mr. Croll thinks, will cause a glacial period over great part of the northern hemisphere. Now, let the case be reversed—the short winter occurs when the earth is nearest the sun in space, and the long summer when it is farthest away. The consequence of this will be greatly lessened radiation in winter, and the equalizing, to a great extent, of that season and the summer in northern regions. These opposite combinations of the earth's position, in relation to the source of heat, account, according to this view, for regularly recurring periods of extreme winter cold, combined with proportionally small summer heat, such as will fail to melt the winter snow, and periods when the summer and winter are lost in constant spring. Could we confine our reasoning to astronomical theory, and leave out other considerations of a geographical nature, Mr. Croll would, we think, make out a pretty strong case by his argument for a "*glacial period*," during the time when the winter occurs at our greatest distance from the sun. But this is not the problem which is of greatest importance, as we are constrained to view the case, —that has respect to a hot climate sufficient for palms and turtles in our northern latitude. Mr. Croll does not attempt to make out this. He has difficulty in making out a period fit even for the *ferns* of the coal-measures, when winter occurs

at our nearest to the sun in the earth's eccentric orbit. He argues only for a "perpetual spring." His mean temperature, calculated for Great Britain, is only 60° F. This, he argues, must have been the summer and winter heat, with scarcely any variation, in the Carboniferous period. But, as we have seen, geology calls for the climate of the hottest parts of India, an equatorial climate whose mean heat is 81°. What we want is, at least, a *tropical* climate in the latitude of London—a climate very different indeed from that which, even according to revised ideas, could suit the vegetation of the Coal period. In thinking of the possibilities of such a climate in the North, it is necessary to keep in mind the truth to which we have already referred, that the length of the polar summer's day, though giving great advantage in the reception of heat by the constantly enlightened parts, presents only a *slanting* face to the sun, and so can never account for the heat and other effects which flow from the vertical radiance of Bengal. Sir Charles Lyell, in criticising Mr. Croll's theory, quotes from the *Encyclopædia Britannica*, the results of the reasoning there given in the article on *climate*. It is to the effect that the sun's rays passing through the atmosphere, so as to fall on the earth's surface at the equator, give 115° of heat, for 51° given in latitude 45° south or north, and for 14° given at either pole.* The latitude of the London clay is 51° 30′ N. The radiance of the sun, which gives 115° F. at the equator, and gives only 51° as far as 45° north latitude, is required to give an equatorial heat more than six degrees further north than where it can give only 51°. How will Mr. Croll, or any one else, make this out, and so explain on this theory the tropical remains in the isle of Sheppey? Yet this is that for which an account is required as the facts of geology stand.

The remains which, as we have seen, are imbedded in the London clay and kindred formations, are such that nothing short of the sun's vertical radiance will account for them. Dr. Hook saw this as early as 1688, and although his idea has been scouted, it is not on that account the less true. But, in addition to all this, any one who has had to do with the growth of palms and other tropical plants in this country, knows that it is not so much want of heat which renders it impossible to grow them satisfactorily, nor is it the want of moisture. These can be supplied; but what we lack is the sun's tropical radiance. Sunshine means much more than mere heat. How to show that this ever fell on the

* Lyell's *Principles of Geology*, vol. i., edition 1867, p. 284.

earth, in such a latitude as that of Britain, as it falls now in India, and raised even the ocean to a temperature such as that of the Indian Ocean now, is the problem which we think astronomy, as generally understood, cannot solve. Even if we grant the truth of the fundamental principles on which the calculations of the first philosophical astronomers of our time are based (and many competent thinkers will not grant so much), we are totally without anything in the popular teachings of the science that accounts in any degree for the facts of geology to which we refer.

In coming to a conclusion,* we are very forcibly reminded of a saying of one great man of science, which has been quoted and applied to a special idea by another of nearly equal standing. We direct attention to it, because it falls so signally short of the whole truth, and yet so faithfully represents a part of that truth. It fails to express that very thought which is of greatest moment as science stands at the present day. Agassiz has said, "that whenever a new and startling fact is brought to light in science, people first say, 'It is not true;' then, 'It is contrary to religion;' and, lastly, that 'Everybody knew it before.' Sir Charles Lyell quotes this in reference to the idea of the former existence of man with many extinct mammalia, holding that this, which he seems to regard as a "fact," has gone through all the three stages spoken of by Agassiz, at least so far as practical geologists are concerned. This idea of the coexistence of men with mammoths, it is important to observe is *not* a FACT, even if perfectly true. It is only an inference, at best, perhaps a theory by which certain facts are partially explained. So far as this matter of coexistence of man with extinct species of animals is concerned, we are not anxious as to what may prove to be its ultimate development. We refer to it at present only in connection with the idea of the *three* stages through which Agassiz said a new and startling fact passes. Such "facts" are often only theories, and we think we have given abundant evidence that the law of such things in geology calls for a *fourth* stage, which follows the three thus mentioned. In this fourth stage, "people" believe and teach the startling doctrine for a generation or two, and then find out that they have been all the while thoroughly deceived! Let any one pass carefully over the ground at which we have but glanced in this paper, and then let him say if the vast

* In preparing this paper I have left out of sight not a few of the speculations by which geology has come into conflict with the Bible, partly because moderate limits had to be studied, and also because I was desirous not to repeat here what I have published already.

majority of ideas that have prevailed in the geological mind have not passed already through all these *four* stages.

What, then, are the relations of geological science, as popularly understood, to the Sacred Scriptures? They are the relations of that which in its fundamental principles has been changing, we might almost say, every hour of its history, to that which has passed down through thousands of years, running the gauntlet between the ranks of ten thousand times ten thousand assailants, remaining unchanged and even untouched to the present moment. So far as the facts and certain inferences of geology are concerned, they do not in any degree affect the Sacred Scriptures. The vast ages that have been made to occupy the minds of men when thinking of the world's history, and are now multiplied into endless millions of years, belong all to that conjectural thought which, as we have seen, is so perpetually changing. Few things are so fitted to humble us as an honest admission of our weakness under the influence of this. Men have thought that they were forced to remodel their ideas of the word of God, and even to abandon the belief of its Divine inspiration, by the force of that which turns out to be only a shifting dream! So we see the wisdom of those who have said to us, as they held back themselves, "Allow your Bibles to remain as they are; wait awhile, till it is seen what these speculations are worth. We have been too often misled by such conjecturings to be in any hurry to acknowledge their weight." And we see now our own well-meant folly, mingling with that of many others, in labouring to construct Scriptural theories that might harmonize with the passing visions of the scientific mind. As the men of science and the men of Scripture—the geologists and the theologians—awake together from their reveries, it seems as if it were to find, as we have already hinted, that the teachings of Moses regarding the world's uprearing are, after all, the grandly comprehensive truth—in very deed the Word of the Living God.

The CHAIRMAN.—It would be a mere idle form for me to ask you for a vote of thanks to Professor Kirk for the interesting and valuable paper he has just read. I am sure no one who has heard it found it too long; our only regret must be, that we had not the time to listen to, and Professor Kirk the physical power to have delivered, one double the length. There are few outsiders of Geology (as Professor Kirk has characterized himself) who have paid any attention to the subject, who will not feel that the Professor's greatest difficulty in writing his paper, must have been in selecting the few baseless theories he has spoken of this evening from among the many whose

fallacies he might have exposed. We have heard much about the difficulties of Revelation in regard to the progress of physical science, and particularly that of Geology. Professor Kirk has given us a very fair exposition of the difficulties of Geology itself, in its claim to be even an approximation to an exact science. When I have been pressed to reconcile Geology with Revelation, I have always said, Let us wait till Geology becomes established as a sound science; then, and not till then, need the theologian care to seek to reconcile the Bible with Geology. While the Professor was reading his paper, I felt what a vast field of facts he had also left untouched, simply because he had so recently brought them before the world in his admirable little book, *The Age of Man, geologically considered in its bearing on the Truths of the Bible.** The theory of man's great antiquity as an inhabitant of the earth, so well received in high geological quarters, and already crumbling so rapidly before the accumulation of new facts, has been so completely refuted in that work, that the Professor seems altogether to have passed the subject by in his paper. In saying all this, I cast no reflection on the pursuit of the real science of Geology. What we do protest most earnestly against is the present habit of neglecting the sound method of Baconian induction,—not only in the science of Geology, but in so many other sciences,—and attempting, by vague hypotheses, hastily built on a few facts, to get a short cut to truth, instead of pursuing the toilsome wearying work of collating and arranging facts irrespective of theory. When men had few facts to reason upon, such a process was excusable—now it is utterly inexcusable. Great as may be the mass of facts known to modern geologists, it sinks into insignificance, compared with what must be accumulated before we can pretend to say we have gathered together the materials necessary to construct a true science of Geology. Not only, as Professor Kirk has pointed out, do we only know a mere superficial scraping as it were of the structure of the globe, but how little do we know even of that! How small a portion of the earth's surface has been geologically mapped,—and even of that how little has been accurately done,—is admitted by our best geologists, who consider the geological map of our own country as falling far behind the present requirements of the science. When we reflect upon the grand and bold theories founded on knowledge so very superficial in respect to that which is necessary to found the science, we cannot be surprised that they should so rapidly fall into oblivion. Not only are the data wanting to construct Geology as a science, but we have to contend also with the difficulties of the problems it presents for solution. Its requirements are almost superhuman. To measure the chronology of given strata demands the skill of a profound mineralogist, and how many of these can we find among the ranks of the geologists? But to be a good mineralogist, implies also a considerable knowledge of chemistry and crystallography. You must have all this knowledge before you can interpret the nature of the material whose age you wish to determine. And even this will not carry you far. You must add to it a knowledge of the whole range of

* Jackson, Walford, and Hodder, 27, Paternoster Row, London.

natural history, of comparative anatomy, and comparative physiology, before you can interpret the palæontological facts of your strata. Then some other condition may call for all the powers of mathematics to solve some dynamical portion of your problem. And as if all this were not enough, Professor Kirk has shown us that we must ask the aid of the science of Electricity. There has been much boasting lately about the connection of the Old World with the New by the electric chain ; and it is a feat of which science may well be proud. But the earth-currents and magnetic storms which affect that cable, give us a glimpse of the important part which electricity may play in the changing structure of the globe. When we consider the vast requirements, the vast amount of knowledge a man must bring to bear, in order rightly to interpret geological facts when he has discovered them, we need not wonder that blunders should be committed. We do not complain of the blunders, but we do complain of the tone of infallibility some men assume, and the absence of that modest humility so requisite in the pursuit of truth. Compare Geology with Astronomy, and you will find that the solution of the problems which has raised the latter almost to the rank of an exact science, is a far easier task than those with which the geologist is called upon to grapple. Professor Kirk has asked us, "What do you know about gravitation ?" You cannot tell what it is. Newton did not profess to know. It was to him the name of an unknown force ; though in his modest queries he seems to consider it not an inherent property of matter, but something external to it. What is the problem of the astronomer ? It deals with the motion of bodies under the influence of this unknown force. Even here the imperfection of our mathematical analysis shows itself. We can only deal with three bodies at a time. And even then, were the problem not simplified by assuming the absence of an appreciable resisting medium, and many other favourable conditions I cannot now enter into, we could neither establish the lunar nor planetary theory. If such difficulties beset the establishment of the comparatively easy science of Physical Astronomy, surely modesty must be most becoming in dealing with the far more abstruse problems of Geology,—a science in my estimation requiring not only a more gigantic intellect than that of Newton, but an age equal to the patriarchs of old, for the sound solution of some of its easiest problems. I need now only express our deepest obligations to Professor Kirk for the valuable instruction he has given us.

The Meeting then adjourned.