JOBERT'S
PHILOSOPHY OF GEOLOGY.

1/-

THE PHILOSOPHY

OF

G E O L O G Y.

BY

A. C. G. JOBERT,

Late Editor of the 'Journal de Géologie,' one of the Authors of 'Recherches sur les Ossemens Fossiles du Puy-de-Dôme.'

"We know all things begin from and end in His everlasting Essence, the Cause of causes, the Power of Powers."

SIR HUMPHRY DAVY

SECOND EDITION.

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TO

SIR RODERICK IMPEY MURCHISON,

V. P. R. S. and G. S., Hon. F. R. S. Ed., Hon. Mem. R. I. Ac., Cor. Royal Inst. of France, President of the British Association for the Advancement of Science, &c.

My dear Sir Roderick,

The plan of this little book has been long sketched, but the conclusions have only been deduced after an attentive examination of the labours of the geologists, during the twelve years which have elapsed, since I fixed my residence in England. Your work on *Russia* has completed the information which was wanting to decide the great question of a general primitive basis. Before the publication of that work, I found it impossible to ground my conclusions on positive geological facts, though my opinion had for a long time previously been fixed, as to the *igneous* stratification of the gneiss and mica-

schist which form the superior part of the inorganic basis of the terrestrial globe.

Having studied in retirement, the ideas which I now offer to the public are the conscientious result of long meditation. In arranging them I have only yielded to the impulse of my own judgment, free from external considerations; and it was but after having again perused the manuscript, and remarking that your name appears, several times, almost in every chapter, that the idea occurred to me of inscribing the book to you, as an act of simple justice and a tribute of the sincere admiration and high esteem, with which

I remain,

My dear Sir Roderick,

Your very humble and obedient Servant,

THE AUTHOR.

LONDON, *January* 25, 1847.

PREFACE

TO THE SECOND EDITION.

In the preface to the first edition of this little book, I remarked, that "it was at first written partly in English and partly in French; and that having translated the French part into English, I intended to publish the whole in the latter language only; but I was so dissatisfied with my own translation, that I shrunk from the idea of making it the original work, and determined to publish the book in the French language also." Five hundred copies were printed both in French and in English; but I soon discovered that it would be very difficult to sell the French part through the usual channels of the book trade, viz.—with the assistance of the publishers, and by advertising only;—and being averse to the work being judged solely from the perusal of my English version, I had a number of prospectuses, containing an extract of the heads of chapters, circulated amongst the members of the principal scientific and literary societies of England. This succeeded beyond my expectations. After a few weeks' circulation, the prospectuses were returned

to me with names of subscribers for no less than three hundred and fifty copies, for both the English and French bound together. These, with the copies sent to newspapers and reviews, left only about one hundred copies of the English, which being advertised, were soon exhausted; and the demand of the trade rendered it necessary to publish the present edition.

After the publication of the First Part, the seventh edition of Mr. C. Lyell's 'Principles of Geology' made its appearance, and in this last edition the theory of *actual causes* is unreservedly and most strictly adhered to; so that the views which I have sketched in the present work are still more strongly contrasted with the doctrine of the eternity of the established order of nature. Thus, between the philosophy of *no creation = no creator* and that of a beginning of the world, through the *fiat* of the Almighty, every one has now a fair opportunity of judging and making a choice.

To the subscribers I return my most sincere thanks; and especially to those kind friends who headed the subscription list, and assisted me in the publication of the book, my gratitude is due. I hope it will be found that I have not laboured in vain, and that some beneficial result will follow from the diffusion of the doctrines which I maintain. The consciousness of having done good is the best reward of mental exertions.

PREFACE

TO THE FIRST EDITION.

This little book was at first written partly in English and partly in French. Having translated the French part into English, I intended to publish the whole in the latter language only; but I was so dissatisfied with my own translation, that I shrunk from the idea of making it the original work, and determined to publish the book in the French language also. Thus I have been reminded, that though now in the habit of clothing my thoughts in a foreign dress, the native forms have still the preponderance in my mind, and that, even when breathing the free air of hospitable England, I must not forget that I am still a Frenchman.

Geologists acquainted with the French language should procure in preference the French version, as it conveys a more accurate expression of my ideas, and critics should compare both texts.

London, July 13th, 1846.

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THE

PHILOSOPHY OF GEOLOGY.

CHAPTER I.

Doctrine of the Eternity of the actual Course of Nature examined and rejected—Idea of Causation—ought not to be founded only upon the observation of the Invariability of the Antecedent and the Consequent facts, in the actual order of Nature—Ocellus Lucanus—Diodorus Siculus—Dr. Brown—Refutation of the Theories and Doctrines of Dr. Hutton and Mr. Lyell—Idea of Space—Infinity of Space—Idea of Time—Encyclopædia Britannica—Lord Bacon—Cosmogonies—March of human Science.

§ 1.

ACCUSTOMED from our infancy to see natural events, or the motions of those objects which surround us, succeeding each other in a constant and regular order, days following days, seasons seasons, years years, in a word all the phenomena of the organic and inorganic world continually reproduced as two

correlative facts, the one *antecedent* the other *consequent;* the Philosophy which naturally presents itself to our mind is that the actual course of things has always been; that day has invariably followed night, night has followed day; that each species of plants or animals originates from parents similar to itself, whose type has existed from all eternity.

We must not, then, be surprised that this philosophy, although in opposition with the cosmogonies and the religious creeds of all nations, should have found followers in remote times, and formed one of the points of scholastic controversy amongst the ancient sages.

Ocellus Lucanus, who lived in the beginning of the fifth century A.C., appears to have been the first who undertook to demonstrate in a special treatise the eternity of the actual course of nature; his book is intitled, *Of the nature of the Universe:* and though these propositions do not appear to have been in favour amongst the Grecian philosophers of the centuries which followed, Diodorus, the Sicilian, who wrote about one hundred years before the

Christian era, tells us that they were discussed by naturalists and historians.

"De primo igitur hominum ortu, duæ apud summæ autoritatis physiologos et historicos sententiæ habentur. Alii enim horum, qui et ortus et interitus expertem esse mundum statuunt, hominum etiam genus ab æterno sine ullo generationis principio extitisse affirmant. Alii contra, qui et genitum hunc mundum, et corruptioni obnoxium esse censent, perinde atque illum, homines quoque certo tempore ortum consecutos asseverant."*

Nevertheless, it is a fact that the ancients have not overthrown O. Lucanus's doctrine by direct arguments; probably because science, in their time, and the abstract nature of their mode of reasoning, did not furnish them with precise facts to oppose it with success; and perhaps also because cosmogonic ideas were admitted *à priori*, as principles above discussion.

On the other hand, the systems of pure philosophy

* Diodori Siculi Bibliotheca, Lib. I.

which have succeeded each other down to our days, have, probably, for the same causes, likewise left undecided the question of the eternity of the established order of things. Moreover, in endeavouring to ground their systems upon the observation of actual facts, modern philosophers necessarily found it impossible to clear their general deductions from the simple, and apparently forcible conclusion, which results from a first insight into the phenomena of nature.

Thus, Dr. Brown, whose works may be considered as a *résumé* of the most logical and consistent views of modern philosophy, founding his arguments upon facts taken in the regular order of things, could only place, as did Lord Bacon two centuries before him, the idea of causation upon the basis of two facts in the constant relation of *Antecedent* and *Consequent.*

The following is a passage of his *Inquiry into the relation of Cause and Effect*, in which this justly celebrated philosopher explains his views with remarkable lucidity.

"It is this mere relation of uniform antecedent, so important, and so universally believed, which appears to constitute all that can be philosophically meant in the words power or causation, to whatever objects, material or spiritual, the words may be applied. If events had succeeded each other in perfect irregularity, such terms never would have been invented; but when the successions are believed to be in regular order, the importance of this regularity to all our wishes, and plans, and actions, has, of course, led to the employment of terms significant of the most valuable distinctions which we are physically able to make.

"We give the name of *Cause* to the object which we believe to be the invariable antecedent of a particular change; we give the name of *Effects* reciprocally to that invariable consequent; and the relation itself, when considered abstractedly, we denominate *Power* in the object that is the invariable antecedent, *Susceptibility* in the object that exhibits in its change the invariable consequent; we say of fire, that it has the power of melting metals; and of

metals, that they are susceptible of fusion by fire; that fire is the *cause* of the fusion, and the fusion the *effect* of the application of fire; but in all this variety of words we mean nothing more than our belief that when a solid metal is subjected, for a certain time, to the application of a strong heat, it will begin afterwards to exist in that different state which is termed liquidity; that, in all past time, in the same circumstances, it would have exhibited the same change, and that it will continue to do so in the same circumstances in all future time. We speak of two appearances which metals present; one before the application of fire, and the other after it; and a simple but universal relation of heat and metallic substances, with respect to these two appearances, is all that is expressed. A *Cause*, therefore, in the fullest definition which it philosophically admits, may be said to be that which immediately precedes any change, and which, existing at any time in similar circumstances, has been always and will be always, immediately followed by a similar change. Priority in the sequence observed, and invariableness

of antecedence in the past and future sequences supposed, are the elements combined in the notion of a cause."

It results from this statement that Dr. Brown considers the idea of *Causation* as originating from the simple relation of two facts so linked together that the first must, of necessity, be followed by the second, or, taking the reverse, that the existence of the second proves, from all evidence, the anterior existence of the former.

Now, this philosophy which follows from the observation of the phenomena belonging to the actual order of nature, and represents the idea of *Causation* as confined within the uniformity or the invariableness of the antecedent fact, entirely rejects all speculations on the origin of things, or, in other words, on that which may have preceded or begun the established order. The philosophical inferences drawn from this doctrine even conduct unavoidably to the system of the eternity of the established order; for if we apply them to the observation of the reproduction of organic beings, we shall never arrive

at any cause but the invariable antecedent of parental generation. It will be the same with the facts belonging to inanimate nature; thus, the consideration of the actual order of seasons will only lead us to the uniform antecedent and consequent of the motion of the earth in its present condition.

However, I hope I shall demonstrate in this book, that it is the aim and tendency of the attentive study of the phenomena of nature, taken in all their combinations, and of the careful examination of their details, not to confine the idea of causation to the appreciation of the relations between two isolated facts, but to pursue that idea, without pausing, in the general order according to which the phenomena succeed and have succeeded each other, either ascending indefinitely from a given fact to the anterior facts, or descending from the anterior fact to those which follow. And the most remarkable feature of the philosophy which results from this method, which modern science has invented, is, that it does not decide before-hand the questions of the *invariable antecedent* and the *invariable consequent*, but leaves

an open field to theory, and allows scientific speculations to remain in the condition of possibly tracing, in the past, facts out of the established course of things,—a beginning of the actual order of nature.

But the relation of cause and effect, as established by Dr. Brown's doctrine, is so deeply rooted in the basis of our ideas, that even eminent naturalists could not forbear adopting *primâ facie* the philosophy of the invariableness of the antecedent and consequent, and discarding, with a sort of disdain, the new speculations and the theoretical investigations towards which the character of recently collected facts forcibly directs our researches and meditations. The study of geology has therefore not only to surmount the obstacles which the deductions of the vulgar, and the preconceived systems of philosophers, have combined to oppose to its progress, but it has also to emancipate itself from the prejudices of men of science, of those even whose valuable labours are full of original observations, of precious facts painfully gathered, and whose only error, in our estimation, is that of attempting to adjust new

results to a decayed system, thus enveloping a science full of life in the shroud of death.

§ II.

Having adopted *à priori* the restricted signification of the idea of causation, such as we have considered it in the preceding section, Dr. Hutton, towards the end of the last century,* and Mr. Lyell, in our days, have been compelled to encompass philosophy within the circle of the invariableness of the antecedent and consequent facts; to withdraw from their investigations all speculation upon a first cause, and to study natural events with the preconceived notion that geology "is in nowise concerned with questions as to the origin of things."

According to the system of Hutton, the mineral strata which compose the basis of existing continents were formerly under the waters of the sea, and have been formed from the *débris* of anterior continents;

* It is however to be observed that Fuchsel, a German geologist, whose works are reviewed in the *Journal de Géologie*, was the first promoter of the theory of actual causes, as Sir H. De la Beche well remarks.

the strata which constituted these old continents themselves were the remains of strata belonging to continents still more ancient, whose materials had been also heaved up from the bosom of the waters; and thus *ad infinitum*.

The system of Hutton forms therefore a circle of eternal upraisings of strata manufactured in what he calls the *mineral regions* with the disintegrated materials of a more ancient order of strata previously upheaved. As to pristine consolidated matter, there is not a resting point to mark the beginning of its existence in the past. It is what Hutton explicitly declares in the conclusions which follow.

"Having in the natural history of this earth seen a succession of worlds, we may from this conclude that there is a system in nature; in like manner as from seeing revolutions of planets it is calculated that there is a system by which they are intended to continue those revolutions. But if the succession of worlds is established in the system of nature, it is in vain to look for any thing higher in the origin of the earth. The result, therefore, of our present inquiry

is, that we find no vestige of a beginning, no prospect of an end."*

Mr. Lyell, adopting the philosophy of Hutton—"that geology is in nowise concerned with questions as to the origin of things," contends in the first pages of his book, "that the most common and serious source of confusion arose from the notion that it was the business of geology to discover the mode in which the earth originated, or, as some imagined, to study the effects of those cosmological causes which were employed by the Author of nature to bring this planet out of a nascent and chaotic state into a more per-

* Dr. Hutton's *Dissertation on the Theory of the Earth*, 1795. Playfair has attempted to demonstrate that the doctrine of Hutton was not opposed to the belief of a creation, and remarks in defence of this philosopher, "that it was one thing to declare that we had *not yet* discovered the traces of a beginning, and another to deny that the earth ever had a beginning." But this is too indirect; for Hutton does not say that we have *not yet* discovered the traces of a beginning, which construction would lead us to suppose that we might some day discover these traces; on the contrary, he positively contends that *it is in vain to look for anything higher than the succession of worlds.*" This is significant enough; and if Hutton did not veil his meaning, his followers do him an injustice in endeavouring to obscure the transparency of his ideas.

fect and habitable condition." And he adds, "an attempt will be made in the sequel of this work to demonstrate that geology differs as widely from cosmogony, as speculations concerning the mode of the first creation of man differ from history."*

In answer to this, let us remark that the confusion, if it exists, has been introduced, not by the geologists who embrace in their investigations the question of a *First cause*, since the nature of the facts themselves has given rise to it; as it is impossible, for instance, to refuse examining whether organized beings have been created at a certain time, when a mass of facts are discovered which seem to prove that life has not existed from all eternity on the earth. The confusion is the consequence of the restricted signification which Mr. Lyell continues to attach to the idea of *causation*, at a time when science has introduced in this idea new elements which have extended its value and bearing.

The proposition that geology "differs widely from

* Principles, 6th ed., p. 5.

cosmogony" amounts to a dogmatic affirmation that the idea of *causation*, in reference to geological investigations, is bounded within the limits of the antecedent and the consequent facts; for the only difference which really subsists between Mr. Lyell's opinions and those of cosmogonist geologists is precisely that the latter put in question the invariableness of the antecedent fact, or reject this invariableness, tracing back or believing that they trace, through a succession of material facts, a time when the antecedent fact stops short, and the established order had no existence.

That "speculations concerning the mode of the first creation of man differ from history," is a proposition which will appear paradoxical to many, but it does not belong to geology. Since Mr. Lyell reproaches those geologists to whom he places himself in opposition, with having thrown confusion into the science. he ought to have combated them with clear and precise arguments. and established principles better fixed than those which can be deduced from such an enunciation as this:—

Geology differs from Cosmogony

as

Speculations on the Creation of Man differ from History.

Propositions like these are certainly better adapted to increase than to remove the confusion. Geology studies facts: these facts it classifies as well as it can, according to their natural order; and from this classification it results that the questions of the origin of the terrestrial globe and of the creation of man fall within its range; at least the majority of geologists think so. How is it, then, that in order to remove the confusion, Mr. Lyell breaks the straight line of science; and, instead of stating in direct terms the question whether geology differs from cosmogony and from speculations on the creation of man, he dismisses from the argument these latter speculations, simply averring that they differ from history? Is it not because the idea of causation, as understood by Mr. Lyell, to be deduced from the

doctrine of the invariableness of the antecedent and consequent, can no more be associated with the investigations upon the creation of man than with the cosmogonic question; and that in pursuing these investigations through the relations they may be supposed to have with history, he avoids the difficulty of proving by direct arguments that speculations concerning the creation of man do not fall within the range of geology?

In rejecting then from the science, inquiries concerning the origin of the earth and the creation of man, and establishing as a settled principle "the identity of the ancient and present system of terrestrial changes," Mr. Lyell has done nothing else but confine the idea of causation to the philosophy of the invariableness of the antecedent and consequent facts; and, for this reason, whenever geological facts are met with in opposition to this invariableness, and whenever these facts lead to the conclusion of a beginning, either in the organic or in the inorganic world, the philosophical results of this naturalist bear the stamp of his primitive error, and the legiti-

mate deductions, drawn from the observation of facts, are in opposition with his principles.

§ III.

However, notwithstanding his fundamental axiom of the eternity of the established order, which re-appears under various forms almost in every page of his book, and which we see enunciated at the beginning of chapter IX. in these terms: "the former changes of the earth belong to one uninterrupted series of physical events, governed by ordinary causes;" and even in opposing what he calls "popular (!) arguments from great vicissitudes of the organic creation in times past," Mr. Lyell finds it expedient to acknowledge a beginning of the human species. But as this admission brings him in contradiction with himself, and destroys the general harmony of his plan, he does his utmost to weaken its importance.

"Is not," says he, "the interference of the human species, it may be asked, such a deviation from the antecedent course of physical events, that the know-

ledge of such a fact tends to destroy all our confidence in the uniformity of the order of nature, both in regard to time past and future?" . . . .

"Now these objections would be unanswerable if adduced against one who was contending for the absolute uniformity, throughout all time, of the succession of sublunary events. If, for instance, he was disposed to indulge in the philosophical reveries of some Egyptian and Greek sects, who represented all the changes both of the moral and material world as repeated at distant intervals, so as to follow each other in their former connexion of place and time." . . . .

Then Mr. Lyell concludes—"the geologists, however, may condemn these tenets as absurd, *without* running into the opposite extreme, and *denying* that the order of nature has from the earliest periods been uniform in the same sense in which we believe it to be uniform at present, and expect it to remain in future."

It must be remarked here that the example upon which Mr. Lyell builds, has a very different bearing

from that which he lays down. The philosophy of the Egyptians and of the Greeks did not contend for an absolute uniformity throughout all times; on the contrary this philosophy, as well as that of the Hindoos, supposed periods of destruction and renovation of the world, followed by periods of repose; in other words, events breaking the uniformity and the regular order of nature; and although the ancients endeavoured to systematise these extraordinary events, they considered them as forming a series apart, intruding through the periods of absolute uniformity.

Giving to Mr. Lyell's argument a simple construction, it may be reduced to this:—

1st. He does not contend for the absolute uniformity of the succession of events.

2ndly. For instance, he condemns as absurd the creeds of the ancients who admitted the absolute uniformity of *the periods* of destruction and renovation of the world.

3rdly. He believes that the order of nature has from the earliest times been uniform, as it is at present, and that it will so remain in future.

Now, the argument is evidently defective, the example which forms the second part of the premiss does not quadrate with the first part: for if Mr. Lyell condemn the uniformity of the periods of destruction and renovation, it should be because he does not contend for the absolute uniformity of events, and recognises, therefore, periods of destruction and renovation *without* this uniformity, whilst, on the contrary, he believes in the constant uniformity of the actual order of nature.

The fallacy of this reasoning will be still more obvious if we suppress the second premiss; there will then remain two propositions in direct opposition to each other.

In the developements which follow, Mr. Lyell endeavours to lessen the importance of the introduction of the human species as a deviation from the established order of things. But his arguments appear to me so loose and so contradictory, that I must confess I find it impossible to analyze them with any method; and my attempts to reduce his propositions into syllogisms have been completely unavailing.

Towards the end of the chapter alluded to, Mr. Lyell confesses, in a manner, that the creation of man cannot be explained in his system; for he declares "that had he presumed to dogmatise respecting the absolute uniformity of the order of nature, he would be checked by witnessing this new and unexpected event, and would form a more just estimate of the limited range of the scheme of the universe." But, how can he pretend that he does not dogmatise, when he contends with Hutton "that geology is in nowise connected with the origin of things,"* when the doctrine taught in every page of his volumes rests upon the preconceived idea of the eternity of the established order, when, at last, in a special chapter,† he is so particularly intent on opposing what he calls the *prejudices which retard the progress of geology;* viz., "the belief in the want of conformity in the causes of changes, or the belief that the course of nature, in the earliest ages, differed from that now established."

* Page 6, Vol. i.

† Ch. V. Vol. i. p. 3.

But, what is most singular, and may justly excite a feeling of surprise in Mr. Lyell's reasoning, is his earnest endeavour to impress upon the mind of the reader that the new and *extraordinary circumstances* of the introduction of man are not of a *physical* but of a *moral* nature!

"When we speculate," says he, "on the vicissitudes of the animate and inanimate creation in former ages, we ought not to look for any anomalous result, unless where man has interfered, or unless clear indications appear of some *other moral source of temporary derangement.*"

Thus in fine, man, who by the strength of his organization, and the power of his intelligence, is brought into communion with all nature; is lord and ruler of all living beings on the earth; who, turning his eyes towards heaven, studies the laws which govern the motions of the stars, and contemplates them in the infinite space; who has measured and weighed the mass of the terrestrial globe and of the spheres revolving around; man, who calculates the speed of light, and traces, through centuries, the

motions of that imponderable fluid; who, multiplying the power of his organs, has acquainted himself with myriads of beings unperceived by his senses; and has discovered in the depth of space innumerable suns rolling beyond the reach of his unassisted sight; man, who, rapt in his ideas and meditating upon himself, regulates the inward movements of his imagination, and dares to consider his mind as a brilliant ray of the supreme and *omnilatent* light reflected in living and sentient creatures; man, whose species grows and developes itself as a *unique* being incessantly advancing towards a perfection to which no limit can be assigned; whose speculations embrace the origin of things and the principle of his own existence, is in Mr. Lyell's system isolated from the creation where he occupies the first rank, and considered by himself, alone, as an anomaly, a parasitical nonentity, a *moral source of temporary derangement*, as if he had not a real existence, and was nothing upon earth but an incomprehensible abstraction, an inexplicable accident!

What more is required to refute such a system,

than to put in an opposite scale a simple statement of the facts themselves, whose mutual dependence and connexion lead invincibly to the idea of a *design*, and show, in the creation of man, the key which crowns the vault of the organic edifice, and the final cause of all the changes which have brought the actual order of things, and completed, by the introduction of a being gifted with reason, the sublime picture of the harmonies of nature?

§ IV.

Answering the objections which his *principles* have raised, Mr. Lyell, in his conclusions endeavours to meet the reproach of assuming that there was never a beginning to the present order of things, and says emphatically; "in whatever direction we pursue our researches, whether in time or space, we discover *everywhere* the clear proofs of a creative intelligence, and of his foresight, wisdom, and power."

Let us remark, in the first place, that we have a right to ask *where* is this clear proof of a creative

power to be found in a system which does not admit of a creation, and how we can assume that there has really been a beginning? As Mr. Lyell does not say upon what ground this *clear proof* remains, his words must be taken only as a *moral* acknowledgment, in contradiction with the whole tenor of his system and the formal opinions expressed in every chapter of his book.

It is not without some repugnance that I come now to consider the questions of *Time* and *Space*,—questions which have raised so many futile and ridiculous controversies amongst theologians, philosophers, and metaphysicians; but it seems impossible to leave without an answer this last resource which the author of the *Principles* calls to the aid of his system.

Mr. Lyell's defence is, that the impossibility of arriving through observation at the limit of the material universe, is not an argument against the existence of this limit, and that, by analogy, the impossibility of finding a direct evidence of a beginning is not an argument against the probability of a be-

ginning. But this is expressed with a cautious and conditional if:* the author does not say how, and by what means, the conviction of a limit or of a beginning can enter our mind; on the contrary, he strenuously maintains, a few lines further, "that as we aspire in vain to assign limits to the works of creation *in space*, we are prepared to find that *in time also*

* "With equal justice might an astronomer be accused of asserting that the works of creation extended throughout infinite space, because he refuses to take for granted that the remotest stars now seen in the heavens are on the utmost verge of the material universe. Every improvement of the telescope has brought thousands of new worlds into view; and it would therefore be rash and unphilosophical to imagine that we already survey the whole extent of the vast scheme, or that it will ever be brought within the sphere of human observation.

"But no argument can be drawn from such premises in favour of the infinity of the space that has been filled with worlds; and if the material universe has any limits, it then follows that it must occupy a minute and infinitesimal point in infinite space.

"So, in tracing back the earth's history, we arrive at the monuments of events which may have happened millions of ages before our times; and if we still find no decided evidence of a commencement, yet the arguments from analogy in support of the probability of a beginning remain unshaken, &c." *Principles*, Vol. III. pp. 404, 405.

the confines of the universe lie beyond the reach of mortal ken."

However, because we do not find the limit of the works of creation which lie BEYOND *our reach in space*, it does not follow that we shall not be able to discover *as to time* the epoch of the creation of the worlds WITHIN *our reach in space.*

The idea of Space is intimately connected with the idea of Matter; it is the idea of Extensiveness considered in the abstract;* and Extensiveness is a quality of matter.

The idea of the Infinity of Space, if we sought to disengage it from the idea of extensiveness, and therefore from the idea of matter, would be absolutely negative, that is to say, it would no more be an idea.

Through our unassisted sight we discover, in the depth of the heavens, innumerable stars: the telescope multiplying the power of our eyes, shows us, beyond these nearer globes, others whose enfeebled

* It is the abstraction of a quality: and if we call a quality an abstraction, it will be the second degree of an abstraction, or the abstraction of an abstraction.

light appears to melt in the distance; imagination, under the guidance of analogy, leads us to suppose, beyond these latter worlds, other worlds again whose light, lost in immensity, will never reveal to us their real existence; and, beyond these, we still picture another more distant range, and worlds without end, in the same manner as we conceive series of numbers to which we can add other numbers without limit.* Such is the philosophical idea of infinity attached to space: if imagination placed a limit beyond which worlds do not exist, it would still suppose the existence of light or of some fluid upon which to settle itself; for if you subtract entirely from the idea of space or extensiveness the idea of matter, there remains nothing which could serve as a basis for an idea.†

* Numbers as well as lines are qualities of matter.

† Dr. Clark has said: "To set bounds to *space* is to suppose it bounded by something which itself takes up space, and that is a contradiction; or else that it is *bounded* by nothing, which is another contradiction." The argument will stand good if we say, to set bounds to *matter* is to suppose it bounded by something which takes up space, &c.

The idea of *Time* is produced by the observation of the succession of events: it is the idea of matter considered in another of its qualities, viz. *Motion*—its various moods.* The idea of *time* is therefore connected with the idea of space through the element common to both ideas,—*matter*. And in reality, it is only when space or when matter itself is beyond our reach that time can be assumed to be beyond our reach also. Therefore, to affirm in reference to the earth, or any heavenly body, that time is beyond our reach, is as inconsistent as it would be to say that such a star which we see, or the earth that we touch, is beyond our reach in space.

The fallacy of Mr. Lyell's defence consists in his attempting to establish an analogy between two dis-

* This simple and natural definition of time will, I hope, be accepted as preferable to far-fetched and incomprehensible metaphysical descriptions such as the following from the Encyclopædia Britannica: "Time can be nothing else than the relation of co-existence apprehended between things that are *permanent*, and those trains of the fleeting ideas which incessantly succeed each other on the theatre of imagination!" (Vol. XIII. p. 640).

tinctly independent ideas, the idea of inaccessible space and that of the movements of accessible matter.* Thus we are reminded of the aphorism of Lord Bacon:—

"Si notiones ipsæ confusæ sint, et temerè a rebus abstractæ; nihil in iis quæ superstruuntur est firmitudinis."†

§ v.

The learned author of the elaborate article PHILOSOPHY in the Encyclopædia Britannica, in reviewing Lord Bacon's works, and speaking of the general belief in the constant uniformity of the relation of cause and effect, expresses himself thus:—

"After all the labours of ingenious men to discover the foundation of this irresistible expectation, we must be contented with saying that such is the constitution of the human mind. It is an universal fact in human thought; and for any thing that has

* The error is of the class which Dr. J. S. Mill calls the fallacy of False Analogy. (*See J. S. Mill's System of Logic*, Vol. II. p. 421.)

† Novum Organum. Lib. prim. Aphorism XIV.

yet been discovered, it is an ultimate fact, not included in any other still more general."*

However, though the observation of the invariable relation of cause and effect must inevitably remain for ever the guide of our material actions, because it is the rule of nature in the present regular order of things, it cannot be urged on our mind as the extreme limit of our ideas; it cannot prevent philosophical speculations on the possibility of an order of things anterior to the present course of events, and to the very existence of our own species.

It must be remarked also that the general tendency to form cosmogonies, and the influence which the founders or promulgators of these systems of the world have exercised, at all times, on human societies, offer the most undeniable proof that the genius of man has long been in quest of a more universal generative fact, which should have the pre-eminence over the relations subsisting between events in the established order; and that all religions have been

* Encyclopædia Britannica, 6th ed., Vol. XVI. p. 1823.

founded upon the belief in a beginning of things, and the idea of a creation of the organized beings which inhabit the earth.

As the march of human science is progressive, it has necessarily begun with the study of the actual phenomena of nature. Inquiries into the past history of the world have only descended to the study of terrestrial events in modern times. Even in the beginning of this century there was not a sufficient number of facts collected for the establishment of a doctrine founded upon direct observations, which might revise and call in question the philosophy of the invariableness of cause and effect.

But these facts geology now furnishes, and after having begun its march from geogenic ideas, and passed through the requisite study of the phenomena of actual nature, philosophy will presently be found to have described a circle, and to have returned to the point marked by the primitive genius of man, and written in the form of a genesis at the head of all historical traditions. And this has happened in virtue of the new and notable fact, that in examining

the phenomena of the established order, science has discovered monuments of the past, hitherto unknown or misunderstood, and that it has begun to reconstruct the series of events which have succeeded each other on the earth, ascending from monuments to monuments, until it has reached the limits of a beginning and a creation, as taught *à priori* by the cosmogonic annals of all nations.

CHAPTER II.

General division of Rocks into Vulcanian and Neptunian. Granite—its igneous fusion. Error of Hutton and Mr. Lyell on its Metamorphic origin—Causes of this Error. Idea of infinity of Time.

§ 1.

THE mass of rocks, whose succession forms the observable part of the terrestrial envelope, naturally divides itself into two great groups. The first contains what we will call *Vulcanian Rocks*, because they are the result of the cooling of a mineral matter in igneous fusion.

The second comprehends the *Neptunian Rocks*. These have been formed in the bosom of the waters, and originate, in great part, from the *disintegration* of Vulcanian Rocks, whose fragments have been carried down into the seas by running waters.

Vulcanian Rocks contain no organic remains:

except such as they may have borrowed from pre-existing Neptunian strata.

Neptunian Rocks are often full of fossil relics of living beings, animals, or plants.

These two kinds of rocks have been produced at different periods, and are still conjointly produced in the present time. Thus lavas ejected by volcanoes, are Vulcanian Rocks; and the beds of sand, clay, and carbonate of lime, deposited in some lakes, accumulated near the mouth of rivers, or spread out on the bottom of seas, form Neptunian Rocks.

Of Vulcanian Rocks, the greatest part consists of granite: this rock is the basis of all others, not that it is every where accessible to our observations, but, when we once meet with it, we do not find under it any other species of rock, to whatever depth we may penetrate, unless it has overflowed on the surface, after having been injected through Neptunian strata, and in this case even it dips under the same strata. Granite, then, may be considered as the basis which supports all the other rocks, and forms the solid crust, or rather, if the expression be allowed, the shell of the terrestrial globe.

§ II.

The igneous origin of granite is now admitted as a fact beyond doubt by all geologists; but some, adopting the theoretical ideas of Hutton, think that this rock has passed through the state of clay and sand, which, like the secondary and tertiary stratified formations, contained fossil remains whose traces have been obliterated by fusion. Others consider the absence of organic remains in the granite as a primitive fact, and see in the consolidation of this rock the simple result of the cooling of the surface of the globe, originally in igneous fusion.

However, the hypothesis of Hutton is undoubtedly grounded upon a mere logical fallacy. All the argument rests upon the implicit admission of the existence of a solid primitive envelope as the generative fact. Thus, according to that hypothesis:—

Granite exists in a solid state.

It is broken and disintegrated in consequence of upheavings and abrasions; it is decomposed either by the agency of air and ambient liquids or fluids,

or by a moleculary reaction of its constituent elements.

These disintegrated parts are washed away by waters into the seas.

They are spread out in the form of regular strata at the bottom of these vast basins.

There they are seized by central agents, and reduced into a state of igneous fusion.

Lastly, they are again raised from the bosom of the seas, and return into a solid state to form new continents.

To give full scope to the argument, let us admit, for an instant, that the granite which now forms the basis of the solid envelope of the earth is in reality a recomposed granite, entirely similar to an anterior and more ancient granite; that it has been upheaved to the surface by central forces; in fine, that it becomes decomposed and passes through the various natural operations which have been described in the preceding lines. Now, suppose you repeat the decompositions, recompositions, and upheavings as often as you think proper, stretching the hypothesis to its

extreme limits; these repetitions cannot destroy the fundamental fact which forms the basis of the argument itself, viz. the *primitive existence in the solid state* of a granite or of a solid crust which has begun the series.

If you withdraw this generative fact, what will remain?

Sandstones and clays, the result of the decomposition of . . . . nothing!

I therefore do not hesitate to declare, however presumptuous this assertion may appear, that the famous theory of Hutton, which has become the stronghold of one half of the modern geologists and the stumbling block of the other half, a theory which reckons a great number of adherents amongst the most distinguished scientific men of the present time, is, after all, nothing but an error of Dialectics, a common fallacy,—what John Stuart Mill calls "a fallacy of confusion"—forgetting what the premises are or imply—a vulgar *petitio principii!*

The comparison, by analogy, between the motions of the terrestrial crust and the revolutions of planets

does not, besides, afford any support to this hypothesis; first, because, the eternity of the revolutions of the planets is a contested fact; and secondly, because, even granting this eternity, the concession does not imply the admission that the order now established at the surface has not had a beginning.

§ III.

That the actual granitic crust of the globe may be the result of a re-fusion of the disintegretated elements of an anterior granite, such as clays and sandstones, is a supposition which would never have been advanced if it had not formed the fundamental basis of Hutton's hypothesis; for if it had been perceived that even this supposition offers no support to the system of the eternity of the established order, inasmuch as it still leaves us under the necessity of admitting a primæval granite at some determinate period, it would have lost all its philosophical value. The supposition was suggested by the hypothesis, because the hypothesis could not subsist without the

supposition. If we demonstrate the fallacy of the hypothesis, the supposition falls to the ground.

Those who are convinced of the fallacy of Hutton's fundamental argument will not stop an instant at the intermediary supposition; they will simply consider the present granitic and gneissose terrestrial crust as the first solid envelope of the globe. Mr. Lyell's developments must neccessarily follow the fate of Hutton's theory, which he has in fact adopted.*

It is because Dr. Hutton and Mr. Lyell have confined their philosophy within the limits of the idea of Causation, deduced from the doctrine of the invariability of the antecedent and consequent facts, that they have been led to suppose an infinite repetition of two facts, viz.: the *destruction* and the *renovation* of the granite: there was, however, an imperative necessity (after remounting through all the intermediate facts) of admitting, as a starting point, the existence of a primæval solid crust before

* Elements of Geology, Vol. I. p. 17.

the decomposition of this same crust. Neglecting or losing sight of this starting point, these naturalists have implicitly admitted that the consequent fact (the destruction of the granite or solid crust) had preceded the antecedent or generative fact (the existence of the granite in the solid state); hence, and under the penalty of being absurd, they have been induced to superadd to the consequent fact a new antecedent fact similar to the primitive one; and repeating indefinitely this process, they have persuaded themselves that they had encompassed the idea of the infinity of time in a circle of events of one uniform kind, reproducing themselves in perpetuity.

But, the idea of Infinity united to that of Time is equivalent to the idea of the movements of matter, *in a continuous series*, without *a necessary connexion with the similarity of the antecedent fact*, or with the relations subsisting between the antecedent and the consequent facts in the actual order of things.

CHAPTER III.

Theory of the Stratification of Primitive Crystalline Rocks.

§ 1.

THE distinction established in the preceding chapter, between Vulcanian and Neptunian Rocks, does not in any way rest upon the phenomena of stratification; and, considered under a certain point of view, this distinction is purely nominal. Vulcanian Rocks frequently offer evidences of being disposed in strata; and these evidences are, according to all appearances, due to circumstances similar to those which have accompanied the deposition of the Neptunian strata. Water itself, diffused through the irregularities of the globe, is a mineral mass in *igneous* fusion under the habitual temperature of warm climates; in the state of rock in cold countries; it forms mountains, plains, and valleys; and sometimes, as in some parts of Siberia, regular strata

which, on a vast extent, compose the basis of the vegetable soil. The perfect stratification of the rocks deposited in water is due to the extreme mobility of this liquid, which allows the stony particles in suspension to precipitate with regularity on the bottom of a basin, thus separating from the mass which contains them, to form an isolated band in the inferior part. But it is evident that even in a liquid whose mobility is less than that of water, as in the substance of a melted granite, if there are parts which, in virtue of a greater mutual affinity, crystallize before the other parts, and if the specific gravity of the crystals in a state of formation is not exactly the same as that of the remainder of the melted matter, there will be a tendency of the mass to arrange itself upon horizontal planes, and to assume appearances more or less analogous to that of the strata deposited in water. Thus may be easily explained the stratification of the micaschist and of gneiss.

Quartz is less fusible than mica; mica less fusible than felspar.

The specific gravity of quartz is . .	2·6 to 2·7
That of felspar	2·54
That of mica	2· to 2·5*

Mica schist is composed of quartz and mica.

In a melted compound of quartzose and micaceous elements, where two kinds of specific affinities were developed together, the one having a tendency to produce crystals of quartz, the other crystals of mica; the mica being fusible at a degree of heat inferior to that of the quartz, the crystals of quartz must have begun to form first in the middle of the refrigerating

* I have adopted for these specific gravities the figures of Mr. Joshua Trimmer, (Practical Geology). For the felspar and quartz, the differences between the various valuations are very little; but it appears that the mica varies considerably; and perhaps these variations correspond with its composition. Mr. Boué estimates the specific gravity of this mineral from 2·94 to 3·: Moss, to 2·949, the Encyclopædia Britannica, from 2·79 to 2·93; whilst Mr. J. Trimmer gives the figure I make use of from 2· to 2·5. If these differences are real, far from being unfavourable to my hypothesis, they form an argument in support of it, inasmuch as they explain the variations, changes, and inversions in the arrangements of the bands of stratification: besides, they do not affect my deductions, which are founded upon the differences of specific gravity between the different species of crystals.

mass, and on account of their greater specific gravity they must have had a tendency to deposit themselves by sinking through the residue, which was to become mica. This tendency of the crystals to descend has been combated either by the great quantity of the crystals themselves, which produced an obstruction in the remaining cooling mass, and imprisoned it in their interstices, or by the viscosity, semi liquidity, or paste-like consistency of the residue ready to pass to the state of mica. And these circumstances have probably occasioned, in part, those little complicated contortions of the leaves of this last mineral which, to this day, have been a puzzle for geologists. This explanation, I think, furnishes a key by means of which we can easily account for the divisions in zones or parallel bands, and all the appearances and accidents of stratification, not only of the micaschist, but of gneiss and granite.

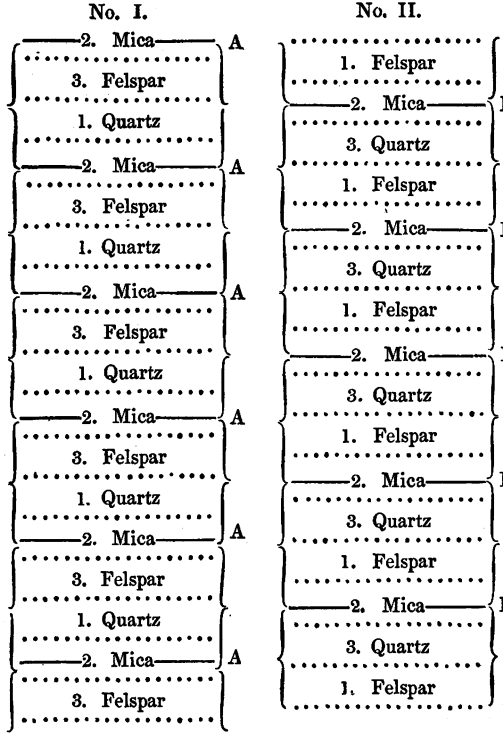
In gneiss, the quartz has begun the process of crystallization; the mica, on account of its greater lightness, had a tendency to rise, the quartz to sink; and where these minerals have been able to find their

way through the felspathic paste, and alter, upon certain lines or planes, the normal proportion of the three ingredients, the rock offers all the character of stratification.

The diagram, No. 1, shows what structure the gneiss must have taken, in the localities where the liquified mass could receive the double impress of the action of the specific relative gravity, and of the affinity or specific moleculary attraction of each of the three constituent parts.

The numbers 1, 2, 3, show the order of the passage to the solid state, according to the degree of fusibility.

Each band of mica (2), as it rose in the melted matter, must have joined the quartz (1) whose crystals, first formed, sank to the inferior part of the felspathic mass (3) which has thus become isolated. The cleavage *of stratification* will then be found in the infra-placed bands of mica A A A A A. Now this structure, indicated by the theory, is exactly that of the gneiss, when it is divided in well-defined little bands.



If we suppose that the specific gravity of the mica approaches 3, the crystals of quartz, formed first, will sink in the liquid, the mica will afterwards

deposit itself upon the quartz, while the felspar will occupy the superior series, as in Diagram No. 2; but in this case, as the specific gravity of the mica will have a tendency to place this mineral in the inferior part, whilst the crystals of quartz will have been the first formed, it may have happened that the motion of the crystals of quartz, when sinking in the mass, has been to a certain extent counterbalanced by the greater specific gravity of the mica, although the latter had only begun to form when the crystals of quartz had already acquired some developement. These two mineral species may then be found entangled between the felspathic bands, as is observed in the specimen figured by Mr. Lyell (p. 381, Elements, Vol. II.), where, however, the mica must be more abundant upon the lines of the cleavage of stratification.

When the gneiss is divided in thick strata, it is because the influences of moleculary attraction have prevailed through all the mass of the stratum, to the exclusion of the influences of specific gravity; and when these latter influences have been completely

neutralized, the entire mass has settled down in the unstratified state. And it is even easy to conceive how a partial influence of the specific gravity, upon a small scale, may on particular planes have divided masses of great thickness.

§ II.

The preceding speculations embrace the structure of all Vulcanian rocks. These rocks contain in their elementary composition the necessary conditions of stratification; and if these conditions, opposed by other influences, have acted in a few cases only, and in a confused manner, and upon particular lines, they do not the less suffice to explain those appearances which the disciples of Hutton regard as the marks of an anterior aqueous stratification, but which, in reality, cannot in any way be considered as a proof of the proto-Neptunian origin of primitive rocks.

As to the more or less irregularly granular form of the crystals of quartz and felspar, which is remarked in the gneiss and micaschist; I do not see the least reason to consider this form as the unoblite-

rated trace of an anterior fragmentary state. These appearances seem to me to result, first, from the irregular entangling, the displacement, and the grazing against each other of the crystals in formation, arising from the differences in specific gravity previously mentioned; and 2ndly, from the circumstances attending a more or less rapid refrigeration, which have occasioned a confused crystallization, and obliterated or effaced the angles and the edges of the crystals.

The opinion of the fragmentary origin of crystalline rocks appears to me to be contradicted by the condition of the mass of the gneiss and micaschists. It is impossible to explain the entanglement of the crystals, and the passages to the granitic, porphyritic, and compact structures, otherwise than by causes similar to those which have produced true granites; the only difference in the structure, between granite and gneiss, is the disposition of the latter in bands of stratification. It is not possible to draw a line of distinction between the granular appearance of the quartz and felspar in granite and in gneiss. In some granites, as in the porphyroid granite of the Ridge

of St. John's Vale, in Cumberland, the crystals of quartz are more regular, showing even perfect prisms with symmetrical pyramids, whilst the crystallization of the felspar is massive and confused; in others, the crystals of felspar are almost perfect, whilst the quartz has a granular appearance, owing to the obliteration of the angles and the edges of the crystals—a circumstance which is explained not by abrasion but by the confused crystallization of every crystal. In the granite of Shapfells (Cumberland), for instance, in which the crystals of felspar are so well developed, and where the mica sometimes shows distinctly its hexagonal plates, the quartz offers generally a granular appearance: one can scarcely perceive the sides of the prisms, and even then their surface is unequal and appears abraded, the angles are rounded and the pyramids have disappeared; in a word, all the mass of this porphyroid granite, with the exception of the large crystals of felspar, when examined with attention, offers this appearance, which has caused Professor J. Phillips, in his Treatise of Geology, to say that the mica and the quartz of gneiss are fragments, not

crystals. However, no one can doubt that the porphyroid granite of Shapfells is a Vulcanian rock, and there is no reason to refuse the same origin to the gneiss in which the grains of quartz offer the same appearances.

As to the scales of mica, if in gneiss their crystalline forms are less regular than in granite, it is because the crystals have been formed more rapidly, and have been subjected to inflexions determined by the action of specific gravity, and the pressure of the crystals of the quartz and the felspar. But these scales are far from offering the appearance of a fragmentary origin such as is remarked in flagstones; on the contrary, they are laid in plates sometimes of a large size, on the irregular protuberances formed by the crystals of quartz and felspar, and, folding and doubling in upon themselves, follow the undulations of the bands—undulations which Mr. J. Phillips explains by the agitation of the bottom of the sea, but which may be only traces of primitive tides on a matter in igneous fusion; tides which, according to Mr. Cordier, must have raised waves of 15 or 20 feet high.

Besides, there is no reason whatever for believing that the obscurity of the crystals, in crystalline rocks, is generally due to a semi-fusion of disintegrated fragments. A crystal is the result of the regular aggregation of molecules around a point, or a central axis; when crystallization is disturbed by foreign causes, the crystal becomes rounded at the angles and the edges, until it entirely loses its character of geometrical regularity. These perturbating causes have exercised so general an influence, that the state of perfect crystal is a state comparatively rare. The author of this little book had the advantage of being for several years the much favoured pupil of L'Abbé Haüy, and of examining with him, almost daily during that time, the minerals which this naturalist continually received from different parts of the globe; he has been accustomed to consider regular crystals as exceptions; the great mass of minerals, and principally those which enter into the composition of rocks, presenting themselves in the state of confused crystallization, an expression which should convey the idea of irregular or precipitated crystallization,

in which sense it was used by Haüy, and not the idea given by Mr. Lyell, in his *Elements*, p. 328, of an irregular arrangement of different species of crystals.* Although in gneiss and micaschist the

* Dr. Justus Liebig, in his letters on chemistry, says on the formation of crystals—"Time and freedom of motion for the particles of bodies are necessary to the formation of crystals. If we force a fluid or a gas to become suddenly solid, leaving no time for its particles to arrange themselves and cohere in that direction in which the cohesive attraction is strongest, *no crystals will be formed*, but the resulting solid will have a different colour, a different degree of hardness and cohesion, and will refract light differently—in one word, will be amorphous."

Notwithstanding all the respect I feel for the authority of so justly celebrated a man of science, I cannot help remarking here, that the amorphous state is but a variation of the crystalline state, and not *the opposite* of this state, as might be deduced from the expressions of Dr. Liebig.

A scale of texture could be constructed of the same mineral species, as carbonate of lime, for instance, showing the passage of crystals from the complete state to the laminary, and subsequently lamelliform or granular, with large grains and small grains, &c., the grains diminishing in size until we come to the amorphous state. In fact, the word *amorphous* has been invented to express the last degree of crystallization—a crystallization *without forms*. The amorphous state appears to result from the cohesion or attraction, at little distances, of very small crystals of an homogeneous mineral species, or some-

crystals offer the appearances of a confused crystallization they are no less crystals; and the celebrated founder of the science of crystallography himself could only have received with a smile of incredulity, the idea of a theory based upon the supposition of an anterior fragmentary state of the *crystals* of the whole mass of crystalline rocks.

§ III.

The hypothesis that specific affinities have been the cause of the division into bands, opposed as it is to the main argument of the *ultra-metamorphists*, does not, in any manner, explain the fact of the stratification itself; for when the specific affinities have not been influenced by another cause, they have simply produced granites and porphyries.

In those places where the melted matter contained amphibolic, hyperstenic, or calcareous elements, the relative specific gravity must have produced compli-

times, as in lavas and basalts, from the aggregation of small crystals of different kinds.

cations of distinct bands, and thus may be easily explained all the series and repetitions of series which divide a gneissose mass.

§ IV.

According to this theory the primitive clay-slate might be considered as finely grained gneiss. The reciprocal attraction between crystals of different species having interfered with the specific affinities, at various periods, sometimes when the crystals were extremely small, sometimes when they had acquired a considerable developement, the Vulcanian Rocks have taken a different texture, from the large-grained granite to the compact basalt, where the grains are imperceptible. When the influences of specific gravity have acted upon a mass which had a tendency to assume the compact form, they have produced the division in small plates which forms the character of primitive clay-slate.

It would only remain to fix a line of demarcation between the Vulcanian and the most ancient Neptunian clay-slates; but in the actual state of science

this question must continue open to new investigations. Perhaps the fourth group of the black schists of Cumberland, described by Professor Sedgwick, forms one of the extremities of this series.

As to the cause which has accelerated or retarded the interference of the reciprocal attractions among crystals produced by specific affinities, or, in other words, which has determined the size of the crystals united by cohesion, this cause has probably been the degree of rapidity in the loss of caloric; in which case, the rocks composed of the smaller crystals would in general occupy the superior ranges in granitic rocks. Thus the theory indicates that the mass of clay-slates should form the superior range, the gneiss ought to follow, whilst the granite should occupy the inferior parts. Now this disposition is exactly that which nature presents to us, excepting the local anomalies,—the slidings, intrusions, and overthrowings, which may have altered and sometimes reversed the series.

The compact form may in some cases be accounted for, by supposing that a comparatively rapid

refrigeration has been accompanied by an equality in the specific gravity of the various crystals which were forming.

The structure of porphyries is very well explained by the slow refrigeration of a felspathic mass; for the specific gravity of the isolated crystals being the same as that of the mass, they could not precipitate so as to form distinct bands.

§ v.

We may conclude, therefore, that when the influences of the specific gravity of the crystals, beginning to form according to the inverse order of the fusibility of each species, have co-existed, in a refrigerating mass, with those conditions which have determined the distribution of crystals belonging to different mineral species, this same mass, instead of assuming either the granitic or the compact structure, has arranged itself in more or less distinct bands of stratification; and these bands differ from the Neptunian strata only by reason of the more decided character imprinted on the latter, by the greater mo-

bility of the liquid in which they were suspended or dissolved before their precipitation.

The disposition of crystals in the mass of large grained granites, such as those of Massachusetts, proves, further, that the consolidation must have begun simultaneously throughout a certain thickness, which could not be less than the space comprised between three vertical series of crystals of each kind, otherwise the crystals could not have increased in bulk, and united together, as we observe in granites.

The greater or lesser rapidity of the refrigeration will also explain the differences in the thickness of the bands of stratification of the same kind of rock; thus, let us suppose that in the accompanying diagram the bands 1, 2, 3, represent the thickness of a series. When the melted matter which has pro-

1.	Felspar.
2.	Mica.
3.	Quartz.
1′	Felspar.
2′	Mica.
3′	Quartz.

duced the bands 3, 2, 1, 3′, 2′, 1′, has begun to cool, the crystals of quartz of the first series had a tendency to sink, and unite with the second band of quartz 3′; but it is to be remarked that whilst the crystals of quartz of the superior group were forming and sinking in the mixture, which has produced the bands 1, 2, 3, the series 1′, 2′, 3′ was itself in a state of refrigeration; and the specific affinities having been in action in this latter series at the same time as in the former, the crystals of quartz of the band 3, must have settled on the surface 1′, when this surface offered a sufficient resistance. It is the time of this resistance which has determined the thickness of the bands 1, 2, 3; if the cooling had been more gradual, there might have been only a single series of a double thickness, for the matter of the bands 1 and 1′, 2 and 2′, 3 and 3′, would have been united. Thus may be explained, by the duration of the process of cooling, the differences of thickness so frequent in the bands of gneiss.

§ VI.

In the preceding speculations I have supposed that the quartz, the mica, and the felspar, have crystallized in a gneissose mass, in igneous fusion, according to the inverse order of their respective natural fusibility; that, thus, in the same manner as in an artificial mixture of lead and rosin, lead, being less fusible, will pass first to the solid state, and, in virtue of its greater specific gravity, will precipitate and form a distinct band under the resinous band, which will coagulate the last; so, in a micaschist, the quartz has crystallized first, and the mica has afterwards formed a second band above the coagulated band of the quartz.

It is, indeed, difficult to conceive that, in the primitive melted mineral mass, things could have happened differently; for how could it be admitted that in micaschist, where two distinct specific affinities have developed themselves simultaneously, the melted matter could have fallen to the degree of refrigeration necessary for the consolidation of the mica,

without the quartz, which solidifies at a much superior temperature, having already passed to the solid state, or to a state approaching solidity.

However, it must not be overlooked that the homogeneous specific affinities, which tended to the formation of crystals of pure quartz, may to a certain extent have been opposed by the presence of the alumina and potash, and other elements, which were to be transformed into mica, and it may have happened that the specific elective attractions, between these micaceous elements, have acted with sufficient energy to determine the prior formation of the crystals of mica, in the quartzose refrigerating mass; though it is not easy to imagine how these crystals could have existed in a solid state, when the quartz was still in a liquid state. We may conceive that the homogenous quartzose affinities were manifested, and produced the solidification of the quartz, in proportion as the crystals of mica were formed, in virtue of the elective affinities; and this view is not at all in opposition with the existence of those little internal movements due to the specific gravity of the

different kinds of crystals, in a state of formation, which have determined the division into bands, and all the conditions of stratification already laid down.

The regular crystallization of one or more mineral species, in virtue of elective affinities, may have occasioned the confused crystallization of other species, by a kind of precipitation more or less rapid. Thus, if we suppose, that in a granitic melted mass, the complex felspathic and micaceous affinities have acted with more intensity than the quartzose affinities, it may have happened that, in proportion as the crystals of felspar and mica were formed, the portion of silica, whose fusion was favoured by the presence of the alumina and potash, which had entered into the composition of the crystals of the complex species, has precipitated, and formed quartz crystals. But as the quartz, on account of its inferior degree of fusibility, must have solidified with a quickness comparatively rapid, its crystals would offer the appearances of a confused or amorphous crystallization, in the midst of which, the crystals of felspar and mica would be embodied, and the rock would present

exactly the appearance of a porphyroid granite, similar to the granite of Shapfells, to which I have alluded in the preceding pages.

Therefore, even if it were demonstrated that, in general, or only in some particular cases, the crystals of one or two of the integrant parts of the gneiss have been formed, in virtue of elective affinities, before the crystals due to homogeneous attractions, the proposed theory accommodates itself easily to this inversion: and, in fact, this theory explains so well all anomalies and exceptions, and is so easily adapted to all cases, that it seems to contain, within itself, anwers to every possible objection.

§ VII.

Real or supposed facts of alternations of micaceous schists or gneiss with fossiliferous strata cannot be set in opposition to this theory. If the stratification of gneiss and micaschist is satisfactorily explained by igneous causes, this stratification can no longer be appealed to as an argument in favour of the proto-Neptunian origin of crystalline rocks, and

considered as the unobliterated trace of a pristine aqueous stratification.

The fact of these alternations may be easily explained by overflowings or injections; and it is no wonder that these melted elements should have acted, in many cases, in such a manner as to produce partial indurations, passages, and liquefactions, either through a direct influence, or through the agency of gases and developed vapours.

The abrasions, breakings-up, and recompositions, which must have been the consequence of the superficial movements produced either by igneous tides or by subterranean dynamical causes, are more than sufficient to explain the accidental presence of angular fragments and pebbles in crystalline rocks; the productions of numerous breccias has been a necessary result of these primitive phenomena.

There is no reason, again, why gneiss and mica-schists should not have been produced at periods comparatively recent, as well as granite; and the action of central heat may have reproduced in some localities the original form of the primitive crystalline rocks

by the melting of Neptunian rocks; since the latter are in great part composed of the same mineral ingredients. But these facts could not in any way shake the basis of my argument. It is upon similar exceptions that the metamorphic Huttonian hypothesis has been founded: whilst in the theory which I propose, they can only be considered as accidents, of an easy explanation, such as appear to be the necessary consequence of repeated displacements among various portions of the solid envelope. In these *pseudo-primitive* rocks, one might then meet with fragmentary parts, pebbles, and even traces of organic fossils, without being prevented by these facts from considering the great mass of crystalline rocks, gneiss, and mica schists, as forming the superior groups of the primitive granitic envelope of the terrestrial globe.

The production of Neptunian clay-slate similar to Vulcanian clay-slate is no more surprising than the existence of crystals of carbonate of lime and quartz produced by aqueous agency, and similar to those of an igneous origin.

CHAPTER IV.

Re-fusion of Granite, *in situ*—Phenomena of Metamorphism—Works of Sir Roderick I. Murchison—Scandinavia—Ural Mountains—Theory of the Igneous Fusion of the Earth.

§ 1.

If the great mass of primitive gneiss and mica schist does not offer, in its actual composition, those characters which have induced geologists to attribute to these rocks a fragmentary origin; and if the bands of stratification, more or less distinctly perceptible in them, are the natural result of the refrigeration of matter in igneous fusion; the Huttonian theory fails in the main argument by which Mr. Lyell has endeavoured to support it; viz. that the crystalline rocks, and particularly the gneiss and mica schists, on account of their stratification and obscure crystallization, form a sort of transition between granite and Neptunian rocks.

The facts of the intrusion and overflowing of granitic matter, through the gneissose strata, receive

an easy explanation from the consideration of the contractions and breaks which must have taken place in the first solid envelope. There can be no doubt that tne granitic penetrations in the gneiss of the Scandinavian chain are the result of the intrusion of primitive igneous matter. According to all appearances, also, a great number of the veins and ramifications which have penetrated crystalline rocks, superincumbent upon granite, such as the gneiss of Cape Wrath, in Scotland, and those of Valorsine at Mont Blanc, in Switzerland, offer examples of the extravasation of the mineral matter, in a state of primitive fusion, under the first consolidated envelope.

Even supposing it to be clearly demonstrated that strata of a Neptunian origin, at first deposited upon a solid surface, are now found resting on granite of a posterior age, as is the case with the limestone of Djelebek, at the north of Drammen;* if the fact cannot be explained by lateral injections, similar to

* See Sir R. I. Murchison's Russia

those which have produced the porphyric masses intruding in the argillaceous limestones and bituminous shales near Christiania, still there will not be the least reason for attributing to that granite a metamorphic origin.

From the position which granite occupies, it is exposed more than any other rock to the accident of a partial re-fusion; and in consequence of the movements which have taken place formerly, and which yet take place, in the solid envelope, there is no doubt that considerable masses, yielding to the pressure of the Neptunian strata, fall again to a level, where heat maintains the central mass in a state of igneous fluidity, and are subjected anew to the action of the subterranean fire. In this manner may be explained all the facts of a re-fusion of granite *in situ*, and even of an accidental fusion of Neptunian strata; still no one can pretend to derive from these facts even the shadow of an argument in favour of the Huttonian metamorphic idea.

It may also be imagined that a primitive granite, supporting Neptunian strata after being re-melted, has

been transformed into a rock of a different species, either through a new arrangement of its constituent parts, or through the addition of new elements, so that a pure granite has become a porphyry, a greenstone, a sienitic rock, or an hyperstenic compound. And it is to be remarked that the re-fusion of granitic masses, by increasing the bulk of these masses, forms of itself the condition necessary for an upraising of the superincumbent strata.

§ II.

One of the circumstances most calculated to throw a doubt on the question of the limits of the metamorphic phenomena is the philosophical scepticism in which Sir Roderick Impey Murchison seems to have entrenched himself, when he speaks of the granitic gneiss of Scandinavia, and of the extraordinary developement of the metamorphic rocks in the Ural mountains.

Before reducing to a system the ideas which I had long since formed, upon the relations existing between granite and gneiss, and upon the causes of

the stratification of these latter rocks, I had studied with the most assiduous attention the works of this geologist. His accurate descriptions, his philosophical sincerity, and the perfect logic with which he draws his deductions, and combines details into general views, would certainly have led me to partake of his scepticism, had not the hypothesis which I have proposed in the preceding chapter constantly supplied me with a distinct base line, where the phenomena of metamorphism stop, and through which the most complicated facts have always seemed to me to receive a ready explanation.

"In Scandinavia," says Sir Roderick, "we have recently convinced ourselves, by clear and indisputable sections, that the lowest beds charged with anything like animals or vegetables are the exact equivalents of the lower silurian strata of the British Isles, and that they have been distinctly formed out of, and rest upon, slaty and other rocks, which had undergone crystallization before their particles were ground up and cemented together, to compose the earliest beds in which organic life is traceable. To

the crystalline masses which preceded that palæozoic succession to which our researches were mostly directed, we apply the term 'azoic,' *not meaning thereby dogmatically to affirm, that nothing organic could have been in existence during these earlier deposits of sedimentary matter*, but simply expressing the fact, that, as far as human researches have reached, no vestiges of living things have been found in them ; so also, from their nature, *they seem* to have been formed under such accompanying conditions of intense heat and fusion, that it is hopeless to expect to find in them traces of organization."

It seems, from this passage, that Sir Roderick admits the *sedimentary* origin of gneiss, and even, implicitly, the sedimentary origin of granite; for he comprehends under the same formula of *azoic rocks* "all the crystalline masses belonging to the ancient group of gneiss, together with the ancient granitic and Plutonic rocks, by which they have been invaded." This opinion is expressed in a still more formal manner, page 17*,* where these rocks are con-

* See Russia, p. 17*.

sidered as owing their crystalline aspect to fusion and metamorphism.

However, I cannot possibly understand the reasons which have induced Sir Roderick, without discussion, to adopt the opinion that the gneiss of Scandinavia are ancient metamorphic rocks, whilst he considers as completely demonstrated "that the granitic gneiss and associated rocks of Sweden formed the solid materials of that country before the earliest vestiges of palæozoic deposits were called into existence," and even traces with precision the line of demarcation which separates the phenomena of the real metamorphism of silurian strata from those of the hypothetical metamorphism of azoic rocks.*

I will content myself, therefore, with remarking that there is not, in the whole of the works of Sir Roderick, a single fact which can prevent me from considering the gneiss of the Scandinavian chain as a part of the first consolidated pellicle of the terrestrial envelope. The granitic intrusions which

* See Russia, p. 14.

pervade this pellicle, far from supporting the hypothesis of absolute metamorphism, exhibit the phenomena of the contraction of the gneissose masses after refrigeration, and of the injections of the melted matter which these masses covered, precisely as we should suppose would be seen, by adopting the simple hypothesis of the gradual consolidation of the terrestrial envelope.

§ III.

In the Ural mountains the phenomena of metamorphism appear to be developed on a large scale, so large, indeed, that to give full scope to the arguments of the partisans of absolute metamorphism, I feel myself obliged to produce the most striking passages in which Sir Roderick expresses his opinion on these appearances :—" He who disbelieves in the theory of metamorphism may here (at Nijny Serginsk) be convinced of its truth, in the short space of a mile ; since he can walk upon the edges of the partially altered beds of grit and schist, until he finds them converted into amorphous quartz rock, in contact

with highly crystallized green-stone, a rock which, from its composition, and from the part it plays in all parts of the world, is now admitted to be of igneous and intrusive character."* . . . . .

"If some persons be disposed to think that certain of the Uralian crystalline rocks, particularly those which appear on various parallels on the Asiatic side of the axis, may, like the azoic rocks of Sweden, have been formed during a period anterior to that to which the term palæozoic ought to be applied, we are at once at issue with them."† . .

"Let not geologists be appalled, when we call upon them to regard the crystalline axis of the Ural as an equivalent (*for the most part*) of the silurian strata."‡

Without wishing to contest the classification of the granites of the eastern flank of the Ural amongst eruptive rocks,§ I may be allowed to opine, that the

* Russia, p. 357. † Id., p. 464. ‡ Id., p. 466.

§ I cannot however forbear expressing some doubt as to this point.

authors of the magnificent work on Russia have not, in their rapid statements, exhausted the question of the fundamental basis of these mountains, and that it is not impossible there may yet be found, in localities hitherto unexplored, the walls of that long, primitive meridian fissure which igneous extravasations appear to have, in great part, obliterated. Sir Roderick himself seems to admit the existence of a primitive basis when he adds:*—

"We have come to the same conclusions as those at which we arrived after an examination of the silurian region of the British isles; that whatever may have been the direction of an *ancient fissure* in the *crust* of the earth, other parallel outbursts and upheavals have naturally taken place along the same line at subsequent epochs."

It appears to me extremely probable that this ancient fissure in the primitive solid crust which supports the Ural Mountains has taken place in granites of the same age as those of the southern granitic

* Russia, p. 469.

steppes, which, according to Sir Roderick, "have afforded materials for the construction of some adjacent Silurian strata."

More complete investigations alone can show to what extent these views are correct. That the question is open to further inquiries cannot be doubted, from the very conclusion of the XVIIIth Chapter of the admirable work we have quoted. "Interstratified as these palæozoic sediments have been in other parallels with large bands of igneous matter, which we believe to have been coeval with their accumulation, and afterwards cut through, in many places, by intrusive rocks, which have altered their original character and often mineralized them, it is impracticable to draw a well-defined base line for this greatly contorted, broken, and often inverted series . . . . accurately and rigidly to determine the boundaries and passages of such highly mineralised products must be the result of long and minute geological labour."*

* Russia, pp. 462, 463.

The crystalline axis of the Ural may be composed of silurian formations; but there must have existed under those formations, at the time when they were deposited, a solid crust which furnished the materials of which they are composed; and if this primitive basis is at present nowhere to be met with, and has in reality ceased to exist, I have no hesitation in saying that it is because it has been re-melted *in situ*, and has supplied the matter of the trappean rocks of the whole chain. Let those who would combat these conclusions show us a single specimen of fossils from a geological period more ancient than the silurian strata, and prove that the Ural rested upon a solid basis containing similar fossils, and differing in this particular from the basis which supports the fossiliferous formations of the Scandinavian chain, of Auvergne, and Canada; until then, they cannot call upon us to admit even the great development of the metamorphic phenomena in the Ural, as an argument in favour of the Huttonian hypothesis, or of Mr. Lyell's system.

If my views are correct, the phenomena of meta-

morphism, whatever may be their developement in the Ural, in the Alps, and in some other particular centres of eruptions, can only be considered as the result of local reactions of the interior igneous mass on the envelope which covers the surface of our planet.

§ IV.

By these considerations we are led to regard the gneissose and granitic crust, accessible to our observations, as the result of the refrigeration advancing from the surface to the centre, and to adopt fully and unreservedly the theory of the primitive igneous fusion of the globe. It is not without a lively feeling of satisfaction that I find on reading the excellent article in the Quarterly Review, for March, 1846, that the author of that article, without stopping to examine the intricate question of the stratification of gneiss and micaschists, arrives at the same conclusions, which he expresses in the following terms:—"Every renewed application to the leading problem of geological dynamics has more and more convinced us

that the most probable solution is afforded by the hypothesis of the general igneous fluidity of the nucleus of our planet, and that the igneous rocks, of whatever age, must be regarded as merely successive eruptions from one and the same central reservoir...

"We consider the lowest granitic rocks of Scandinavia and Canada as the cooled down masses of the universal igneous basis. The crust of gneiss appears to us to have been most probably the first product resulting from the gradual refrigeration of these masses."

§ v.

The theory of the primæval igneous fusion of the globe, which seems to pursue the geologist in his march, and arrest him at every step, to offer the clearest and most rational explanation of the phenomena which have succeeded and still succeed each other on the earth, proposed *à priori* by Descartes and Leibnitz, adopted by Buffon, Laplace, Sir W. Herschel, Fourrier, Baron Humboldt, Mr. Cordier, and all modern geologists who have

not been misled by the Huttonian fallacy, which Mr. Lyell has supported and developed with so much talent and perseverance; this theory, we say, appears destined to become the centre towards which all the investigations of geologists will be directed, and remains *to the present time* the primitive anterior fact to which we are led, in tracing up events from modern times to that remote period when the earth presented a virgin surface, which neither vegetation nor life had yet embellished or fecundified.

The form of the terrestrial globe, flattened towards the poles, raised at the equator; the actual fluidity of water, which covers three-fourths of the surface; the constant diminution of caloric, *demonstrated by the cooling down of lavas* and of the entire mass of the Vulcanian rocks of all times; the bursting, upheaving, and sinking down of the solid envelope at various epochs; the opening of crevices, and the filling up of veins,—such are the principal facts upon which this theory is founded. The rapid increase of heat, in proportion as we descend to the interior; the inclined position of stratified rocks;

earthquakes (inexplicable on the supposition of the globe being entirely solid); modern volcanic eruptions; the existence of thermal springs, and a multitude of concomitant facts, prove that even to this day this solid crust, which we tread with a confident step, and upon which we raise monuments that seem to defy the ravages of time, forms but the thin shell of a molten spheroid, whose burning matter roars under this frail envelope.

END OF THE FIRST PART.

THE PHILOSOPHY OF GEOLOGY.

SECOND PART.

THE

PHILOSOPHY OF GEOLOGY.

CHAPTER V.

Base-line of Neptunian Rocks—Intimate Union of Gneiss and Micaschist with Granite—Answers to objections—Development of the Theory of the Igneous Stratification of Crystalline Schists—Importance of this question—Facts—Works of Sir Roderick Murchison—Philosophical question of a Beginning of Life resolved—Labours of Keilhau—De Saussure—New arguments against the partisans of Metamorphism—Position which they are forced to accept—Hasty Generalizations—Theoretical line which divides the Crystalline Schists into two distinct Groups.

§ 1.

THE preceding investigations have led us to recognise a general primitive basis upon which the fossiliferous strata have deposited themselves, which compose the superior layer of the terrestrial crust. Whether this first solid basis subsists still in its primordial state, or, if it has been retaken by the

central fire and transformed into eruptive granitic, trappean, or basaltic rocks, it no less forms a pyrogenic system, whose existence is anterior to the organic creations of which the numerous spoils are enclosed in the Neptunian formations. The study of these details would be here out of its place. I content myself with submitting these views to the examination of geologists and philosophers. They explain in a satisfactory manner the singular fact of the occasional disappearance of the solid basis upon which fossiliferous strata have incontestably been deposited, and the replacement of this basis by rocks consolidated afterwards, but of a chemical nature, either similar or slightly modified by the introduction of some new elements. It is to the action of these *deuto-pyrogenic* rocks upon the Neptunian roof which they support, and on the sides of the fissures where they have been injected, as well as to the eruptions coming from the *central igneous* reservoir,* that the phenomena of meta-

* In opposition to the ideas admitted by the majority of geologists, Mr. Hopkins has arrived, through calculations

morphism must be attributed. These phenomena, therefore (and I cannot too much insist on this

founded on the observation of the phenomena of precession, at the opinion that the *minimum* of the thickness of the solid envelope embraces a quarter or a fifth of the radius of the terrestrial sphere; whence it would result that this envelope forms about the four-seventh of the entire mass. The consequence of this would be that the influence of the central reservoir could scarcely be felt on the surface. But Mr. Maclaren, even in adopting the results of Mr. Hopkins, in an article in Professor Jameson's 'Philosophical Journal,' confesses conscientiously that the conclusions of Mr. Hopkins rest on a very narrow basis: "It is," he observes, "something analogous to the estimation of the distance of the stars deduced from the difference of one or two seconds in their apparent position, a difference which can scarcely be distinguished from errors of observation."

Is it not evident that calculations resting upon a datum so uncertain cannot be opposed to opinions founded upon the examination of the solid crust itself? If this crust was three hundred leagues thick, how could we account for the phenomenon of earthquakes? How could we explain the breaks, the faults, the innumerable fissures, produced at not very ancient periods; the movements of depression and elevation of this solid envelope, the upheaving of the strata and sometimes their complete overturning, the constant increase of temperature in proportion as we penetrate deeper *into* the interior; the identity of volcanic productions in all countries; the existence of thermal springs, &c. &c.?

Notwithstanding then the high esteem which we must feel

point), cannot supply an argument in favour of Mr. Lyell's system; and only prove that the state of consolidation of Vulcanian rocks is in some cases of a date posterior to the deposition of the Neptunian strata with which they are in contact.

§ II.

However difficult it may be upon some lines of elevation, as in a part of the Alpine regions, to fix the age of a crystalline rock, and to decide if the character which this rock offers be due to a metamorphic action, or if it belongs to the ancient group of primordial gneiss, this difficulty is reduced to a question of classification for each particular case. The great mass of gneiss and micaschist is inti-

for the labours of Mr. Hopkins, they cannot make us forget those of the celebrated Fourrier, nor the calculations of M. Cordier; and it does not seem that they could be put in competition with the deductions drawn from direct geological observations, nor obtain more influence than the ingenious speculations of M. Poisson, on the possibility of explaining the phenomena of internal heat, by the inequalities of the temperature of the different parts of the celestial space, through the midst of which the globe has successively passed.

mately united with the ancient granite; the well-ascertained metamorphic transformations of Neptunian rock into gneiss, quartz rock, or micaschist, are but rare exceptions, and take from primordial rocks only a small fraction of their total sum. If, therefore, the phenomenon of the stratification of the mass of gneiss and micaschist does not indicate the passage of these rocks to the fossiliferous systems which lie upon them, they must be considered, with a part of the primitive clay slate,* as being a

* Although I have imposed on myself the task of not overloading this book with local details, and of reducing my quotations to that which is absolutely indispensable for the general arguments, I cannot refrain from citing, in support of my opinions, a passage from the paper of Mr. Weaver on the geological relations of the clay slate with the granite in eastern Ireland.

"In the whole expanse of the clay slate formation I have never perceived, either on the western or on the eastern side of the granitic chain, the slightest vestige of organic remains. Hence I cannot subscribe to the application of the term transition, which has been bestowed upon some of these rocks, as well as upon the analogous tracts of clay slate in other parts of Ireland. . . . . I am of opinion that neither the mere occurrence of matter mechanically divided in the composition of rocks, nor the curvatures or inflexions which their

portion of the basis upon which Neptunian formations have successively accumulated.

§ III.

I am quite aware of the objections which may be made to these propositions. A new idea, which overthrows theoretical arrangements (around which scientific men of uncontested merit have grouped numerous facts, which they have, in great part, collected themselves), can only be received after a severe examination. The question is, whether this idea adapts itself better than the old formulæ to the mass of gathered facts, and whether it will dissipate doubts in which preceding theories have enveloped these facts?

Let us apply these remarks to the question raised in the last two chapters.

Is the stratification of the great mass of crystal-

strata sometimes display, entitle them to a place among the transition formation: in the case before us we have seen that the rocks in question are connected by insensible gradations with micaslate, and even with the fundamental granite itself." (*Transactions of the Geol. Soc.*, Vol. V., 1821, p. 196.)

line schists an igneous or an aqueous stratification? or, to make use of more exact expressions, (for I repeat it, water being a mineral mass in igneous fusion, there is no real opposition between the two qualifications—igneous and aqueous,) has the stratification of these rocks taken place in their own substance at a time when they were in a state of primitive fusion? or, is this stratification the unerased mark of a watery stratification, similar to that of clay and sandstone?

Such is the question which I have endeavoured to clear up, and which, from the very expression of a geologist whose name occupies one of the first ranks amongst modern scientific celebrities, deserves the most attentive scrutiny.* It is, in fact, the solution of this question which can alone decide, through the testimony of facts, whether we may be allowed to discover the marks of the first vegetative

* "To assume that gneiss, micaslate, and other old formations of crystalline strata are metamorphic, is nothing better than to beg some of the greatest questions in geology." (*Professor A. Sedgwick, Trans. Geol. Soc.*, Vol. III., 2nd Series. p. 462.)

and animal organization, and to trace back, through irrefragable proofs, the beginning of life upon this earth.

It is not enough that Sir Roderick I. Murchison has traversed, with the eye of genius, the deep mass of the Silurian formations, and has succeeded, after years of laborious investigation, in penetrating the tomb where the spoils of the oldest known generation remain buried: the supporters of general metamorphism reject a definitive conclusion, and maintain that the traces of organization in the rocks which support the Silurian beds have been effaced by metamorphic action.* But if the igneous strati-

* Some geologists have expressed the opinion that crystalline schists might have been formed in water and hardened by heat before the time of the appearance of organic beings; but this hypothesis can only be considered as an expedient which rests upon gratuitous suppositions, such as the formation of beds of sand and detritus through causes different from those which have produced similar beds in subsequent periods, or the existence of a system of continental surfaces and seas absolutely untenanted. This opinion does not refute the objection of the metamorphist geologists; and cannot be supported if the theory of igneous stratification of crystalline rocks be true.

fication of crystalline schists is considered as a proved fact, the beautiful discoveries of Sir Roderick show us in reality the remains of the most ancient creation which has inhabited the earth: the Huttonian hypothesis is thus deprived of its last argument, and the philosophical question of a beginning of life definitively resolved; for under the population contemporaneous to the fucoidal beds (with the exception, perhaps, of what the microscope could one day reveal in the equivalent of the Silurian inferior group), all traces of organization *necessarily* disappear; since the rocks which form the basis of the Silurian formations do not owe their crystalline texture to metamorphism, but compose certainly the first solid envelope of the globe.

The deductions, in the works of Professor Keilhau, with which I have become acquainted since the publication of the first part of this work; the passages of the granite, which this geologist points out, to the stratified forms, considered together with the obscurity in which he confesses that the origin of the great mass of crystalline rocks is still involved, can only

strengthen me in the opinion, that the theory of an igneous stratification of crystalline schists offers the only guide which can direct the geologist through the labyrinth of difficulties with which a too limited interpretation of the general principle of stratification had encircled science, leaving it entirely to the speculations of metamorphist geologists.

"The greater part of the crystalline rocks," says Professor Keilhau, "have an entirely hidden origin and development. The direct observation of the mode of formation of these is so difficult, that it has not yet been definitively determined (for I must be allowed this assertion) to which principal class the agent belongs that has, here especially, been in operation. Chemistry alone cannot decide in this matter; for the same minerals can be composed in nature through different processes: by the side of the celebrated fact which showed the possibility of the formation of felspar 'by heat,' chemistry itself now places experiments which prove the possibility of producing felspar 'in the moist way.'"

Let us add to this, that Saussure, in his 'Travels,'

published from 1779 to 1796, has perfectly well established the stratification of granite in the Alps.*

From his multiplied observations, this excellent naturalist concludes, with reason, that the granite and foliated rocks (now crystalline schists) have a similar origin.

If, then, it is now recognised that granite is an igneous production, the researches of Saussure, as well as those of Professor Keilhau, furnish a peremptory argument in favour of the igneous stratification of crystalline schists. No mineralogist will suppose that the bands of schorl (tourmaline), which frequently mark the lines of stratification in the Alps, could have a fragmentary origin; and if the stratification of granites is due to rows of crystals, why should that of gneiss and mica schists be attributed to fragments?

Supporting their views on partial observations of obliterated fossils, and the entanglement of Neptunian

* See the paragraphs 567, 569, 604, 613, 642, 643, 661, 662, 664, 676, 1682 to 1691, 1706, 1726, 1729, 1730, 1743, 1747, 1752 to 1759, 1800 to 1803, 1847 to 1863.

strata with bands classified amongst crystalline rocks, the philosophers of the Huttonian school have endeavoured to generalize the accidents of metamorphism, and to take hold of these phenomena as of an argument in favour of the philosophy of actual causes, or invariability of antecedence and sequence between cause and effect. These generalizations could not have any other result than to throw back philosophy to the ancient doctrine of a circle of identical material motions, without a beginning or an end; the doctrine of a world without a creation, a universe without a creator; for it would be useless to deny it, the theory of absolute metamorphism leads us to this conclusion.*

* Nothing shows so well how this theory rests upon vague and undetermined notions as the definition of Mr. Lyell himself, in his *Elements of Geology*. "The metamorphic theory *affirms* (*sic*, p. 411) that an action existing in the interior of the earth at an unknown depth, whether thermal, electrical, or other, analogous to that exerted near intruding masses of granite, has in the course of *vast* and indefinite periods, and when rising *perhaps* from a *large heated surface* (!), reduced strata (Neptunian strata) thousands of yards thick to a state of semi-fusion; so that on cooling they have become crystal-

It appears to me the more necessary to mark as distinctly as possible the position which the disciples of Hutton are obliged to accept, because a certain class of English writers, even in rejecting these extreme conclusions, do not the less adopt as a maxim, that "geology has nothing to do with questions which concern the origin of things,"—an affirmation which, on their part, is so presumptuous and dogmatic, that it has not even the merit of being laid down as the logical deduction of any system whatever.

Let it not be believed, however, that in unveiling

line, like gneiss. Granite *may have been* another result of the same action, in a higher state of intensity, by which a thorough fusion has been produced; and in this manner the passage from granite into gneiss may be explained." (pp. 411 and 412.)

"Gneiss and micaschist *may be* nothing more than altered micaceous and argillaceous sandstones" (*i. e.* altered fossiliferous strata), p. 412.—See also 'Principles,' p. 375 and foll., 5th edition.

I cannot help remarking here on the singularity of this convenient *large heated surface*, in a system so opposed to the primitive igneous fusion of the globe!

the *substratum* of their doctrines, my object is to pronounce anathema against the labours of metamorphist geologists. Even in opposing them, I am happy to do homage to the inventive genius which has inspired their speculations, and no one, more than I, admires the works of Hutton, and in particular those of Mr. Lyell, as collections of facts and detached views. The *hasty generalizations* of these geologists are not the only ones which have fallen before the conquests of science and the irresistible progress of ideas.....Alas! alas! shade of William Herschel! what has become of this famous *generalization*, which so many well-organized mathematical heads have cherished during long years—THE NEBULOUS THEORY? Error, magnificent error! HASTY GENERALIZATION!....but which has no less contributed to the progress of science; for that error alone has created the telescope of Lord Rosse. Alas! alas! Science itself is sometimes blind; it goes on groping, and it is only in passing through error that it arrives at last at the discovery of truth!

§ IV.

From the preceding remarks we shall consider the primitive basis, anterior to the Neptunian formations, as placed upon a theoretical line, which divides the crystalline schists into two distinct groups: the first composed of the great mass of these schists, united with the fundamental granite through the bond of a common origin; the second group will contain (as exceptions) the crystalline schists, which are linked with the Neptunian formations, either through the epoch of their appearance in the middle of these formations, or through their fragmentary origin and their subsequent metamorphic transformation.

CHAPTER VI.

Table of the Neptunian Rocks—Mineral Composition of the Neptunian Systems—Origin of the Materials which enter into their composition—Mechanical Products—Chemical Products—Thermal Springs considered as Lava—Order of Mineralogical Superposition—Division in small strata, forming a complete History of Subterraneous Meteorology —Unheeded importance of these divisions.

§ 1.

On the consolidated envelope of the terrestrial globe, and in the irregularities of the primordial rocks, we now perceive the scattered groups of strata deposited in the bosom of waters, at various periods. These Neptunian beds, considered in their mineralogical characters, are classified in the following table. (The broken line  indicates in the second column the general dislocations between the systems; and in the first column, this same line corresponds to the destruction of ancient populations, and the appearance of new generations of organized beings, which take their place.)

SYNOPTIC TABLE OF NEPTUNIAN ROCKS.

Periods. 1.	Fossiliferous Systems. 2.	Principal Mineralogical Characters.	Formations.
Super-cretaceous Period. — Third Population.	System of modern alluvium. 11.	Sands—Sandstones —Clay— Limestone.	1. Modern alluvium.
	System of ancient alluvium. 10.	Erratic Blocks— Sand—Oxide of Iron —Clay.	1. Group of Erratic Blocks. 2. Ancient alluvium.
	Tertiary System. 9.	Limestone—Sandstone—Clay—Marl —Gypsum—Silex.	1. Upper tertiary. 2. Lower tertiary.
Secondary Period. — Second Population.	Cretaceous System. 8.	Chalk—Clay— Marl—Silex.	1. Upper cretaceous. 2. Lower cretaceous.
	Green-sand System. 7.	Sandstone—Clay— Marl—Silex.	1. Upper green-sand. 2. Lower green-sand.
	Oolithic System. 6.	Sandstone—Clay— Marl—Limestone— Oxide of Iron.	1. Upper oolithe. 2. Middle oolithe. 3. Lower oolithe. 4. Lias.
	Triassic System. 5.	Clay—Saliferous Marls—Silex— Sandstones.	1. Saliferous marls. 2. Upper red sandstone.
Palæozoic Period. — First Population.	Permian System. 4.	Magnesian limestone —Variegated marls —Sandstones—Clay —Oxide of Iron.	1. Magnesian limestone. 2. Middle red sandstone.
	Carboniferous System. 3.	Sandstone—Coal— Clay—Oxide of Iron —Pyrites—Silex— Limestone.	1. Coal. 2. Carboniferous limestone.
	Devonian System. 2.	Limestone—Oxide of Iron—Clay— Silex.	1. Old red sandstone.
	Silurian System. 1.	Sandstone—Clay— Limestone.	1. Upper Silurian. 2. Lower Silurian.
Primordial Rocks.	Inorganic.	Quartz—Mica— Felspar—Hornblende—Hyperstene, &c.	1. Primitive clay slate. 2. Micaschist. 3. Gneiss. 4. Granite.

The mineral composition of the Neptunian systems shows that the materials, which form their mass, have, for a great portion, a fragmentary origin. They principally consist of compressed and cemented *débris*, such as sandstones and clays. But another part of those strata—limestone, iron, and silex—are the produce of chemical precipitates.

If, on the one hand, it is indubitable that the matter of the sandstones and clay has been, with few exceptions, furnished by the disintegration of pre-existing rocks; on the other hand, the limestone beds have a thickness so much out of proportion with the small quantity of lime contained in the granite and associated rocks, that we must attribute to them a distinct origin.

When we examine in a tertiary basin, surrounded by granitic rocks,* the relative proportion of the mechanical detritus and the chemical precipitates, we infallibly recognise that the limestones cannot

* See my *Mémoire sur le Fait de la Division des Terrains en un grand Nombre de Couches de différente Nature*,—'Annales des Sciences Naturelles,' November, 1829, p. 225.

be the residue of the decomposition of the surrounding masses, which have furnished the sandstones and clays; for these masses contain only an accidental proportion of lime of half to one per cent., whilst the limestone, which, on account of its state of solution and extreme division, must have spread to a greater horizontal extent than the sandstone and clay, composes nearly one-half of the total thickness.

The opinion that the calcareous matter might be an animal product, combined from simple elements by the vital powers of organic beings, has been perfectly well refuted by Mr. Lyell, and rests only upon a supposition of forces absolutely unknown in the actual order of nature.*

The calcareous travertins often containing oxide of iron, and the siliceous incrustations which are still deposited at the present time, show us, through analogy, the probable origin of the chemical precipitates which enter into the composition of Neptunian beds.

* See C. Lyell's 'Principles of Geology,' 5th ed., Vol. III., p. 300.

Thermal springs, so numerous in countries agitated by subterraneous movements, and which, from the most ancient geological periods, have left the traces of their passage in the fissures of the terrestrial crust, and deposited the walls of metallic veins,* have, most likely, supplied the greatest part of the substance of chemical strata in the various clysmian epochs. Now, as these springs appear to come from the same place as the melted mineral matter ejected by volcanoes, we can consider them as true lavas which, mixing with the atmospheric waters in the lakes or seas, where the latter have swept the detritus of the terrestrial surfaces, imprint the indelible mark of general Vulcanism even into the bosom of the Neptunian strata themselves.

§ II.

The division of Neptunian strata into periods, systems, and formation, as established on the order of mineralogical superposition, rests in part upon an unecrtain basis, for it is often difficult or even im-

* ' Recherches sur les Fossiles du Puy-de-Dôme.'

possible to fix the line where one division stops, and the division which follows begins. "A formation continues yet, sometimes with the one which succeeds to it; the beds melt imperceptibly the one into the other, so that one cannot determine the point of contact. . . . . A kind of conflict arises between the products of both epochs, their beds alternate, and those which predominate acquire the preponderance only after some time." But these very difficulties, opposed to perfect mineralogical divisions between the periods and systems, prove that we must not lose sight of the task which was the first aim of geological science, that of re-establishing the succession of facts by uniting the periods, systems, and formations through their primitive points of contact. It seems possible to unite all the epochs, and it is a most important result of the labours of Professor Sedgwick, and particularly of those of Sir Roderick Murchison, that notwithstanding the breaks between formations, systems, and periods, it will not be impossible to reunite the portions of this chain so often broken, and to reconstruct, through direct

observation, a complete chronological series of the Neptunian strata, by means of sections taken in localities where these strata have preserved their parallelism and their original normal relations.

§ III.

The only character of mineralogical division, perfectly clear and distinct, which belongs to all Neptunian formations, is that of the stratification in itself, that is to say, of the separation into small beds or parallel bands, whose thickness seldom attains to a few feet, and diminishes sometimes to the fraction of a line. These small beds have been as yet little examined as to their details, though this study might conduct to deductions not wanting in importance.

In fact, these distinct bands, considered in their most minute divisions, form a meteorological fossil history, whose leaves reproduce, with a sort of photographic exactness, the action of rains, seasons, storms, tides, currents, and other destructive agents on the surface of the globe, from the time when the earth

has begun to be moistened by waters falling from the atmosphere, and collected in lakes or seas. Concomitant accidents, such as the upraisings of the soil, and the displacements produced by water itself in Neptunian beds during their respective deposition, have, in a great part, thrown confusion amongst the strata; but it must not be forgotten that the remarks at the end of the last paragraph prove that in selected localities, the phenomenon of the division into small beds forms a complete register of subterranean meteorology, a kind of instrument which, applied with discernment to the measure of geological times, must have a practical value, which to this day has been almost entirely neglected.* The study of these small divisions is one of the *avenirs* of science.

* For more details see my *Mémoire*, before quoted, *sur la Division des Terrains,—Annales des Sciences Naturelles*, 1829; and *Annales des Sciences d' Observation*, Vol. II., p. 382. Consult also *Le Guide du Géologue Voyageur*, by Ami Boué, Vol. I., p. 369 to 371; and *Bulletin de la Société Géologique de France*, A. Boué, tome 1er, p. 119.

CHAPTER VII.

Organic Fossil bodies entombed in Neptunian Strata—Microscopic Animalcules—Successive Creations—Relations of Contemporaneity between Fossils and Mineral Strata—New Phasis of the question of the Eternity of the established order—Speculations of Lamarck and Geoffroi-St.-Hilaire—*The Vestiges of Creation*—Refutation of the Doctrine of the Transformation of Species—Ideas of Brocchi—Hypothesis of Mr. Lyell on the Destruction of Ancient Races and the Appearances of New Species, examined in its details, and rejected—Creation of Species the spontaneous result of a Supreme Will.

§ 1.

THESE Neptunian strata, resting on the first solid envelope of the globe, form an immense and majestic sepulchre, where are enclosed the remains of generations of organic beings, which the labours of the miner and the hammer of the geologist extract from their dark recesses; and whose kinds and species the patient genius of modern science re-establishes, classifying them in its systems, often with the assistance of a single fragment, or of a simple

cast or an impression which has, by chance, escaped the gnawing power of time.

We cannot consider without admiration, in their variety of species, and the singularity of their forms, these organized beings, of all classes, of which geology reveals to us the past existence. But with what astonishment is not our imagination seized when we contemplate the fecundity of the organic principle, manifesting itself by the production of individual existences in that which is infinitely small! The works of Ehrenberg have recently ascertained the presence of microscopic animalcules, to the number of twenty-three millions, or a thousand millions of individuals, in the space of a cubic line of stone or of siliceous iron! Thick beds, almost entirely composed of the shells of infusorial animalcules, cover large spaces in the new as well as in the ancient continent, and from the last investigations of the celebrated zoologist we have quoted, they are found in prodigious numbers in decomposed lavas, and even in the substance of scoriæ and pumice-stones! Does it not seem that the principle of life acts near the melted surface?

§ II.

The organized beings, whose precious spoils have been preserved in the stony shell of the earth, have not manifested their presence at the same geological epoch; and, according to all appearances, considerable intervals of time have occurred between the creation of the first inhabitants of the globe, and the appearance of the species which compose the actual population.

Now, innumerable observations, collected in every place where the eye of geologists has been able to penetrate, have caused it to be recognised as an established truth, that there is between the appearance of organic species and the order of superposition of beds, such a relation of contemporaneousness, that the remains of fossil species have become the best *criterion* of the age of the beds.

§ III.

Here comes again, in another of its phases, the question of the eternity of the established order.

Those who refuse to recognise the previous ex-

istence of the globe as an inorganic matter deprived of organic inhabitants, or who, in other words, defend the doctrine of the eternity of actual causes, required, in order to explain the extinction of ancient species and the creation of new races, an hypothesis in harmony with the Huttonian principle of a succession of events, without a beginning or an end.

Some of these philosophers, adopting the speculations of Lamarck, supported by the views of Geoffroi-St.-Hilaire, and recently reproduced by the anonymous author of the 'Vestiges of Creation,' have therefore supposed, in matter, the existence of an inherent principle, tending to produce a general type, viz., a simple vesicle, in the bosom of which another vesicle develops itself, endowed, like the former, with the property of engendering a new vesicle; and so on, without assigning a term to this progression. Thus would be formed, at first, animals of a simple structure, whose organs, modifying and adapting themselves to the conditions of existence in which they are placed, would, through a succession of slow transformations, assume forms more and

more complicated, and attain in time the most elevated organizations.

But the supposition of the formation of this elementary vesicle, however simple it might be, cannot dispense with the intervention of a designing principle, which must have endowed this same vesicle with all the attributes necessary to its development in superior organizations, comprising all the phenomena of intellect, with its most sublime individualities; and there is a wide difference between the admission of such a principle, and the supposition of an electrical blind force, capable of producing a nucleated vesicle in the midst of a substance *previously organized*, such as albumen, as the author of the 'Vestiges' proposes. There is not the slightest reason to think that the principle which could have had the power of placing in an elementary vesicle all the conditions necessary to its future transformation, could not create, by a single act, the complete being itself with its perfect organization.

As to the transmutation of species through gene-

ration, it will be sufficient to remark that there is not, in living nature, a single confirmed example of a permanent transition from one species to another; and that in the immense collection of remains which compose the natural history of fossil animals, there does not exist a single fragment which could be offered in evidence of the reality of the passage from one to another species.

Mr. Lyell opposes the ideas of Lamarck with considerable talent, and the numerous pages of his book devoted to this interesting discussion form one of the most brilliant parts of his 'Principles of Geology,' to which I can only refer the reader.

In his summing up this naturalist concludes—"That there is a capacity in all species to accommodate themselves, to a certain extent, to a change of external circumstances, this extent varying greatly according to the species;" but that "the species have a real existence in nature; and that each was endowed at the time of its creation with the attributes and organization by which it is now distinguished."

However, to explain the extinction of species, Mr. Lyell, after having rejected the idea of Brocchi, that the death of a species might be dependent on some peculiarity of constitution, as well as the death of individuals, considers as causes of destruction, the increase of human population, the development of some inferior species in numbers, and particularly the disappearance of the conditions of existence of species in their various stations. "Stations," says he, "comprehend all the circumstances, whether relating to the animate or inanimate world, which determine whether a given plant or animal can exist in a given place; so that if it be shown that stations can become essentially modified by the influence of known causes, it will follow that species as well as individuals are mortal."

After having examined the various organic causes of changes, Mr. Lyell arrives at the conclusion "that the organic causes of changes, by which species may become exterminated, must, throughout *myriads* of future ages, work an entire change in the state of organic creation." Whence he infers

that " the mind is prepared, by the contemplation of such future revolutions, to look for the sign of others, of an analogous nature, in the monument of the past;" and, at last, that these changes are an evidence in favour of the uniformity of the system, unless, indeed, we are precluded from speaking of uniformity when we characterize a principle of endless variation."—(chap. ix. p. 19.)

In the tenth chapter Mr. Lyell examines the influence of inorganic causes. " Every change," says he, " in the physical geography tends to the destruction of species;" and he thus arrives in the beginning of chapter xi. at the conclusion that the species existing at any particular period must, in the course of ages, become extinct one after the other, in virtue of causes analogous to actual causes, and that their successive extinction is a part of the constant and regular course of nature."

After having thus disposed of the argument relative to the extinction of species, in such manner as to leave in its integrality the doctrine of the invariability of the established order, Mr. Lyell looks out

for the means of reconstruction, or of the introduction of new species.

"Is it possible," he asks, "that new species can be called into being from time to time, and yet that so astonishing a phenomenon can escape the observation of naturalists? . . . . . Perhaps it may be said, in reply, that within the last two or three centuries some forest tree or a new quadruped might have been observed to appear suddenly in those parts of England or France which had been most thoroughly investigated."

But he refutes this objection through the consideration that "its force depends entirely on the rate of fluctuation in the animate world:" he remarks that "exclusive of microscopic beings, there are between one and two millions of species now inhabiting the terraqueous globe; so that if only one of these were to become extinct annually, and one new one were to be every year called into being, much more than a million of years might be required to bring about a complete revolution in organic life;" and as the mammifers do not form the thousandth

part of the animal kingdom, "if one species only of the whole animal kingdom died out in forty years, no more than one mammifer might disappear in forty thousand years in a region of the dimensions of Europe." "It is easy therefore to see that in countries of the size of England and France periods of much greater duration must elapse before it could be possible to authenticate the first appearance of one of the larger animals and plants."—(p. 151, ch. xi.)

At the end of the sixteenth chapter we have another glimpse at the idea of the eternity of the established order, even in regard to mankind; for though admitting the recent origin of man, founded on the argument of Berkeley (the absence of human fossils and objects of art in fossiliferous beds), he concludes in these terms: "None of the works of a mortal being can be eternal. . . . . Even when they have been included in rocky strata, they must nevertheless eventually perish; for every year some portion of the earth's crust is shattered by earthquakes, or melted by volcanic fire, or ground to dust by the moving waters on the surface. The river of Lethe,

as Bacon eloquently remarks, runneth as well above ground as below." Mr. Lyell here evidently alludes to metamorphic actions, which, in his theory of actual causes, must erase the marks even of human fossils. This *esoteric* conclusion appears to be in contradiction with what precedes, though it perfectly agrees with the Huttonian system.

The philosophical consequences which can be deduced from Mr. Lyell's views on the extinction of ancient races and the introduction of new species, are that these changes depend on causes analogous to the actual operations of nature. He gives, it is true, fair reasons for the extinction of a few species. But what is the principle which presides at the appearance of new species? He seems to consider this principle as a law belonging to the established order, but whose action manifests itself at such remote distances of time that it is not given to us to observe it in the short duration of our existence. All that he tells us respecting the cause of their successive creation is, that it constitutes, "like their gradual extinction, a regular part of the economy of nature."

New species of trees or mammifers, insects or fishes, appear, from time to time, on the earth, just like mushrooms, distributed here and there, without it being possible to trace the origin of the germ, or without it being necessary to consider this extraordinary event, as a fact distinct from the phenomena which constitute the regular order of nature!

The system would have been more rational if Mr. Lyell, modifying the ideas of Brocchi, had supposed a natural limit to the existence of the species, and, at the same time, an inherent organic principle which would have caused it to give birth, at the moment of its destruction, to a superior species, through a process similar to that of the metamorphosis of insects, from the state of larvæ to that of a fly or butterfly. He might have considered, for instance, the trilobites as larvæ destined to procreate, at the moment of their extinction, as species, the new families and the new genera which succeed to them. The species of fishes of the old red sandstone would have been the tadpoles of the species which have followed them; he might even have advanced that Nature had employed, for

the production of new classes, means different from those which are known to us; that prolific aggregations of trilobites might have engendered the Saurian reptiles, which in the Permian and Triassic systems succeed to these crustacea which entirely disappear in the last of these systems. But though Mr. Lyell's views, thus modified, would have appeared more intelligible, these suppositions would have added nothing to the probability of the hypothesis itself.

It is easy to see that this hypothesis presupposes that organization and life have existed from all eternity on the earth. If, as Mr. Lyell proposes, we admit a kind of natural law, in virtue of which a new species appears to replace another species, which becomes extinct, we find ourselves placed in the alternative of admitting, either that a number of species equal to the number of the present species has existed from all eternity, or that there has been a general primitive creation: otherwise *the earth would never have been tenanted but by a single species.* Since, therefore, Mr. Lyell has entirely left aside the question of a general primitive creation,

he must have admitted as his starting point the eternity of a condition similar to the actual state.

In fine, the doctrine of the destruction of species one by one, and of a corresponding creation, falls before the general fact, so well established, of the simultaneous appearance of numerous species in the same strata, and of the sudden disappearance of other species in the same beds at contemporaneous geological epochs, or at least at very short intervals of time. If Mr. Lyell should pretend that his system is not opposed to the belief in a primitive original creation, this pretension would be fatal to the doctrine of actual causes, and would be equivalent to abandoning the Huttonian philosophy *in toto*.

§ III.

The only conclusion to which we can be led by the fact of the succession of fossil genera and species, entombed in the solid strata of the globe, is then, that the creation of organic beings was the spontaneous result of the intervention of a Supreme Will. All these creatures have, in their forms and habits,

common features, because all are the result of the same Divine thought; but they possess also distinctive characters, not only because the intellect which has presided at their creation has adjusted their forms and attributes to the circumstances of time and place, in which they were to find their conditions of existence, but also because their Author has chosen to manifest his power by the multiplicity of types, whose variety we admire in the harmonious assemblages, which he has been pleased to distribute through each epoch.

CHAPTER VIII.

Changes in the Organic Kingdom—Connexion between the Phenomena of the destruction of Species, the appearance of New Races, and the breaking up of the Surface of the Globe—Hypothesis of the Author published in 1828—Objections of Sir Roderick Murchison against this Hypothesis—New developments—Application to the condition of European Russia—Objection from the character of the Organization in the Permian System—Development and Practical Application of the Hypothesis by M. Elie de Beaumont—Examination of these Developments—Two great Hiatuses dividing the Fossil Organizations into three distinct populations—Examination of M. Pictet's opinion on the Speciality of the Fossils in each formation—These opinions have little consistency.

§ 1.

WHAT are the particular circumstances of time and place which have accompanied the appearance and the extinction of the organic species on the earth?

Such is now the question which must be examined by those geologists who reject the doctrine of the eternity of the established order.

With this question we must unite that of the changes which have happened, since the epoch of the appearance of organization, down to the present times, for the existence of species must be in relation with the condition of the surfaces, and the composition of liquids and ambient fluids.

The direct influence of heat; the modifications introduced in the composition of the atmosphere, which have been the result of this influence; the invasion of the solutions of the mineral substance, employed to form the solid framework of organized beings, and which has very likely furnished, at the same time, an excess of carbonic acid destined to feed the plants, show that the successive phases of the refrigeration of the globe have a necessary connexion with the condition of existence of the populations which at various periods have inhabited the surface.

§ II.

But there is an order of phenomena which we cannot neglect taking into account, in the appreciation of the relations of central actions with the ex-

tinction of species, in the midst of the terrestrial strata, and of their replacement by new creations.

If, on the one hand, we see entire generations suddenly disappearing, and giving place to other populations; on the other hand we perceive geological periods separated, in some countries, by events which have broken up the surfaces, either furrowing them with deep ravines, or scattering the strata, through subterraneous commotions, with an energy which appears unknown in the annals of the actual epoch.

Now, the observation of these phenomena, and of their possible connexion, had, from the year 1828, inspired me with the idea of an hypothesis, in which I endeavoured to establish a relation between the gradual refrigeration of the globe, the formation of fissures and veins, the upraisings of mountains and scooping out of basins, the displacement of strata, and finally the destruction of ancient races, and the creation of new species at corresponding periods.*

* See *Recherches sur les Ossemens Fossiles du Puy-de-Dôme*, par l'Abbé Croizet et Jobert aîné, 1 vol. 4to., Paris, 1828,

§ III.

It is to this hypothesis that Sir Roderick Murchison alludes, in the conclusion of his work on Russia, of which I reproduce the following passage.

"The theoretical doctrine derived from an examination of a small portion of the globe, which supposes that the termination of groups of former organic beings was entirely dependent upon contiguous eruptions, which, ravaging the earth at given periods, and dismembering the former beds of the ocean, destroyed its existing inhabitants, must therefore bend before such copious evidences. These evidences most clearly announce, that over spaces as large as other European kingdoms, the sediment of one palæozoic period was accumulated around the relics of a peculiar set of animals, and then tranquilly succeeded by another large formation, where different groups of creatures were brought into being,

pages 115, 117, 122, &c. I think I ought to take the sole responsibility of this hypothesis, which I had reserved to myself to develop, as may be seen page 108 of the *Recherches*.

without any sudden revolutions or fractures of those portions of the crust of the planet."*

I may be allowed to remark, here, that I do not attach to my hypothesis any other importance than that which it may deserve, as an attempt to bring together facts which appear to have relations of concomitance; and I sincerely confess that it is a satisfaction for me to see that these ideas, published for the first time in 1828, form still the *frame* in which a great number of geologists continue to arrange their arguments. However, I am quite disposed to give them up, if it is shown that they have become insufficient. The supposition that they may have contributed to the advancement of the science will always be for me a source of consolation, when the hypothesis shall have been absorbed by a conception better adapted to the facts.

Nevertheless, the moment has scarcely arrived for repudiating entirely this hypothesis; for imperfect as it is, one cannot see very distinctly what could be put in its place.

* Russia, p. 584.

When, without taking into account the fact of the refrigeration of the globe, which has so very probably acted as a cause, we consider simply these three great generalities which science has acquired—

Firstly—The destruction of ancient species;

Secondly—The creation of new organic types;

Thirdly—The great changes and dislocations which the earth has undergone on its surface and in the thickness of its crust;

we naturally ask ourselves whether there is not, between these generalities, some intimate relation of contact or dependency. When we picture those broad movements of the soil, which seem to have raised the Pyrenees and the Apennines, towards the end of the period represented by the cretaceous system; and when we see the whole of the species disappear, engulfed in this system, and to yield the place to an entirely new population, we cannot help being impressed with the idea that the dislocation of the crust—which has taken place between the two facts of a general organic destruction and a subsequent crea-

tion—has some connexion with these two facts, and has produced the modifications in the conditions of existence which have exterminated the ancient races, and called forth the renewed intervention of the organizing power.

It is to be remarked that, even if the solid crust of the globe had been entirely disrupted, at the end of the cretaceous epoch, it would not be to the material fact of the breaking up, alone, that the hypothesis would attribute the destruction of contemporaneous races, but *to the change in the conditions of life produced by the disruption;* and the idea that this breaking-up has evoked the creative power which has produced the next population, seems forcibly to impose itself on the imagination.

A general or only a partial revolution, even in modifying the conditions of organic life, must have allowed the greatest part of the strata composing the crust of the globe to retain their horizontality; and Sir Roderick Murchison recognises grand and broad movements of elevation and depression, to which the whole country of Russia has been sub-

jected, without the primitive horizontality of the strata having been altered.

We could compare a general disruption of the terrestrial envelope to the breaking of the ice on a frozen lake, without an issue; the fragments of the sheets of ice, resting on the surface of such a lake, will undergo little displacement, and if the frost comes again soon to reunite the pieces, the most part will have preserved their horizontality. The whole of European Russia, situated in the triangle which might be traced from Denmark to the Caspian Sea, from the latter to the northern extremity of the Ural, and from this point to Denmark, forms a frozen piece, which, immense as it is, represents only a fraction of the surface of the whole globe. The eruptive rocks which have raised, and often metamorphosed the chains of Scandinavia, the Caucasus, the Carpathian, and the Ural mountains, seem to mark the lines of soldering of this enormous fragment.

§ IV.

"But," says the learned author of the article on

'The Vestiges,' in the *Edinburgh Review*, speaking of the Triassic system,

"It is not too much to say that Nature has destroyed all her old moulds of workmanship and begun a new work on a different plan; yet is there no break or interruption in the regular sequence of deposits: we accept these facts of Nature as we find them. The physical conditions of the earth were changed, and creative wisdom called into new being organic structure to suit the change."

We must, however, remark that a powerful convulsion has taken place between the Permian and the carboniferous system; and though this convulsion does not appear to have destroyed the carboniferous types (a circumstance which may authorize the classification of the Permian system in the upper part of the Palæozoic series), it may have happened that the conditions of organization have been modified but slowly and by degrees, after the disruption of the strata anterior to that system, up to the time when these conditions have been so transformed, that all the ancient races have become extinct, and the

Triassic era, so graphically described by the clever writer above mentioned, has begun.

After all, and though several eminent geologists, amongst whom the celebrated Agassiz, in opposition to Sir Roderick Murchison, persist in separating the Permian system from the Palæozoic period, and placing it in the secondary period, I cannot conceal from myself that the difficulty is a real one, though it does not appear weighty enough to cause the definitive rejection of the hypothesis of a relation of concomitance between the great disruptions of the solid crust, the destruction of ancient races, and the creation of new terrestrial populations; especially when no other idea offers itself in place of this hypothesis to unite these three great geological facts within the same view.

§ v.

Pursuing this hypothesis, of which I had traced the first sketch in 1828, of a coincidence between the refrigeration of the globe, the raising up of mountains, and the changes in organic types, M. Elie de

Beaumont employed himself in 1829 to develop it by practical applications, and has imprinted upon it a special character; dividing the Neptunian formations into twelve systems of upraisings, corresponding each to a fossiliferous division: he has even added, to my original hypothesis, the ingenious view that all the chains of mountains of the same epoch are situated on parallel lines, whatever may be the locality which they occupy upon the earth; and if this additional view is opposed by many geologists, it has no less led to the recognition, as Sir Roderick Murchison remarks, that though various epochs of upraisings have successively taken place on the same line, the directions imprinted by the first upraisings are often placed on independent lines; as, for example, the mountains of Scandinavia, the Ural, and the Caucasus.

The applications of M. de Beaumont, and those undertaken by the geologists who have adopted his views, have powerfully contributed to the establishment of the *systems* and their sub-divisions in *formations* and *sub-formations*.

The supposition of a coincidence between the twelve systems of upraisings of M. de Beaumont and twelve epochs of sedimentary deposits, with corresponding organic modifications, appears admissible within certain limits; for each system is in part characterized by its own fossils. However, we must not forget that there are only, in reality, two great hiatuses which separate into three populations * the fossils contained in the whole mass of the Neptunian formations, viz., the hiatus which isolates the Palæozoic populations comprised between the basis of the Silurian system and the Permian system inclusively, and the hiatus between the tertiary period and the chalk.

Though each system is distinguished by characteristic species, other species appear to continue with the new ones; so that to admit a destruction and a complete renewal between each system, we should

* I do not here take into account infusorial animals, because it is too difficult to determine the species. I also neglect the two species of shells which are supposed to belong at the same time to the tertiary and the cretaceous systems.

be obliged to suppose that species whose remains are absolutely like those of the species which have preceded, have been created anew, together with those which show themselves for the first time; and thus adopt the singular creed which is transmitted to us in the verses of the Latin poet, when he describes the times which have followed the Deluge of Deucalion :—

" Tellus . . . . . .
Edidit innumeras species: partimque figuras
Retulit antiquas: partim nova monstra creavit."
Ov. Met., Lib. I.

§ VI.

The absence of some species in inferior strata, and their disappearance in superior strata, do not prove that these species have only existed during the middle epoch of a system; for the cause of this absence may depend on the emigration of the species, on their small development in numbers, and on fluctuations in the conditions of existence in the same locality. There are numerous examples of the disappearance in some middle beds, of species which are

met with in the superior and inferior beds of the same system.

We may judge from the discoveries which have taken place, in the last few years, in the middle of the geological epoch represented by the supercretaceous period, how unsafe it would be to draw definitive conclusions from the fact of the absence of some genera, or some species, from one formation, or one system to another. No doubt a great number of species have made their appearance, and others have disappeared, in certain particular beds of the periods, and even of the systems; but it does not follow that the time of their birth and of their extinction coincide with the place of our observations. Until very lately, geologists had fixed the epoch of the appearance of quadrumanes above the theoretical line which separates modern from ancient alluvium; but subsequent discoveries have shown remains of quadrumanes, which have not yet been well distinguished from living species, as low as the inferior part of the tertiary system.

Notwithstanding this, M. Pictet, a distinguished

palæontologist, professor of anatomy at Geneva, adopting the divisions of M. de Beaumont, and of the geologists who follow his classification, has lately advanced the opinion that each formation contains only its own species, and that the animals of the geological epoch corresponding to that formation have lived neither before nor after. He supports his opinion, in great part, by the consideration that the fossil remains which we are enabled to examine, such as shells and bones, might have belonged to species whose differences consisted in the soft parts, which have not been preserved.

The opinion of M. Pictet, though it is, to a certain extent, entertained also by M. Agassiz, appears too hazardous, no decisive argument having been produced in its favour; it does violence to the numerous facts of the passage—from one formation, or even from a system, to another—of species whose identity cannot be contested on the authority of a simple assumption, or of an allegation without any proof.

CHAPTER IX.

Ancient Alluvium—Erratic Blocks—their dispersion through Local Causes proved by Sir Roderick Murchison—Gold and Platinum in Ancient Alluvium—Philosophical remarks on this subject.

§ 1.

The last geological event, preceding the period of tranquillity and regular succession which comprehends the whole of the historical era, is that which has produced the dispersion of erratic boulders in the middle of the ancient alluvium. These boulders, and the alluvium accompanying them, had been long considered as the result of a great diluvian catastrophe, which had destroyed the population contemporaneous with the mammoth and the great mastodon. As far back as the year 1828, my collaborator (M. l'Abbé Croizet) and I, in our '*Recherches sur les Fossiles du Puy-de-Dôme*,' had contributed, as well as we could, to erase from the French nomenclature the Theory of the *Diluvium*,

and Messrs. Lyell and Murchison, in the course of the following year, published a memoir which terminated this error in England. It remained to clear up a very difficult question, which, even now, excites a lively controversy amongst geologists. This question is that of erratic blocks, or boulders—that is to say, of those enormous fragments of rocks, for the most part granitic or crystalline, spread upon the surfaces in various localities, and which occupy an important place in the ancient alluvium.

Sir Roderick Murchison has established that the alluvial deposits and the erratic blocks, which cover an extent of 2,000 miles, in the line passing from the German Ocean to the White Sea, and advance from 400 to 800 miles into the interior of the land, come from the mountains of Scandinavia; and that all these materials have been transported, in the bed of an ancient sea, through aqueous movements, "consequent on powerful waves of translation, and of currents occasioned by relative and often paroxysmal changes of level of sea and land,"*

* Russia, p. 553.

a circumstance that the presence of marine shells appears to prove in an irresistible manner.

Although geologists may differ on details, according to the localities which each has particularly examined, and without entering into an examination of accessory circumstances, such as the transport of the blocks upon frozen surfaces, their descent on the declivities of mountains with icebergs, their floating upon fragments of ice, I shall merely remark, that Sir Roderick has demonstrated that the dispersion of these blocks is owing, like that of the ancient alluvium, to local causes, which have no connexion with a general cataclysm, but with great local displacements of water. If, as M. de Beaumont thinks, such movements of the soil and of the waters have taken place on the margin of written history, the traditions of various deluges have perhaps no other origin than the memory of these great events.*

* We find in the second *Oratio* of Gregorius Nazantinus, against Julian, a most curious passage, which would seem to give some weight to this opinion, and even has a singular relation of resemblance to the questions above discussed:—

"Talem manifestavi monstrum (Julianum) quale antea

§ II.

I cannot better finish this chapter than in reproducing here the remarkable conclusion at which Sir Roderick Murchison arrives on the occasion of the ancient alluvium of Russia.

"The only detritus in which grains and portions of gold and platinum have been found is, in truth, that in which remains of mammoths and rhinoceroses have also been detected; and coupling this last fact with the omission of all auriferous veins in the more ancient alluvia of the chain, there can be no doubt that in this region gold was one of the most recent mineral productions anterior to the historic æra."

Now, it is extremely probable that the veins and auriferous penetrations in the American continent, which, according to Mr. Necker, are the result of a sublimation produced on the contact of igneous rocks, or at a short distance from them, may be

nunquam fuisset, tamen si multa diluvia, multaque divulgata fuerint incendia, terræ quoque apparuerint hiatus, nec non homines ab humano natum penitus diversi, animalia monstrosa et diverso modo composita quæ natura modo innovandi producere solet."—*Leipsic edition*, 1522, p. 18.

referred to a time contemporaneous with, or little remote from, the metallic and alluvial impregnations of the declivities of the Ural.

The philosophy which it is natural to deduce from these circumstances, is that gold, this powerful prime mover of civilization, the general vehicle of the distribution of the riches produced by human industry, and platinum, which has become in the hands of the chemist the most powerful instrument of analytic research and scientific progress, have made their appearance upon the globe just after the last events, which have placed the continents in their present conditions. These metals did not exist in the soil at an æra when they would have been without value to creatures endowed with limited instinct; but they have been poured, from the interior, in the midst of the resources accumulated from period to period, for the use and the instruction of a being endowed with reason, as the complement of the gifts which a foreseeing wisdom has been pleased to lavish upon the surfaces destined for his sojourn!

CHAPTER X.

Concluding remarks—Analysis of the preceding Chapters —Nebulous Theory—New Views for the Classification of Facts which have preceded the Igneous Fusion of the Globe —Oxygenation of Bases—Molecular Oxygenic Attractions —Elective Attractions—Constitution of Comets—that Molecular Attractions did not exist at a time when the Atoms were already gathered in Virtue of the Law of General Attraction—Constitution of the Æther—The Law of Molecular Attraction due to the Special Intervention of the Creative Power—Idea of Zeno reproduced by Boscovich—Abstract Idea of the *Point*—Idea of Atom—Divisibility of Matter—Natural Limit of this Divisibility—Atoms of the Chemists—Atoms of the Philosophers—Mr. Faraday—Examination of the Theory of the *Centres of Forces*—Mr. Airy—Arrangement of Mineral Terrestrial Substances explained by the Hypothesis of the development of Molecular Attraction at a Special Time—Formation of Water and Atmosphere by Transudation.

§ 1.

We have established, in the preceding pages, that the philosophical generalizations of Hutton rest upon an error of logic, founded on the restricted signification which metaphysicians have assigned to the idea of *causation*, in confining it to the doctrine of

the invariable antecedent and the invariable consequent. We have shown also, that the systematic classifications of geological facts, grouped around this doctrine, do not afford it any real support; that the phenomenon of the stratification of crystalline schists cannot be cited in favour of the monstrous hypothesis of an eternal metamorphic action; and lastly, we have proved that the facts relating to the creation of organic types cannot be explained without the direct intervention of a Divine will; and that this intervention has manifested itself as often as new conditions of vegetable and animal life have presented themselves, on the cooled surfaces of our globe.

It now remains to inquire whether we may be allowed to go back to the time anterior to the liquid state of the mineral matter, whose refrigeration has formed the granitic and crystalline mass of the terrestrial globe?

Here it would be natural to institute an inquiry into the nebulous theory of William Herschel, adopted by La Place, and, even in these last few

years, by many geologists and mathematicians. This theory, however, has been deprived of its prestige by the reduction of a great number of nebulæ into groups of distinct stars, through the powerful telescope of Lord Rosse; and it would be merely a gratuitous supposition, to imagine that the nebulæ which might resist the power of this telescope are not also composed of stellar aggregations; for the natural induction is, that distance alone prevents their decomposition.

It is in the structure of primordial rocks that we ought to inquire into the condition of matter before its state of igneous liquidity, but the study of the terrestrial crust, under this point of view, has not yet been undertaken.* The metamorphic transfor-

* There are, however, a few facts which can be made to bear upon this subject, such as the following:—

Dr. Mac Culloch, in his papers on the geology of various parts of Scotland (Trans. of Geol. Soc., vol. ii. p. 432), describes specimens of tourmaline, from the veins of granite of Portsoy, broken across their axes: "the fractures are filled by the quartz and felspar, which constitute the body of the rock."

Here it is evident that the tourmaline has first passed to the solid state, since the quartz (and felspar?) has filled up

mations, to which the Huttonian doctrine attributes the condition of crystalline schists, form a kind of impediment which geologists have scarcely thought

the cracks; and that the tourmaline was, at a certain stage, in a highly elastic state, since another crystal (an acicular one) "is bent so as to form a considerable curvature."

It seems also, from particular phenomena observed in the Falkland Islands, and very accurately described by Mr. C. Darwin (Quarterly Journal of the Geological Society, 1846, No. 7), that the quartz-rock (which composes hills and hillocks in these regions) "must obviously have been in a pasty condition when it suffered abrupt curvatures without fracture; and it was impossible to examine these veins without recognising in them the effects of the stretching, and in the fibres, or imperfect crystals of quartz, the adhesive nature of the ductile mass." (Page 373.)

Mr. Darwin also quotes the following note:—"In a paper by M. Elie de Beaumont, read before the Société Philomathique, May, 1839 (L'Institut, 1839, p. 161), it is stated that M. Gaudin was able to draw out threads of melted quartz. M. Gaudin also found that quartz (differently from alumina) retained its viscidity for some time when cooling,—a fact to be borne in mind when we attempt to account for the remarkable flexures which nearly all the quartzose ranges in this island, and likewise in many other parts of the world, have undergone."

On the other hand, I have examined with some attention several specimens of graphic granite, sent to me by Mr. Tennant, with the view of assuring myself whether it was possible

of removing. Indeed, if we consider the anterior state of the crystalline schists, and of the granite itself, as a fragmentary state, analogous to that of

to trace in the structure of this granite the process of crystallization. I succeeded in isolating a certain number of crystals of quartz from the midst of the felspar, and found that, in general, the crystals were flattened and contorted as if they had been strongly pressed between the felspathic mineral matter. It is very remarkable that these crystals, even the most flattened and distorted, still retain corresponding prismatic faces; upon the most disfigured I often succeeded in discovering, though sometimes with difficulty, the corresponding sides of the prisms; and when I could not entirely succeed, it appeared to be because the crystal was in part broken. I can only account for these distortions by supposing that the crystals were first formed in the melted mass, but remained in a pasty, or jelly-form state, after the consolidation of the felspar: a conclusion which perfectly agrees with the remarks of Messrs. Mac Culloch, Darwin, and Gaudin, and shows how quartz (not in a liquid, but in a soft state) may have been squeezed into cracks, veins, fissures, dikes, and even into lateral beds, through the pressure of superincumbent masses. But quartz, being pure oxide (or acid) of silicon, must have existed in a melted state before the tourmaline, felspar, &c. &c. began to crystallize —for these minerals contain a portion of quartz, and are necessarily second, in the order of production, to their constituent elements.

The probability is that the quartz formed first into soft crystals, yielding to the influence of elective affinities the

the fossiliferous strata, the study of primordial rocks stops at that invariable antecedent, and science can only continue to move in the circle of infinite metamorphic changes, marked out in Mr. Lyell's system.

The hypothesis of the igneous stratification of crystalline schists, places the theory of the igneous fusion of the globe again on its original basis; it leaves an open field for new researches, without any other limit to the powers of science than the imperfection, or the present insufficiency, of our investigations.

Now, without attaching an exaggerated value to the following views, they will at least help me to demonstrate that it is not impossible to arrive, through a chain of inductions, at the classification of the facts which have preceded the igneous fusion of the

portions which were necessary for the development, or combination, of the other specific elements, distributed in the mass. Then the mica, the felspar, the tourmaline, and other complex species crystallized and became solid; whilst the quartz retained still, for a time, its soft or pasty condition.

globe, in their natural order of ascending succession.

§ II.

The fact of the oxygenation of earthy bases, such as silica, alumina, magnesia, potassia, sodium, &c., has necessarily preceded the phenomenon of elective affinities, which has produced the complex mineral species, such as felspar, mica, tourmaline, hyperstene, hornblende, &c.

The fact of oxygenation being the result of a molecular attraction between the oxygen and the metal of the bases, presupposes the individual separate existence of the oxygen and of the metal of the bases, before oxygenation.

We, therefore, distinguish here two kinds of molecular attractions, which have succeeded each other in the following order :—

1°. Molecular oxygenic attractions.

2°. Molecular elective attractions.

But we can carry the argument further, and conceive a condition of matter independent of the

molecular oxygenic and elective attractions considered together.

May we not be allowed to ask if these attractions exist now in the constitution of comets? These bodies, endowed with a simple motion of translation, are, like the planets, regulated by the laws of celestial gravitation; but, is it not because molecular affinities are wanting in the particles of which they are formed, that they have not a nucleus?

However this may be, the fact alone that molecular oxygenic attractions have manifested themselves at a fixed time, leads us to the idea that matter has not been eternally endowed with the quality of molecular attraction; and by this I wish to express, not only the opinion that molecular attractions have begun to act, at the moment when matter has been sufficiently condensed to allow atoms to unite; but that the property of molecular attraction itself did not exist in atoms, at a time when they were already gathered together in clusters, in virtue of the law of general attraction.

Pursuing induction within its legitimate limits, we

can yet deprive matter of the two qualities of celestial attraction and proper motion, and arrive thus at the idea of a simple æther, uniformly diffused through infinite space; the atoms whereof, maintained in their relations of distance by a mutual repulsion, wait until supreme immanence gives them the quality of gravitation, and communicates to them proper motion—the life of inorganic matter —then molecular attraction—the law of love between atoms.

Now, as such an æther appears to be yet existing, is it not from its essence that the materials which compose the stars and clusters of stars have been drawn?

§ III.

In all the philosophical systems which have succeeded each other to the present time, from the Hindoos, the Egyptians, the Chaldeans, the Greeks, to the most recent theories of modern science, atoms have been considered as passing from the æthereal condition to the fluid, liquid, and solid state, in virtue of a constitution inherent in them, or given to them

along with all the other qualities of the common matter of our globe. According to the new views which geological studies open, in my opinion, to philosophy, the atoms did not possess, in the beginning, the aggregative qualities which they now present, but received them, from the hand of the Creator, at the moment when they were necessary to effect the transformation required.

If it be granted that life, instinct, intellect, and reason have been attached to matter at a certain time only, why should we suppose that general attraction, proper motion, and molecular attractions have not also come successively, in order to endow the atoms with the qualities needful for astral individualities, and necessary to the liquid condition, and to the crystalline forms? and if, in order to explain the appearance and the development of organic creations, we have been obliged to have recourse to distinct manifestations of Divine intervention, why should we not attribute to the same influence the dispensation of those qualities which have brought inorganic matter to its perfect state?

§ IV.

These propositions, far from being hostile to the chemical doctrine of definite proportions, appear to form an argument in its favour; because they suppose primordial atoms endowed with similar forms and equal volumes. The union of these atoms, in numbers, has, in these views, produced the bodies which chemistry calls simple.

The idea of Zeno, revived by Boscovich, and which is equivalent to the theory of Berkeley, "that the atoms have no real existence, but consist in a number of points," seems to have its origin in an error of dialectic. We cannot conceive a point without extension. The abstract idea of the point, in geometry, rests on the conception of a fraction of matter so minute, that its volume could not produce an error in the results of calculation. But this abstraction cannot sever the idea of a point from the idea of matter.

The idea of particle, molecule, or atom, is the result of analogical reasoning applied to the divisibility of matter, and brought to its last limit.

If we divide a grain of sand into two parts, until the individuality of each fragment has become inappreciable, the mind can still take hold of this fragment and continue the division by a mental contrivance. Whatever may be the extreme which imagination can reach, the particle, whereof our power of thought has not relinquished its hold, will retain its material quality; and if we could not fix a limit to this division, we should necessarily arrive at the idea that matter is infinitely divisible. But *science has traced a natural limit to this decomposition*—a limit not the less distinctly marked for having hitherto been unheeded.

§ v.

Each imperceptible fragment of this grain of sand, which our idea only can seize, is not composed of an homogeneous substance. Chemistry informs us that it can be decomposed into two or more parts (each having a distinct nature), which have united to form mineral species in definite proportions. Mental division, of necessity, stops at the moment

when it finds itself in presence of particles having each different properties. Whatever may be the real minuteness of the constituting parts of the oxygen and silicium, which compose a fragment of quartzose sand, the distinct properties of their atoms, and the similarity of their combinations, give to each of these atoms a character of *individuality*, and likeness* with its congeners, which require us to attribute to them a form and a fixed bulk.

It would be useless, for the argument here pursued, to penetrate farther into the constitution of this atom. Chemical science is obliged to consider it as simple; and if the preceding deductions are not tainted with some logical imperfection, it must be received as a demonstrated proposition that *the atom of the chemists has a real existence.*

§ VI.

The modern philosophers, who have discussed these questions, have fallen into a mistake in ap-

* This has been, in part, perceived by Sir J. Herschel. See *Discourse on Natural Philosophy.*

plying to atomic philosophy arguments grounded on phenomena studied in the relations which obtain between the chemical atoms themselves. Hence arises much of the confusion which has invaded science.

Notwithstanding all my admiration for the profound knowledge and the generalizations of Dr. Faraday, I do not think that his system of centres of forces can be supported for an instant, in opposition to the argument just produced in favour of the absolute existence of the chemical atoms.

I cannot see why Dr. Faraday should omit to take into account the specific qualities of simple bodies in themselves, and prefer to repose his speculations on the interstices, assuming that these interstices ought to be invariably open or invariably shut to the passage of the electric fluid; whilst it is evident that they can only be under the influence of the force which preserves the molecules united, and that it is to this force, residing in the molecules, or to a property attached to it, that the conductible or non-conductible qualities of bodies ought to be attributed.

Dr. Faraday has not established a distinction be-

tween the atoms of the chemists and the atoms of philosophers, which are things so very distinct. He has committed the mistake of comparing the matter of the æther with ordinary matter.*

To produce an argument in favour of the non-absolute existence of the atoms of philosophers, it would be necessary, according to Dr. Faraday's manner of reasoning, to study the relations between æther and the interstices of æther, and not, as he has done, the relations between the substance and the pores of rosin or iron. It would be necessary to discover the nature of the force which maintains the equilibrium between the atoms of the æther—a force which we have considered as an inherent repulsive quality. Analogy leads us to believe that the atom of the chemists is a multiple of the atom of the philosophers, and we have the authority of astronomers in favour of the resisting quality of æther; a circumstance which, as remarked by Mr. Airy, Dr. Faraday has omitted to take into account. It

* Philosophical Magazine, vol. xxviii., p. 346.

forms, however, a powerful argument in favour of the atomic philosophy.

The expression, "*centres of forces*," can only be considered as synonymous with that of *point*; and a change of words cannot add any weight to an argument. Moreover, what *could* be the forces composing these *centres*?

The atom of æther is imponderable—Dr. Faraday admits it—the only qualities we can suppose it endowed with being, *firstly*, size and form—qualities so united that the one could not subsist independently of the other. Hence we ought to consider them together as a single quality. *Secondly*, The other quality would be the repulsive property manifested by one atom towards other atoms. Now, the expression of "*centres of forces*" having for its end to deprive the atom of the double quality of form and size, represents the repulsive property only. But how can we conceive a repulsive property which constitutes, by itself alone, a *centre of forces*? We see, then, that here there is absolutely nothing whereon an idea can rest, and that the hypothesis has no consistency.

As regards the interstices of the æther. . . . . Arrived at this *substratum*, we have reached the bounds of human intellect. It only remains to consider the repulsive property attached to the atoms as the effect of a latent Will, which maintains them in inertia, or arranges and moves them at pleasure, to form worlds and systems of worlds.

§ VII.

It is easy to conceive the arrangement of the mineral substances in the interior of the earth and on its surface, through the hypothesis that the law of molecular attraction has only been communicated to matter after the atoms have been gathered into stellar and planetary groups, in the state of fluid or semi-fluid masses.

It seems probable that the law of molecular attraction has developed itself simultaneously, in all the bulk of the terrestrial mass, and that it has produced, at first, the *similar affinities* which generate simple bodies, such as oxygen, silicium, &c. As soon as the simple bodies gifted with specific

affinities have been in presence of each other, matter has passed to the liquid state, on account of the powerful affinity between the oxygen and the earthy bases which form the great mass of the globe. In this melted matter, elective affinities have, at last, determined the production of complex species, and these combinations are still going on in the interior of the globe, in proportion as the refrigeration and crystallization advance.

Nothing proves that water and air have originally surrounded the surface of our planet; the hypothesis that the oxydation could have proceeded from the surface to the centre is absolutely unintelligible. The little quantity of oxygen contained in the air, compared to that which exists combined with the mass of the globe, makes it probable that the air has been disengaged from the interior, in the same manner as carbonic acid escapes, even at the present time, either in a free state, or by the intermedium of thermal springs.

The presence of water in notable quantities, in the crystallization of Vulcanian rocks, and the ac-

tual fact of the interior aqueous exudation, which produces thermal springs, show us that water also may have spread itself on the surface by a kind of transudation, in proportion as matter has become consolidated.

Air and water would only then have covered the surface in consequence of the refrigeration, at a period when animals and plants could find their conditions of existence in these media, which the wisdom of the Creator had destined for their abode.

CHAPTER XI.

General Summary.

The main proposition I have endeavoured to demonstrate in this work, is that the phenomena which have succeeded each other on the terrestrial globe, and in all the sidereal system our inquiries can reach, must be considered, not as the consequence of an eternal law of invariable revolutions, enclosed in the circle of the uniform movements which governs the actual order of things, but as the result of the repeated intervention of a supreme Providence, whose thought has successively brought out the actual order, after having directed matter in all its transformations, and left, from period to period, visible traces of its power, its solicitude, and its munificence.

In perusing the pages of this little book, the reader will recognise, I hope, that, in all my investigations, I have not, for an instant, lost sight of

those remarkable words of one of the greatest lights of science, which the present century has seen extinguished, words that I have adopted as my motto:—

"We know all things begin from, and end in, his everlasting Essence, the Cause of causes, the Power of powers."
Sir Humphry Davy.

NOTE ON THE ATOMIC PHILOSOPHY OF THE ANCIENTS.

"ATOMICAL philosophy, according to Posidonius the Stoic, as we are informed by Strabo (lib. xvi.), is more ancient than the times of the Trojan war, and was first invented by one Moschus, a Sidonian, or rather, if we prefer the testimony of Sextus Empiricus, a Phœnician (Advers. Mathemat., p. 367). This Moschus is doubtless the same person with that Moschus the physiologist mentioned by Jamblicus in his Life of Pythagoras, for he informs us that Pythagoras, during his residence at Sidon in Phœnicia, conversed with the prophets that were the successors of Moschus the physiologist, and was instructed by them.

Hence it appears that this philosophy was not invented either by Epicurus or Democritus."—(*Note of Thomas Taylor,* '*Translation of the Theætetus of Plato,*' p. 25.)

There are a great number of passages in the writings of Aristotle and Plato where the atomic philosophy is alluded to, and sometimes discussed, as in the Theætetus and the Timæus.* The ancient Greeks

* It is remarkable that, though the ancient Greeks were almost absolutely destitute of positive mineralogical knowledge, they conceived the *four elements* to be composed of regular geometrical molecules; and had thus a kind of theory which is not without a singular analogy in the modern science of crystallography, founded by Haüy; as may be seen from the following quotation:—"The Pythagoreans and Plato supposed two primogenial right-angled triangles, the one isosceles, but the other scalene, having the greater side the double in length of the less, and which is bisected by a perpendicular from the vertex to the base, and from the isosceles triangle, indeed, which Timæus calls a semi-square: four such having their right angles conjoined in one centre, a square is formed; but the union of six such triangles having eight angles, forms a cube, which is the element of earth, but the semi-triangle constitutes the pyramid, the octahedron, and the icosahedron, which are distributed to fire, air, and water; and the pyramid indeed consists of four equilateral triangles, each of which composes six semi-triangles; but the octahedron

had this advantage over the chemists, in our days, that they reduced matter by a mental operation into first elements or atoms, not being impeded, in their speculations, by the discovery of simple bodies, whose distinct nature has formed an obstacle to modern philosophical generalizations. But the philosophy of the Hindoos was certainly more beautiful and even more clear than that of the Greeks, if we can judge by what has been translated from their ancient works. It appears from Mr. Colebrooke's researches that they not only embraced the doctrine of atoms, but that this doctrine was the object of lively discussion amongst them.

There are certainly passages in the Vedas which

consists of eight equilateral triangles and forty-eight semi-triangles, and the icosahedron is formed from twenty equilateral triangles, but one hundred and twenty semi-triangles: hence, these three being composed from one element, viz., the semi-triangle, are naturally adapted, according to the Pythagoreans and Plato, to be changed into each other. But earth, as being composed from another triangle specially different, can neither be resolved into the other three bodies, nor be composed from them." (Taylor's *Dissertation on the Philosophy of Aristotle.*)

have a very striking resemblance to the speculations of modern science. I trust a few quotations from these passages will not be found out of place in this note.

"This universe is compacted from the minute portions of those divine and active principles, The Great Soul, or First Emanation, Consciousness and Five Perceptions; a mutable universe from immutable ideas.

* * * *

"The Being whose powers are incomprehensible having created me (Menū) and this universe, again became absorbed in the Supreme Spirit, changing the time of energy for the hour of repose.

"When that power awakes, then has this world its full expansion; but when he slumbers with a tranquil spirit, then the whole system fades away...

"Thus that immutable power, by waking and reposing alternately, revivifies and destroys, in eternal succession, this whole assemblage of locomotive and immoveable creatures.....

"At the close of his night, having long reposed, he

awakes, and awaking, exerts intellect, or reproduces the great principle of *animation*, whose property it is to exist unperceived by sense.

"Intellect, called into action by his Will to create worlds, performs again the work of creation; and thence first emerges the subtile æther, to which philosophers ascribe the quality of transmitting sound.

"From æther, effecting a transmutation in form, springs the pure and potent air, a vehicle of all scents; and air is held endued with the quality of touch.

"Then from air operating a change, rises light or fire, making objects visible, dispelling gloom, spreading bright rays, and it is declared to have the quality of figure.

"But from light, a change being effected, comes water, with the quality of taste; and from water is deposited earth, with the quality of smell: such were they created in the beginning."*

* It is worthy of remark that we find traces of this philosophy even in the old books of the Chinese; thus we read in the *Y King*, a book quoted by the Chinese Lo-pi, who lived

Independently of the sublime poetry of this passage, and of the depth of thought with which the omnipotence of the *First Cause* is expressed, it is evident that the writer has produced a complete system of destructions and renovations of the world; that he has indicated periods of perturbations, during which the Supreme power has annihilated all that enjoyed life; and periods of repose, which begin by new creations and succeed the periods of disorder and destruction.

The Supreme Intellect is represented as creating by his simple *fiat* the subtile æther, which is transformed into air, then into water, and at last solid earth; so that it is manifest that *the primeval æthereal condition of matter* formed one of the creeds of the ancient Hindoos; creeds which correspond with the modern

about 950 years before the Christian era, the following passage:—

"Everything that has a body and form has been made by that which has neither a form nor a body. . . . . The being who has neither form nor sound is the source whence originate all sensible sounds: his son is light, his grandson is water."—*L' Y King et le Chou King*, 4to., Paris, 1770.

opinions of the formation of planets and stars by the aggregation of matter spread into space.

Assuredly we find in these passages some point evidently in arrear with the philosophical results of modern science; but still it is true that the fundamental idea of the transition of matter from the æthereal to the gaseous, from the gaseous to the liquid, and from the liquid to the solid state, is there entire and distinct. It is even remarkable that light appears only at the transition from the gaseous to the liquid state! And it is not improbable that the Institutes of Menū are themselves but an imperfect translation of much more ancient books; for it is well known that the Brahmins pretend, and maintain with perseverance, that prior to the language used in the Vedas there was a more ancient language, of which books still exist, which the Brahmins themselves cannot read, but which they assert contain astronomical tables of very remote antiquity.

Others may cast a disdainful glance on these traditions, which have traversed ages to appear before us, still imposing in their grandeur; as for me, far

from trampling upon these eloquent ruins, I can only consider them as the sublime remains of majestic monuments raised by the men of the primeval times. If these speculations are not the result of a profound science, acquired by patient study and contemplation, they offer us the visible traces of a primitive Divine revelation, coeval with the creation of the race.

Perhaps the progress of civilization is but the result of the efforts of the genius of man to retrieve its primitive position; and the aspirations of philosophy have no other aim than to reconquer a brilliant condition of omniscience which mankind had lost, through its degeneration, in an early conflict between mind and matter.

THE END.

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