A.M.D.G.

EXTRACTS

from

GEOLOGY

by

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in mathematical geography and astronomy. Thus it is proved that the density of the globe increases from the surface to the centre. We infer besides, from its spheroidal form, although not rigourously, the fluid precedent state of the materials composing the earth.

Something more convincing (especially if taken in connection with the spheroidal form) of the previous liquid state of the earth is afforded by physical geography. Earthquakes, vulcanic eruptions, the production and submersion of islands, the issue of gases from the fissure in the earth, hot springs, eruption of warm mud, the alternate elevation and submersion of vast continents, the formation of mountainchains, the change of the configuration of the land and the distribution of the waters on the surface of the globe give a good evidence of an exceedingly active matter confined within the earth, ignited and liquid, and indirectly give evidence also of the preceding state of the whole mass of the earth.

Although physical geography cannot overlook the above mentioned phenomena in as much as they affect the surface of the globe, the search and study of the physical condition, out of which they arise, enters into the subject of geology.

The first and simplest fact leading directly to some knowledge of the condition of the globe below the surface, is the gradually increasing temperature in proportion to the depth. Thermometric observations made in mines and other deep excavations, and on the temperature of water rising in Artesian wells, prove that there is a constant and regular increase of temperature at the rate of about one thermometric degree for every 50 feet of depth, or an increase of about 100° per mile. But the range of direct observations is very limited, for of the more than 20,000,000 of feet, which is the length of the terrestrial radius or distance from the surface to the centre, the number of those through which in boring or mining operations, man has been able to descend does not exceed much 2000. Taking however in connection with these observations the others above mentioned and others also to be mentioned hereafter, if not absolute certainty a degree of probability hardly differing from certainty is obtained concerning the gradual and constant increase of temperature from the surface towards the centre, at least to a depth considerably below that of direct observation.

We may here observe that geological investigations on account especially of

cities and towns destroyed and thousands of living beings buried beneath their ruins. Postponing for the present the other phenomena we may observe that this phenomenon alone reveals sufficiently the presence of an interhal and restless agent, whatever be the character and circumstances of the concussions. To infer with accuracy from the internal cause the dynamical effect it would be necessary to know the mode and energy of the action of the interior mass, the manner in which this action is applied to the solid crust, the exact thickness and consistency of the latter and other circumstances, which are not within our reach. It will be enough for us to observe first that this effect manifests itself in various ways, in vertical and oscillatory motion and occasionally in horizontal and gyratory derangement. To give then some probable explanation of the first two modes of motion, we may regard the fluid mass subject, like the waters of the ocean, to undulations. Now the materials of which the terrestrial shell is formed in it's various parts have either a strength superior to that of the wave, or equal to it, or the pressing force of the subterranean wave is greater than the strength of the shell. In the first and second case the shell may remain motionless like the rock when the sea-waves dash upon it, or it will partly yield by some dislocation or vibratory motion according to the elasticity of that section upon which the wave or waves act and according to the energy of that action. Thus we have a vertical and oscillatory motion and the part of the surface of the earth thus affected and the bodies placed upon it, suffer a sort of disturbance, which can beautifully be compared to that of a ship floating upon water, on which a system of waves is formed.

In the latter case the shell must be fractured to a greater or less extent. In case of a complete fracture the phenomenon assumes a volcanic character, but if the fracture be only external the effect is still called an earthquake which must be attended by horizontal motion and may be followed by gyratory motion and a variety of others. We need not add that in cases of this kind ruin and destruction are inevitable consequences of the terrific commotion. After the earthquake which destroyed Riobamba in 1797 and that which took place in Calabria in 1783, walls were changed in their direction, rows of trees, which were previously straight and parallel were after the shock in different directions and even in curved rows.

Two objections can chiefly be opposed to the explanation of the phenomenon of earthquakes by the restless condition of the liquid mass below the crust of the earth. The first is that earthquakes are preceded by peculiar atmospheric phenomena, a fact which does not seem to evince sufficient connection with the cause assigned to earthquakes. The second is that earthquakes are local phenomena, excluding therefore a cause which should affect every part of the terrestrial surface alike.

The first of these objections is nothing but a popular impression which prevails without any foundation in fact. Humboldt states not only as the result of his own experience, but as that of those who have lived for many years in regions where earthquakes are frequent, that they take place indifferently in all weathers & in all states of the atmosphere.

Nevertheless in some cases the subterranean convulsion appears to have been attended with atmospheric effect which would indicate some conection between the phenomena and the electric state of the surface and of the atmosphere.

On the other hand it is not improbable, or certainly not impossible that as the atmosphere and surface of the globe may be acted upon concerning their condition and state so also vice-versa the state of the atmosphere and surface may act upon the candent subterranean liquid and determine either currents or convulsions reacting in their turn on the solid crust of the earth. We could thus account for those statistical results, from which it would seem that there exists probably some connection between the prevalence of the earthquakes and the seasons of the year. It would seem that they are of most frequent occurrence at the epochs of equinoxes.

The fact that earthquakes occur more frequently in some regions than in others can be explained by the different structure, materials and thickness of the terrestrial shell in its various parts, in consequence of which the same parts may be more or less susceptible of receiving and transmitting the undulations or concussions. Hence even if some regions on the surface of the globe would be privileged to such an extent as never to be visited by such terrestrial commotions, we could not rigourously infer from it that the cause of these commotions does not reside in the melted subterranean matter. But without having recourse to this answer to the objection of the locality of the phenomenon, it is enough to observe that although earthquakes are of frequent occurrence in some regions, they are not however taking place exclusively in them, but we find earthquakes occurring in every sort of soil and strata, from the loose alluvial soil of Holland to superficial strata of granite.

The Peruvians who are of all nations the most familiar with earthquakes give the name of bridges to certain tracts of land which preserve their immunity from the shocks that affect the country on either side of them for centuries. This fact, whatever be the cause productive of the convulsions, shows evidently that the mechanical structure of certain strata are such as to arrest the undulations.

We may here mention also a remarkable observation made by Humboldt. The intermediate region between the lake Baikal in Syberia and the Celestial mountains in Chinese Turkistan, which are two centres of concussion, presents immunity from earthquakes. The same eminent naturalist explains the fact very ingeniously by the principle of interference which plays so important a part in Optics & Acoustics.

In addition to the preceding remarks it is to be observed, that earthquakes far from being confined within a limited range have in some cases been manifested over a large portion of the globe. The great earthquake by which Lisbon was destroyed on the 1st of Nov. 1755, was felt over the whole extent of Europe, nay more: across the Atlantic to the West-Indies and across the continent of North-America to the great Northern Lakes. Distant fountains were interrupted and the solid surface of the bottom of the ocean shared in the general undulations manifested over so great an extent of the continent.

It is a fact not unworthy of remark, that notwithstanding the backward state of physical science general among the ancients, the true physical cause of earthquakes was indicated in unequivocal terms by Pliny who denominated them <u>subterranean</u> <u>storms</u>, and Seneca gave the germ of all that was known

about their causes until a very recent date.
Humboldt who has been personal witness to a considerable number of these phenomena, and has elaborately investigated the recorded effects of the most remarkable of them says that the undulations are propagated chiefly in parallel lines and with a progressive velocity of from 20 to 30 miles per minute. He observes besides that there are cases in which the waves, issuing from a centre of undulations, are propagated in circles around it; but these cases are rare and the height of the waves diminish as their distance from the common centre increases.
Earthquakes are often attended by awful subterranean sounds. These noises are seldom heard at the place where the earthquake has the greatest violence and sometimes are perceived at places situated beyond the limits of the shocks, sometimes also the subterranean sound is heard after the shocks have ceased.
The character of the noise attending earthquakes differs greatly in different cases. Sometimes it was a rolling sound like that of thunder or of cannon discharged in rapid succession. Sometimes it is described as resembling the clanking

of chains. At Quito it is often sudden, like a near thunderclap, and sometimes clear and ringing, like the clashing of glass, as if enormous masses of vitrified matter were shattered in subterranean caverns.

Owing to the fact that solid bodies are good conductors of sound, the subterranean noise may be and is in fact heard at great distances from the seat of the agency which produces it.

Thermal Springs and Jets of Gases.

We have already observed that when the energy of the subterranean agent is greater than the strength of the shell, the commotion is attended by fracture, either total, i.e. going so far as to reach the origin of the concussion, or partial, i.e. more or less superficial. In both cases it happens, although differently, that matter is ejected. In the case of partial or superficial disruption, which is the one here taken into consideration, the physical character of the matter thrown out and the state in which it is found the moment of its ejection depend upon the nature and temperature or depth of the strata from which it proceeds.

Of all substances thus thrown out, water is the most frequent. This liquid appears to be deposited in terrestrial strata having more or less considerable depth. According to the otherwise well established fact, that the temperature increases with the depth, the temperatures of these different liquid strata must be different from each other, and the greater the depth is, the higher will be the temperature.

Existing springs confirm both facts. There are springs rising from different depths and their temperature, when they rise from depths lying below the stratum of invariable temperature, increases with their depth: these phenomena have been carefully observed in Artesian wells and the fact of increasing temperature has supplied a thermal index to the depth of hot springs.

Another fact in confirmation of the correctness of the common cause assigned for increasing temperature is, that thermal springs from very extensive observations prove to be completely independent of the strata from and under which they rise. They do not prevail exclusively in volcanic regions. Indeed, Humboldt affirms, that the hottest permanent springs hitherto discovered are some found by himself at a great distance from any volcano, as for example the Aguas calientes de las Trincheras between Puerto Cabello and New Valencia in Venezuela.

From what precedes we see that there may be reservoirs, from which water rises at such a depth that its temperature greatly exceeds the boiling point. In this case steam would issue from the crevices of the earth as it does from the safety-valve of a steamengine. Now numerous facts warrant this supposition. There are eruptions of steam or boiling water called Fumarolles and Geysers. The most remarkable examples are presented in the country surrounding the celebrated volcano of Hecla in Iceland. Eruptions of hot steam are projected from the crevices of the soil in the form of white colums, that rise to heights varying from 30 to 60 feet: The same phenomena are manifested on a considerable scale in Tuscany in the neighbourhood of Monte Cerboli, Castel Nuovo and Monte Rotondo and are generally disposed in a single line of from 20 to 25 miles in length.

These jets of vapor partake of the nature of volcanic eruption: they include chemical agents, which attack the rocks with which they come in contact. The same volcanic character is observable in the Geysers, or jets of boiling water. One of these hot springs is mentioned among the great number of those which prevail in Iceland, which every half half hour, projects a column of boiling water 18 feet in diameter to the height of 150 feet.

The water thus ejected contains a certain proportion of silica, which is deposited in a state of hydrate upon all the surrounding bodies, and sometimes forms mounds of considerable extent, at the summit of which is an opening from which the liquid issues.

The vapour of water is not the only elastic fluid which forces its way from the interior to the surface of the globe. Various gases are also ejected in enormous quantities. The gas called carburetted hydrogen, which evolved by artificial processes, is now so universally used for the purpose of illumination issues in vast quantities from the interior of the earth through fissures of greater or less magnitude, and thus presented by nature herself has actually been used for illumination in China for more than ten centuries. The gas collected in tubes of bamboo and thus rendered portable has been used for illumination during all that period in the city of Thinnug-tschew. But of all the ejections of gaseous substances from the interior by far the most frequent and abundant is carbonic acid.

A circumstance which connects the gaseous ejections with the preceding phenomena is their ordinarily high temperature. They are besides an indication of volcanic activity, or as we shall see better in the following article, they are effects of volcanos not fully developed. The most remarkable circumstance attending these gaseous and prodigiously abundant emissions is their dissolving power. They have an astonishing effect on solid substances with which they come in contact; they pulverise, dissolve and decompose them in every possible manner. they reduce them to the consistency of pasty substances and form out of them new compositions of every kind. The most remarkable example of this sort is observable in the eruptions of Java, which abound very much in gaseous and vaporous emissions.

The transition from the ejection of gases and liquids to that of molten rocks (which belongs to volcanoes completely formed) is marked by the intermediate phenomena of the ejection of hot mud. From the facts mentioned above we may easily account for these phenomena. The same dissolving power manifested by gaseous jets on external solids, can be equally, and even more, effective beneath the surface on the lower strata of the terrestrial crust which, melted by this action, must tend to obstruct the passage of the gaseous jet, by whose vigor and abundance the mud thus formed is ejected from the crevices. Eruptions of this kind, called Salses or mud Volcanoes, are, according to Humboldt, characterised in their origin by the imposing phenomena of earthquakes, subterranean thunder, the upswelling of vast tracts of country and the emission of lofty jets of flames. These phenomena are in great part attributed (not without good reasons as will be seen hereafter) to the action of copious gaseous eruptions in the formation of the actual terrestrial crust.

Volcanoes.

Although the examples of subterranean activity presented by superficial convulsions, earthquakes, thermal springs, salses and jets of gas and steam conspire to prove the active internal force of the terrestrial mass; yet none of them prove as well the ignited and liquid state of the same mass, as volcanoes do.

The process observable in the formation of volcanoes proves besides the activity and energy of the liquid fire which fills the solid shell of the earth. The internal force acting with unequal effect on different parts of the solid crust of the earth, surmounts its resistance at points to such an extent, as to upheave the incumbent strata, raising them into domeshaped mass es without however producing actual fracture. Sometimes the mass thus upheaved gives way at the summit of the dome, and separates so as to leave a circular cavity of a certain depth surrounded by a nearly perpendicular wall, having on the exterior a gradual slope, which formed the declivity of the dome before the disruption. This roundish cavity is called a crater of elevation.

If the energy of the subterranean force be sufficiently intense, the floor of this crater will be burst asunder & holes and fissures will be formed in it communicating with the interior of the globe, then steam and acid gasses will be ejected in vast quantities, followed by ignited scoriae and red hot stones after which will follow in a state of pasty fusion that incandescent matter which has been called lava. Thus an active volcano is formed.

The eruptions of volcanic lava are ordinally occasional phenomena and generally volcanoes are never uniformly active. This variability admits of explanation. When an internal wave or tide of the fiery central ocean passes the base of the opening, a pressure may be produced by which the molten matter is forced up and ejected in the form of lava. In the ordinary state of a volcano, when no eruption of lava takes place, volumes of smoke more or less dense usually rise from the fissures, and upon looking down into them, the incandescence of their walls and of the matter they include is visible. This light, illuminating the smoke and ashes, which rise over the crater, often gives to them a lurid gleam which looks like, and is sometimes mistaken for, flame.

The intervals of activity and repose in volcanoes are often of very long duration. In the time of Nero Etna was considered as approaching to extinction, and according to Aelian, the summit of the mountain at a later period was gradually sinking, so that it could no longer serve as a landmark for vessels at sea at the same distances.

However volcanoes of no great elevation seem to be characterised by the most unceasing activity. A remarkable example of this kind is offered by Stromboli in the island of the same name, situated of the north coast of Sicily. This volcano has been in a state of activity from the Homeric to the present time, so unceasing that it has served and still serves all the purposes of a stupendous light-house to ships navigating on that part of the Mediterranean.

Volcanoes either active or extinct are to be met with on every part of the globe, another fact which well accords with the cause of their production. We may infer from this that the bed of the ocean is not exempt from these volcanic eruptions. This, in fact is the case and to volcanic action is owing the sudden rising of some islands out of the bottom of the deep. Thus in 1831. the island of Julia arose in the Mediterranean, about 30 miles to the S.W. of Sicily. Bogoslaw appeared in like manner in 1814 in the Aleutinian Archipelago, Sabrina and another among the Azores in 1811, besides various others around Iceland, in the Indian Archipelago, the Philippines, the Moluccas, and of the coast of Kamtschatka. One of the most remarkable examples of this kind was presented in the case of the island which arose in 1796. at 30 miles from the northern point of Unalaska.

Remarkable examples of submarine eruptions have been presented also from the most remote time in the Mediterranean and the Levant. According to ancient historians the bay included between the islands of Santorin and Theresia in the Grecian Archipelago, has been the special theatre of these phenomena.

These submarine volcanic phenomena are generally preceded by incandescent matter thrown above the waters, by sonorous and pumicious matter appearing on the surface, by burning rocks which float in the midst of vaporous waves and by the ebullition of the sea the temperature of which then becomes much elevated.

Undulations of the Land.

Pliny relates a tradition, according to which Sicily was separated from Italy, Cyprus from Syria and Euboea from Boetia by earthquakes. Plato also relates, that a large island called Atlantis, which in ancient times existed west of the Straits of Gibraltar, was engulfed by the ocean. These events, which are in perfect harmony with the phenomena described above, explain another well known fact ascribed in former days to a different cause.

There are cases in which the dry land has been invaded by the sea, or the bed of the sea has been left dry by the retirement of the water. The solid and apparently permanent character of the land on the one hand and the extreme mobility of water on the other very naturally suggested the idea of ascribing the phenomenon to the change in the level of the ocean. The possibility however of the reverse is well supported by the above-mentioned phenomena. It has besides been proved by observations, made upon the level of the ocean, that it has not suffered any general change within historic times. It is plain therefore, that the case in which the land has been innundated by the ocean must be ascribed to the sinking of the land, and those in which the waters have deserted their bed, to the rising of the bottom of the sea.

It has been long observed in different parts of Sweden, that the level of the surrounding ocean was subject to an apparent but slow and gradual change; in some places rising and in others falling. The Academy of Upsal in 1731, commenced a series of observations with a view of determining the fact whether these apparent changes of the ocean were real, or whether it were not caused by an actual change in the level of the land. It was found that the apparent depression of the level of the ocean was different in different places, and in some places it appeared even to have been raised, and from all the observations was deduced, that in Finland and in a great part of Sweden, the surface was gradually raised without any perceptible shock, while in the southern parts of the peninsula a corresponding depression was observed.

Similar swelling and depression of the land have been manifested elsewhere. Thus for example during four centuries the western coast of Greenland has been continually sinking through an extent of 600 m. N. and S. It appears also that the whole continent of S. America is gradually sinking.

An interesting modern example of the subsidence of a considerable tract of country clothed with forests in the vicinity of the Columbia River in N. America is described by S. Parker in his journal of an exploring expedition beyond the Rocky Mountains.

But the example which seems more than others to attract the attention of geologists is the alternate elevation and depression of the ground upon which the temple of Jupiter Serapis stands at Pozzuoli near Naples. It appears from clear indications that this ground has changed its level more than once being heaved up.

wards and downwards alternately.

The disproportion existing between the thickness of the solid crust of the globe and the mass of matter in a state of igneous fusion, which it encloses, explains the undulations of the land, as well as the other phenomena of the same nature examined above. And _vice versa_ this last phenomenon adds to the validity of the argument desumed from the others in favor of the fluid condition of the nucleus of the globe.

The first consequence which is drawn from the admitted gradual transition of the terrestrial crust from the liquid to the solid state and from the power of the nucleus on the same crust of the earth in its actual condition, is, that much more considerable changes and disruptions together with their consequences must have occurred at remote, than at more recent periods.

The earlier the epochs the thinner the terrestrial crust must have been, and the less its resistance to the internal force. Forces which would now fail to produce any sensible effect upon its form, would at these epochs have been sufficient to produce disruption.

Admitting therefore the original fluid

state of the whole mass of the globe we might expect to find on its surface monuments and records of gigantic catastrophes, which have preceded historical times. Now the conformation of the various parts of the surface of the globe, seem to give the most incontrovertible evidence, that, at earlier periods, changes have occurred on a scale so prodigious, that compared with them, the most devastating earthquakes and volcanic eruptions of our times are utterly insignificant.

The formation of the vast ridges of the Andes, which traverse the new continent from N. to S., and that of the Alps or Himalaya which traverse the old continent from E. to W., are stupendous examples of this kind.

The disquisition of this class of pre-historical phenomena forms a vast section of the study of geology, and one which notwithstanding the numerous obscurities in which it is necessarily involved, is remarkably attractive. We will briefly sketch the subject by first presenting at one view the series of these phenomena as already observed, classified and explained by geologists, adding afterwards some remarks on such of them as are more remarkable.

Adamitic

Pre-historical Convulsions of the Shell of the Globe.

The phenomena of historical times lead us to admit that by the gradual process of cooling produced by radiation the surface of the earth became solidified, a thin skin of solid matter being first formed upon it, which as the cooling continued, became gradually thicker, the increase of thickness being produced by more and more solidified matter collected on its inner surface. like ice collecting on ponds

We easily conceive also that at first the temperature of the terrestrial surface was necessarily such that water could not exist upon it in the liquid state, but according as the temperature of the surface became gradually lower, the aqueous vapours being condensed and precipitated, formed upon it rivers oceans and lakes, liable however to great changes. The igneous matter acting unequally against the inner surface of the yet thin shell cracked it from time to time producing large fissures, through which the igneous pasty fluid issued, cooling and solidifying when exposed to the external atmosphere. Each convulsion necessarily changed the relative levels of the different parts of the solid surface, and this was attended by a corresponding change in the distribution of the waters of the ocean. We see that upon the occasion of these extensive and vigorous convulsions, the waters variously spread over the surface of the globe would rush with furious impetuosity over such parts of the land as would fall to a lower level, while at other places the solid bed of the ocean would rise above the surface of the waters forming new continents and islands. Catastrophes of this kind having left on the surface of the globe visible traces, have enabled geologists to demonstrate their occurrence and even to ascertain, to a certain extent at least, the dates and order in which they occurred

For a long period of time, during which these catastrophes were developed at intervals, the superficial temperature depended infinitely more upon the internal heat transmitted to the surface than upon the effects of solar radiation. Hence follows the original uniform temperature at all altitudes; diminishing however continually but for a long period certainly far above the limit compatible with the existence of any form of organic life. During this interval therefore the surface of the globe was unanimated by life and unadorned by vegetation, such, seemingly, as it is represented to us in the Mosaic narration by the words: "And the earth was void and empty."

At length the temperature being reduced to a point compatible with organized creatures, the earth was peopled with animals and clothed with vegetation but these animals and this vegetation differed altogether from those which in successive periods and now animate and cover the globe.

But the crust of the earth was at this period not yet strong enough, as it is at present, to resist the action of the enclosed boiling mass, and subject consequently to catastrophes; similar to those that had preceded organized nature. Such in fact is the case and traces have remained on the surface of the earth indicating these successive convulsions. By researches made on the crust of the earth, & by careful analysis of the constitution of its strata and of the animal and vegetable remains contained in them, geologists have ascertained, with at least a high degree of probability, that as before the first appearance of organized creatures, four great convulsions of the globe had occurred, so likewise subsequently no less than

28 successive convulsions of the same kind had taken place, each of which seems to have been attended with the complete destruction of animals and plants, which existed upon the globe.

These assertions appear to surpass the limits of credibility, not indeed on account of any intrinsecal repugnance assignable in the nature of the events, but on account of the immense range they embrace, both in the series of multiplied creations and in the immense duration of time indispensably supposed by them. This range so much surpasses our preconceived notions derived from the present state of things, and from the order of events connected with it; that the mind imagines it sees repugnance in admitting such a range and in passing those limits, which from a habit of seeing nothing beyond, present themselves to it as the last. Just as in questions concerning space the magnitude of created things with which we are familiar, imprints on the mind a range with limits, a wide range even, we may say, but one nevertheless, which assuming the appearance of being confined within natural boundaries so acts on the mind, that it is not brought out of it without reluctance. But when the evidence of facts proves the truth of an assertion, the reluctance felt in admitting it, must be set aside. Now the actual occurrence of several convulsions, and the existence of the successive animal and vegetable kingdoms differing one from another in the species of which they were constituted, has been proved by geologists by two species of evidence, one depending on the condition of the stratification and elevation of systems of mountains still extant, the other offered by the discovery of the buried remains of each of the several animal and vegetable kingdoms above-mentioned.

The force of these facts towards demonstrating the reality of those catastrophes, will be better appreciated by a more detailed exposition of the various stages of transition.

Natural Cosmogony and Mosaic Narration.

But before we enter upon the examination of the historical periods of our globe and of the circumstances attending the formation and modifications of its crust, it will not be amiss to elucidate a point which might seem to destroy at one stroke the inferences deduced from investigations and the results of the labors concerning natural cosmogony. The age of the earth, according to geological investigations, would surpass incredibly the period com mencing with the human family, a period well defined in the inspired history of Moses. Now does Moses assert that the human race and the globe inhabited by men are co-eval? In this case none of the inferences concerning the origin of the terrestrial globe deduced from geological observations could be admissable. But if Moses (whose object was principally that of giving the chronology which belongs to men) in the verses of the first chapter of Genesis narrating the creation preceding man, does not openly establish the co-eval origin of man and of the earth, we may safely interpret the words of the inspired historian conformably to the evidence of well established facts. Si manifestae certaeque rationi, says St. Augustine (Ep. VII ad Marcellin.) velut sacrarum literarum objicitur auctoritas, non intelligit qui hoc facit, et non scripturae sensum (ad quem penetrare non potuit) sed suum potius objicit veritati: nec id quod in ea, sed id quod in se ipse velut pro ea invenit, opponit. And in another place (Gen. ad litt. L.I. c. 21.) Hoc indubitanter tenendum est, ut quidquid sapientes hujus mundi de natura rerum veraciter demonstrare potuerint ostendamus nostris libris non esse contrarium. St. Thomas maintains the same doctrine and expresses it in different places.

But in the Mosaic narration concerning

the creation preceding that of man, not only is there no open asseration concerning the co-eval or nearly co-eval origin of all created things, but we may find in its words enough to prove that the period between the first creation and that of man is of an indefinite length, that is such that, considering it of any duration, it leaves intact the Mosaic narration. We may add besides that on account of the history of the creation, as we read it in the first chapter of Genesis, this cosmo-gonic knowledge derived from natural sciences has been proposed and felicitously explained: according to which mode of explanation, the Mosaic narrative would contain or allude to truths unknown to men for many centuries. So that scientific knowledge, instead of opposing revealed truth, would rather afford a forcible argument in favor of the divine inspiration of the Mosaic history. So true is that which Pereira says in his learned commentaries on Genesis - verum omne semper cum vero congruit: from which he infers that non potest veritas sacrarum literarum veris rationibus et experimentis humanarum doctrinarum esse contraria (quapropter) Illud diligenter cavendum et omnino fugiendum est, ne in tractanda Mosis doctrina, quidquam affirmative et asseveranter sentiamus et dicamus quod repugnet manifestis experimentis et rationibus philosophiae, vel aliarum disciplinarum.

A detailed discussion of this interesting subject would greatly exceed the limits within which the present digression must be confined. It will suffice briefly to point out such sentences in the Mosaic narrative, which offer a good foundation on which to base a satisfactory agreement between natural and revealed cosmogony.

We shall begin by observing that Moses mentions two distinct creations without assigning any duration of time intervening between the first and the second: thus he commences the book of Genesis - In the beginning God created heaven and earth; and the earth was void and empty, and darkness was upon the face of the deep; and the Spirit of God moved over the waters. Then he begins to enumerate and describe the work of the six days, which is evidently distinguished from the preceding creation. But how long did the earth remain void and empty? How long did the spirit of God move over the waters? this is not said. Petavius (De op. sex dier. L.1. c.10. §6.) speaking of the duration of time between the original creation and the first day, says quod intervallum quantum fuerit nulla divinatio potest assequi. There are learned naturalists and theologians, among others Cardinal Wiseman, who willingly admit a succession of conclusions, such as appear to us from scientific researches, to have occurred during the period which elapsed between the original creation and the first day. But adopting this opinion, although we would find no difficulty in reconciling it with the primitive convulsions of the globe, we could not so easily find the same agreement with successive convulsions, unless we suppose organized creatures, animals and plants, to have appeared even before the days in which, according to the Mosaic narration, these creatures being called forth were brought into existence. To prove a complete and satisfactory agreement, it seems that some other period besides the one preceding the first day is indispensable. But here is where the main difficulty lies; for if the six days mentioned by Moses are to be admitted of the same length as our days, and succeeding each other without any interval between them, the period required before man's creation cannot be found. Now ought the words <u>day</u>, <u>morning</u> and <u>evening</u> of the Mosaic text to be taken as implying the same meaning which is given to them when applied to our present days? That the word day may represent different measures of time, may be inferred from the Mosaic narration itself.

The word day is taken for an undetermined duration of time where we read <u>and he</u> (God) <u>called the light day</u> (c. 1. v. 5.); it is taken for a determined duration of time where in the same verse and in the following it is said <u>there was evening and morning one day</u>: it is also taken as the integral measure of a number of determined durations where Moses tells us: These are the generations of the Heaven and of the Earth, when they were created, in the day that the Lord God made the Heaven and the Earth (c. 2. v. 4.). The word day therefore not only in other passages of inspired writing, but also in the Mosaic narrative, is employed to denote different durations of time. This word then alone does not seem to imply that it ought to be taken for the interval of the twenty four hours which measure our days; unless some concurring circumstance should define this measure. But the context affords none of these circumstances, nor does the partition which Moses makes of the days into evening and morning add any defined measure. Nay, we may remark that the words morning and evening applied to the days of the creation, have essentially a different meaning from that which is given to them when applied to our days, for which they refer to the rising and the setting of the sun. But the sun was created the fourth day: therefore the words morning and evening, which we find also applied to the days which preceded the production of the sun, have in the Mosaic narration a different meaning from that which they bear when referred to our ordinary days. Vespera, says St. Augustine, in toto illo triduo antequam fierent luminaria, consummati operis terminus non absurde fortasse intelligitur; mane vero tanquam futurae operationis significatio (De Gen. ad l. CXVII.). And if the words morning and evening have in the Mosaic narrative a signification different from that applied to our days, it seems that the days also to which they were applied were different from ours.

The obstacle opposed to giving to the days of creation a different duration from that of ours, is the interpretation commonly given by the Fathers and by the expositors, according to which the days of creation do not differ from our ordinary days. But we may remark first that the church, having pronounced no judgment on the subject, and permitting besides the adoption of opinions different from the common interpret-on of the Fathers; if there are well grounded reasons, we may safely recede from their opinions. But besides, the Fathers and interpreters are not all unanimous in maintaining opinion. Suffice it to mention St. Augustine and St. Thomas. The first speaking of the *one day* in which God said *let there be light*, asks *An hic dies temporis totius nomen est, et omnia volumina saeculorum hoc vocabulo includit, ideoque non dictus est primus sed unus dies?* Moreover, in the same work De Gen. ad lit. and afterwards in the other De Civ. Dei, he maintains that the six days, as far as the duration of time is concerned, ought to be taken for one day and even for one instant. St. Thomas adopts this opinion, of which he says that it is *rationabilior et magis ab irrisione infidelium S. Scripturam defendens, quod valde observandum docet Augustinus, ut* (scilicet) *sic scripturae exponantur quod ab infidelibus non irrideantur*. We infer from these passages that we may recede from the literal meaning concerning the days of creation in the Mosaic narrative. Certainly it recedes more to assert that these days represent one instant, than, leaving their distinction and order, to extend their duration. We must not here leave it unobserved that although St. Augustine advances the opinion just mentioned, he does not maintain it as certain - *neque enim*, says he, *ita hanc confirmo, ut alia quae praeponenda sit in-*

venire non posse contendam (de G. ad L. IV. 25. - Retr. II. 21). Which is the opinion preferable to which the saint makes allusion? Let us hear it from his own words. Quisquis... aliam requirit in illorum dierum enumeratione sententiam, quae non in prophetia figuraté, sed in hac creaturarum conditione proprie meliusque possit intelligi, quaerat et divinitus adjutus adinveniat.

The measure of the days of creation equal to that of ordinary days being excluded, the Mosaic narrative offers no difficulty whatever to the doctrine of natural cosmogony. The days may be periods of any length; and if such scientific discoveries would perfectly agree with revealed history; an accord which with rare ability has been developed in a commentary on the Mosaic history, by John B. Pianciani S.J.; from which we have drawn the present extract, and to which we refer for a further and better information.

Stratification.

A clearer knowledge of the history of pre-adamitic Earth, and particularly of the manner in which the convulsions of the globe have affected its surface, leaving traces by which to study the same history and determine more in detail the original and successive periods of it; may be obtained by first tracing out the mode and order in which strata have been formed.

Let it first be observed that the matter composing the strata is called by geologists Rocks, a term used in this science in a sense somewhat different from its common signification. Rocks in the geological sense does not necessarily imply masses of stone, but signifies any agglomeration of matter which may be found to enter into the composition of the crust of the earth. In this sense, clay and sand come under the name of Rocks, as well as granite and marble.

The word stratum means bed or layer, and it is a well-known fact, that the materials composing the crust of the earth are disposed in layers superposed in a regular order, each layer taken in succession, consisting generally of the same constituents in the same state. These strata are very numerous: they have however been reduced to the five following classes: The igneous rocks – The transition or metamorphic rocks – The secondary rocks – the tertiary rocks – and finally the so-called diluvial and alluvial layers upon which the superficial soil is spread.

We shall briefly notice these five great layers each of which consists of numerous subordinate strata: but let us first examine more carefully the process of the original solidification of the terrestrial surface.

In the extremely exalted temperature of the surface of the globe, not only was the presence of any fluid like water necessarily excluded from it, but a portion of the materials constituting afterwards the solid shell, we must admit to have been in a state of sublimation, and together with aqueous vapours mixed with the atmosphere in which the candent globe was enveloped.

Let us now suppose that while by the continual radiation of heat the temperature of the surface was gradually falling below the point of fusion, forming first a thin skin, and then a thicker shell, the spheroidal form of the globe to have remained totally undisturbed. By the superficial temperature falling at length in consequence of the continued effect of radiation to lower and lower degrees, the sublimated matter would first precipitate on the surface and cover it; then the condensation of the vapour would ensue, and the entire surface of the globe would be covered with an ocean of uniform depth. De Beaumont observes that in this process the solidification being attended by contraction, and the contraction taking place from the inner towards the outer surface of the shell, a vacant space would remain between the central mass in fusion and the interior surface of the shell: hence the difficulty and even impossibility of an invariable permanency of equilibrium. The internal fluid matter would dash and press upon the crust surrounding it, and at intervals it would act with more than ordinary vigor, modifying thus the shape of the shell, by causing swelling and depressions and diversifying consequently the surface of the globe by land and water. Thus the waters were gathered together in one place; and.. the dry land appeared (I. Gen. 9.). At this period of the age of our globe, on account of the yet high degree of temperature and of its uniformity over the whole surface, we must admit a much larger amount of evaporation and corresponding condensation and consequently a copious, perhaps continual fall of rain over the seas and over the dry land. Now the action of the water falling upon the solid crust of the earth, by erosion and disintegration, and exposure to atmospheric action, produced various changes in its condition; and the parts thus washed off being subsequently deposited at the bottom of the waters, produced a primitive stratification. But the restless matter enclosed in the solid shell acting continually on it, continued to produce a series of modifications varying and interchanging the position of the seas and of the dry land: thus some of the stratified sections coming out of the water and the temperature of the shell being reduced to a lower point, the land was made ready for vegetation, and both land and water made fit for the existence of organized bodies. The first form of life however called by the Creator into existence, were such as were adapted to the physical condition of the globe, marine tribes, terrestrial, fluviatic or lacustrine.

These stages of the shell of the globe produced by the diminution of temperature, and by the action of the internal liquid mass, do not evidently depend on the mode in which the internal agent affects the crust, and whether we suppose a gradual swelling or sinking of the land, or some sudden and general catastrophe, the partition of the surface into dry land and water will be attended in both cases by the same consequences.

Let us now suppose one of such gigantic commotions affecting the entire surface of the earth, and taking place at the end of a long period after the creation of organized bodies.

It is first to be observed that after the apparition of organized creatures, a new stratification commences, formed by the remains of animals and vegetables: the action of rain which previously could affect nothing but barren rock, found subsequently a variety of other substances spread over the dry land, to be swept from it and deposited below the waters in the form of strata. We cannot suppose however that all the remains, especially vegetable, were thus carried away from the land: but we must admit on the contrary that a large proportion of them remained to form a stratification on the dry land itself. We may notice a remarkable difference between the terrestrial and subaquatic deposits. The former cannot contain but remains of land animals or land productions, while the latter contain both terrestrial and aquatic remains, and evidently more aquatic than terrestrial. This difference in the formation of strata affords a clear indication of the land which at certain periods was above the waters, and of that which was covered by them. But if a universal convulsion takes place, the tranquil and regular formation of strata would be suddenly changed into a precipitous agglomeration of every variety of substances. Upon the occurrence of these phenomena, enormous masses of water would rush with furious impetuosity over such parts of the land as would fall to a lower level carrying along everything incapable of resisting their power, which they may meet with in these vast tracts of land inundated by them. After convulsions of this kind, the waters at first turbid and holding in suspension a great quantity of the matter washed away and eroded from the former land, as well as enormous quantities of remains of the animals and plants previously existing, would after a time become tranquil, and then a process of vast importance to the preservation of the history of the globe would take place. The organic remains of animals and plants suspended in the waters, would be deposited at the bottom of the ocean, and over them would subside also the solid matter sustained in a state of comminution in the waters. The remains would thus be buried in strata sensibly horizontal, and being covered up by the earthy and mineral matter which would subside from the waters, they would be protected from the destructive action of water, and thereafter of air also; and would thus be preserved, as records of the past history of the earth, to future generations.

The analysis in fact of the different layers will show at once which are those that have been formed by a slow, uniform, and tranquil process, and which are those that have resulted from a tumultuary agglomeration of every variety of substances; from the same traces the event of a convulsion of extraordinary power, after a period of greater or less tranquillity, and of greater or less duration, both of which circumstances may be sufficiently well indicated by the sediments themselves, formed precedently to the catastrophe.

If one convulsion alone of such universally destructive power should have occurred after the production and a period of growth and multiplication of organized bodies, the past history of the earth would be easily traced out. But the catastrophe which put an end to the first period of organized creation, being succeded by other periods like-wise ended by similar catastrophes, it follows that a series of strata must be formed which, on account of the numerous and great modifications meanwhile undergone by the terrestrial shell, must present themselves to the naturalist involved in embarassing complication. Happily however, although the catastrophes which mark those periods have affected the surface of the earth at large, they have not affected it equally every where: and there are large tracts of land which bear evidence of not having been much disturbed during some, at least, of the successive periods, being either covered by waters or remaining above their level during the whole interval.

The stratifications of these portions of the terrestrial crust must succede one another in order of time. Suppose, for instance, a tract of land to have remained in nearly the same condition and covered by the ocean from the first settling down to the third or fourth period of organized creation. The primitive rock resulting from the solidification of the surface and yet interiorly at contact with the melted matter will be covered with the first stratification, of the same nature as the primitive rock and resulting in fact from nothing else but a communica= tion of the same substance. Over this first stratification a second stratum is spread containing partly the sub. stance of the first stratum but char= acterized chiefly by the presence of some organized bodies; over this se= cond stratum a third is found contain= ing indeed some of the elements of the two preceding strata but principally formed out of the remains of organ- ized bodies belonging to the new peri od and the presence of which is not to be found in the lower strata. The succeding strata are formed in a similar manner and each of them is characterized by the productions of its own period. Now as some tracts of land have remained undisturbed during a time embracing the first pe= riods of the globe's formation and oth= ers during a number of succeding pe- riods, we may find in them the se= ries and order of the same peri= ods from the commencement to the present epoch. But besides the or=

derly succession of strata observ=able in some sections of the ter-restrial crust, on which we may without much difficulty recognize the various periods of the history of our globe, the same periods may be inferred also from such other sec-tions of the terrestrial surface as, in a greater or less degree, have been disturbed by catastrophes.

Great layers.

Let us now pass ti see more in particular the structure of the a-bove mentioned principal strata or great layers.

The lowest or fundamental layer called igneous rock consists exclusive-ly of agglomerations of mineral mas-ses in a state of crystallization. This, as may be easily seen, is the condi=tion which matter would necessarily assume in solidifying when gradu-ally cooled from a state of fusion and a corresponding high degree of tempera-ture. Under such circumstances the solidified materials would present ex-actly the appearance presented by the igneous rocks, that is, that of an agglomeration of crystals arbitrarily thrown together and consequently mixed without regularity or order. The parts of the primitive rocks however, which have been brought under the observation of geoligists, are considered as forming the external part of this solid layer. The same rocks, from the circumstance just mentioned, are often denominated Plutonic or igneous rocks, or rocks of igneous origin. They may be regarded as the original materials of which the entire crust of the globe is formed. They consist chiefly of that rock familiar to all observers of mountainous countries called Granite, the most imperishable of stones and therefore the most valuable for building purposes. Granite is an agglomeration of the crystals of three minerals called Feldspar, Mica & Quartz and in the fundamental layer it is mixed in small proportions with the minerals called Amphibole, Pyroxene and Peridote. Among the three principal constituents of granite feldspar may be easily distinguished as it forms the gray part which is easily (relatively) scratched: Oxide of iron and Manganese are occasionally mixed with it and, although present in extremely minute quantity, produce nev-

ertheless a very striking appearance, rendering the rock white, cream-colored or red according to the proportion in which they are present. Mica is the shining, glossy particles of the stone which reflect light like bits of glass or metal.
Its name is derived from micans that is, glittering. Mica also exists in many other rocks and in sand. Quartz, which appears in granite in the form of white crystals, is the substance known as Silex or Silica or earth of flints. It is one of the hardest and most abundant of mineral substances entering into the composition of other mineral masses. Silica is familiarly known as Rock crystal.
If these constituents of the igneous rocks were chemically combined with one another instead of being mechanically juxta-posed they would, according to the general law, be always found in the same invariable numerical proportion; but being merely agglomerated by cohesion they may exist in any proportion whatever, and hence has arisen a corresponding variety of granites. In some specimens the quartz and mica are altogether absent, and then the granite, consisting of feldspar only in the pasty

and crystallized state, takes the name of Porphyry: in other specimens, the proportion of feldspar being large and that of mica and quartz small, the rock is called Porphyrous granite.

In general, the little lamina of mica are distributed irregularly through the granite, their faces being turned in all conceivable directions. In certain specimens however, they are observed to be placed parallel to each other, so as to give the rock a lamellated, slaty or schistous texture. The granite in this case takes the name of Gneiss, from the Danish gnister.

These are the various classes of granite resulting from the different proportions of its constituents which are themselves, not simple substances, but compounds formed, not by mechanical juxtaposition, but by chemical combination. Thus feldspar is a compound of the silicates of several chemical substances such as alumina, lime and potash or soda; that is, it is a combination of these severally with silicic acid. Mica is composed of like silicates with the addition of silicate of iron. Quartz is in fact silicic acid itself. It is therefore plain how importand a part silex or earth of flints plays in the formation of the terres=trial crust.

The process by which the primitive strata are formed shows that they must partake in a great measure of the nature of the igneous rocks. In fact they occasionally partake so much of it that in the earlier epochs of geological researches they were Classed with the igneous rocks. However they also partake partly of the nature of the rocks resting upon them; and for this reason they are styled Transition or Metamophic strata. They are likewise distinguished from igneous rocks by sufficiently evident marks of incipient stratification. This circumstance, which establishes so clear a distinction between the igneous rocks and the superincumbent strata, has caused the latter to be called stratified rocks while the former are called unstratified rocks.

Metamorphic rocks result from two different precipitations, that of sublimated matter preceding the presence of waters on the surface of the globe and that of matter suspended in the water after it covered the crust of the earth.

Hence transition rocks show traces

of both processes of formation: there is in them stratification combined with crystallization and such crystallization as might be expected from the sublimated matter falling on the globe.
The principal rocks composing the transition system are the gneiss mentioned above, crystallized lime-stone, quartz, hornblend, thick layers of a rock called old-red sandstone and many other varieties of slate and shale.
A circumstance, important on account of its affording a marked trace of catastrophes previous to the existence of organized bodies, must be noticed here. Subaqueous deposits, which, on account of the slow process of their formation and the mobility of the fluid, are formed in parallel and regular layers, may be either of uniform structure or of a structure uniformly varied, that is, of a succession of minor layers diminishing in density & in the size of the particles composing them. Suppose a period of tranquility during which the regular order of erosion and decomposition is effected by the action of water and

air on the dry portion of the terrestrial crust and the consequent gathering of those pulverised materials by the flowing of waters is deposited at the bottom of the ocean. We cannot see in this process but a formation of layers of much uniformity throughout, since all the varieties of elements concurring in the formation of these strata must continually reach the bottom of the sea and in a commonly uniform proportion. But in a case of general catastrophe when a large amount of materials hardly to be gathered together by a long tranquil period and differing in specific gravity and dimensions, happens to be mixed at once and tumultuarily with water, the first portion of the comminuted materials thus suspended, which will sink and commence a layer, consists of such as on account of their specific gravity sink more readily.

Thus the whole deposit formed by gradual setting of the suspended matter must be formed by successive strata of which those formed of materials most apt to subside will hold the lower position. Such accordingly is found to be the case.

Above the transition rocks succeeds a series of layers which have been denominated secondary rocks. These consist chiefly of chalk (oxid of calcium) clay, argillaceous slate, shale, red and brown sandstone, limestone, iron and led ore and coal. The presence of chalk and limestone and of metallic ore gives a clear indication of a catastrophe attended by copious eruptions. The same strata abound also in organic remains, animal as well as vegetable, often in a high state of preservation. The extent to which the Earth was the theatre of organic life, at the epoc of the deposition of these numerous strata, may be conceived when it is stated that in 1834 a German geologist counted no less than 9000 species the remains of which at that date had been found below the superior limits of the stratified rocks, not one of which has ever existed since the earth became the abitation of man — Among the animal remains which abound in these secondary strata may be mentioned corals, crinoides, mussels, trilobites, fishes, reptiles, insects, marine and fresh-water shells, sponges & animalcules countless in number — Of the reptiles, the most remarkable are various species of lizard-shaped animals, constructed on a scale of colossal magnitude: their generic appellation is Saurians but they have been also variously denominated

Megalosaurus, Plesiosaurus, Ichtyosaurus and so on.

Upon the secondary rocks reposes a series of strata of more recent deposition, called on that account *tertiary rocks*. These consist of a thick bed of clay, limestone, sand, pebbles and white sandstone. They abound in organic remains, which are distinguished from those of the lower and more ancient strata by including a considerable proportion of the still living species. Thus the lowest strata of the tertiary rocks contain 5 per cent. and the superior strata 10 per cent of the species found among the animal tribes, which still continue upon the earth.

In fine, superposed upon these tertiary are several layers of earthy matter, upon which the actual organized world is placed. These are usually resolved into two beds, the lower of which, denominated *diluvial* consists of deposits of gravel and clay with boulder-stones, rounded in different degrees by attrition, giving thus indication of having been carried from a distance by some extraordinary action of water, from which the general name *drift* has been given to them.

The superior bed consists of sand, clay & gravel, upon which the surface soil, which is the theatre of agriculture, rests. This consists of decayed and decomposed vegetable matter mixed with more or less of the disintegrated matter of the inferior beds. This uppermost layer is produced chiefly by the ordinary action of water and is denominated alluvial.

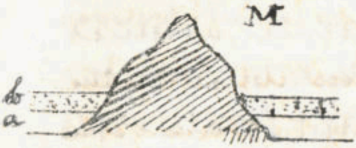
Such are the five principal groups of rocks, into which geologists have divided the matter which forms the shell of the globe. The transition, secondary and tertiary groups have each been subdivided into several layers or strata, each of which is distinguished by the peculiar sorts of mineral matter of which it is composed, and the peculiar species of organic remains which it contains. Geologists however are not agreed either as to the limits of the five principal groups or as to the distribution into subordinate strata. But whatever be the mode of this distribution, it is plain that the character and order of the sedimentary strata constitute a chronological scale indicative of the history of their formation although the absolute interval of time necessary for the deposition of the strata severally cannot be certainly determined.

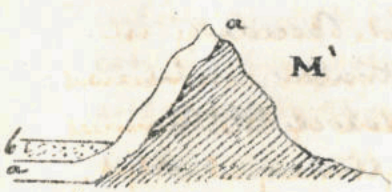
Names have been given in some cases to strata or groups of strata, from the localities in which they are found at the surface, as for example the *Jurassic* [from Mt Jura] the *Silurian*, the *Cambrian* and the *Devonian* groups. In other cases, names are derived from the prevalent materials constituting them, as the Cretaceous, Oolitic and Carboniferous groups. Other names have been adopted from the order of the deposits as for example Eocene, Miocene, Pleiocene, and Pleistocene, from the greek words signifying the earliest, less recent, more recent and most recent. Another set of names has been taken from the presence, absence or dates of the forms of life exhibited by the organic remains found in the strata. Thus those that are destitute of all such remains are called Azoic. The term Cainozoic is applied to the most recent strata, including organic remains, Mesozoic to the middle strata, Paleozoic to the ancient strata, Protozoic to the first in which life appears and Hypozoic to those strata which lie below the range of all organic remains and which consequently coincide with the azoic. The igneous or unstratified rocks are also distinguished from the stratified rocks by another appellation, the first are called Plutonic the latter Neptunian or Sedimentary rocks and sometimes rocks of aqueous origin.

Mountain-Ranges

Another great feature of the surface of the globe are mountain-ranges: they are also remarkable chronological monuments of the history of the Earth and indications of extraordinary convulsions.

When we see anywhere the sedimentary strata lifted up, we can pronounce with certainty that they have been disturbed from their original position, which was horizontal, by a force acting from beneath. Let M, M' represent two different mountains and suppose that at the foot of M we find the horizontal strata a and b. It becomes evident that the elevation of M took place before the deposition of the same strata.





But if the stratum aa is found to be lifted up, resting on the acclivity of M' while b is still horizontal; in this case the date of the formation of M' is after the deposition of a and before that of b. Mr Elie de Beaumont availing himself of this simple criterion, has found that the chains of mountains in general whose directions are parallel have the same geological date. Mountain ranges, therefore, which until the date of the application of this criterion were regarded as geologically distinct and independent are now brought into the same systems: that is each mountain system is not to be regarded as a single chain but as a number of parallel chains, near or distant from each other within any assignable limits. It may be observed also that the parts even of the same chain are not always continuous, but sometimes broken by intervals along which the crust sinks to the level of the surrounding plain.

The systems of mountains which have thus been grouped according to their geological dates have usually received denominations from some remarkable locality in which their prevalence is most conspicuous. Thus one is called the system of the Pyrenees, another the system of the principal Alps, another the system of the western Alps and so on. An accurate examination of the sedimentary depositions has shown, besides the date of the formation of the system, that their production has been always sudden: a gradual ascent would be attended by a corresponding ascent of progressive stratification and not by an abrupt division of the strata formed previously to the upheaving of the crust from those which succede them.

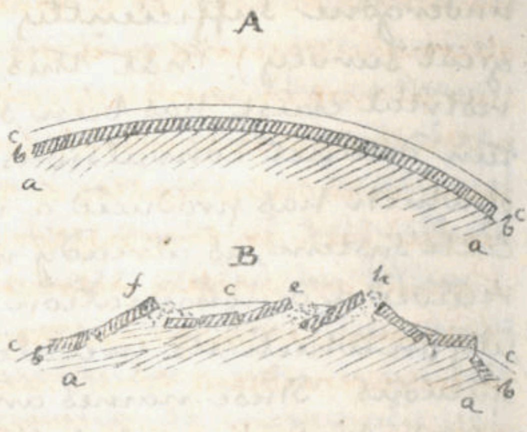
The formation of mountain systems presents a point of striking resemblance to the phenomenon of earthquakes. The undulations of earthquakes are, as we have seen, sudden and chiefly propagated in parallel lines. This point of resemblance is another clear indication of the identity of the cause of both effects which has been well styled by Pliny subterranean storm. In fact the convulsions of our atmosphere, which we call storms or hurricanes so incredibly powerful and so rapid in their motion are obedient to certain laws which govern the periods of their coming and the lines of their routs. We may also observe here that if an agent like the atmosphere, of comparatively insignificant density, can produce such effects as are those attending its commotion on occasion of violent storms; it is not surprising that great convulsions of the terrestrial crust should be affected by an ocean of materials of great density. And taking the convulsions such as they are we find a most satisfactory explanation of them in the existence of this internal ocean.

According to the results obtained from the researches of Mr Elie Beaumont it appears from a comparison of the various mountains ranges of Europe (the only part of the globe which has hitherto undergone sufficiently accurate geological survey) that this part of the terrestrial crust has been subject to seventeen distinct convulsions, at least, each of which has produced a mountain system. Each system, as already mentioned, has received a denomination from some locality in which its prevalence is most conspicuous. These names and the order in which these several systems have been elevated are as follows I Vandée, II Finistère, III Longmynd, IV Morbihan, V Hundsruck, VI Ballons, VII North of England VIII Hainault, IX Rhine, X Thuringerwald XI Côte d'Or, XII Monte viso XIII Pyrenees, XIV Corsica XV Western Alps XVI Principal Alps, XVII Taenarus. A detailed explanation of the stratigraphical character of each system would be too long for the present extract: we will limit ourselves to some general observations and some examples.

Arranged here in chronological order Vandée being the oldest

Let A represent a section of a part of the terrestrial crust covered by the ocean before a convulsion. The liquid central mass is represented in the annexed figures by aa, bb represents the solid crust covered by the ocean cc. A vigorous pressure of the liquid mass would breack the shell into fragments of greater or less

magnitude
trowing them
into various
positions as
shown in fig
B. Thus the
piece f being
tilted obliquely,
would be rai-
sed at one end
above the surface of the ocean, depressed
at the other: and a chain of mountains
formed in this manner would have a
gentle declivity on one side and abrupt
precipices on the other, such as the Py-
renees and the Andes. In other places the
two parts fractured would form gentle
declivities on both sides as at h. The
matter in fusion within the crust for-
cing its passage through the opening be
tween them, would be solidified by the
process of cooling on arriving above them.
Thus chains of mountains would be for
med of moderate declivities on both sides,
having igneous rocks at their summits.
In fine some fragments such as e, would
remain nearly level and if pushed abo
ve the surface of the sea, they would
form extensive plains of dry land, if remai
ning below the same surface they would

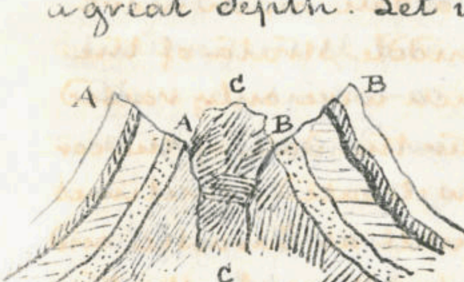


Here we have only the profile but we must remember that the crust is broken along a great distance form the bottom of a shallow sea. The alternate raising and depressing of extensive plains of land either in connection with the formation of systems of mountains or independently of them is an well marked fact in the history of our globe and it may be briefly noticed here.

All these remarks pertain to land covered by the sea or water. Strata are not formed but under water.

During each period, the deposition of strata corresponding to it has been manifestly confined to such parts of the earth only as were covered with water, and hence we are able to trace the geographical limits of sea and land, by tracing the limits of the deposits characteristic of each stratum. Thus when, for instance, we use the expression Silurian sea we mean that portion of the globe which, during the silurian period was covered by water and those portions must necessarily be co-extensive with and limited by silurian deposits. In the same manner during the cretaceous period, the globe, as before, consisting of land and water, the cretaceous deposits were made only in those parts which were then covered by water and formed the bottom of what is called the <u>cretaceous sea</u>; the other parts of the earth, which at that epoch formed the land, being consequently destitute of cretaceous strata: The absence therefore and the presence of the same deposits indicates the distribution of the land and water during the periods in which the deposits were made. Thus for example an extensive plateau in the centre of France has been dry land from the most remote geological epochs and generally, from the observations made on this subject, it results that the outlines of land and water have been different in different epochs.

As the absence and presence of the deposits has enabled geologists to define the outlines of land and water at various epochs; so the uplifted sides of the mountains have disclosed to their investigation the structure of the terrestrial crust to a great depth. Let in fact AA, BB, represent the corresponding parts of the crust fractured and uplifted by the matter in fusion CC. The depth AA or BB of the crust



thus exposed to view, often far excedes any which could be reached by direct excavation, mining or boring. Besides this great advantage an extensive portion of the same strata is disclosed to an easy and protracted investigation.

Let us now pass to examine a little more in detail the formation and character of the systems of the western and of the principal Alps, as an example of other systems or similar preceding formations. We select the Alps in preference of other examples on account of their being the loftiest of all European systems and, with the exception of the system of Taenarus, the most recent of all.

According to the analysis of M. Elie de Beaumont, the Western Alps, that is the Swiss Alps and those of Savoy and Dauphiné, present traces of catastrophes which took place, since the elevation of the system of Côte d'Or: the actual profile however of the Chain has a date much more recent. In fact the middle strata of the tertiary system which were only raised above the waters after the date of the corsican system are now elevated sometimes to vast altitudes as well as Jurassic and Cretaceous formations. The only strata found horizontal are the upper tertiary. The matter, which broke through the crust of the earth in this catastrophe, was the particular species of granite of which Mount Blanc and Mount Rosa are formed. A multitude of granitic islands in different parts of the continent are also formed

of it and on their sides appear inclined the tertiary cretaceous and Jurassic strata.
This catastrophe produced not only the lofty chains of Savoy and Dauphiné but extended its influence over Europe north and south. On the one side Nova Zembla and the whole Scandinavian peninsula were affected by it and on the other it produced a series of dislocations which are seen from Narbonne to Catalonia, determining the position of the whole Mediterranean coast of Spain. Its influence was felt south of the Mediterranean, producing the mountains of Morocco as well as those of the regency of Tunis.

The system of the principal Alps has produced the greatest features of relief upon the European continent. The lacustrine deposits formed after the elevation of the Western Alps, were themselves dislocated by it, and along the foot of the chain there are no other horizontal strata than the diluvial deposits of the present epoch. The matter pressed up from the inner regions of the globe by this catastrophe were the different varieties of Melaphyres, the Sienites, the Euphotites and Serpentines which forced up all the tertiary deposits of Piedmont and Provence, as well as the granitic rocks which constitute the most elevated summits of the principal chain of the Alps.

Not only were all the mountains which extend from the Valais and St Gothard into Austria raised on this occasion, but the greater part of the surface of Europe shared in the movement. The surface of the continent was lifted into a gentle acclivity directed towards the line which traces the summit of this great chain. It is thus for example that the plains of Bavaria rise slowly in a rather south-easterly direction and those of Lombardy in an opposite direction. In the south of France, in like manner the tertiary formation rises from the south towards the north from the borders of the Mediterranean to Saint-Vallier, and on the other side the inclination is in the opposite direction. From the borders of the Loire the surface rises gently on the one side in the direction N.N.W, and on the other in the direction S.S.E. as far as the valleys of Auvergne.

This description and analysis however rapid and limited to the last catastrophes, shows nevertheless clearly enough they all tended to one definite end; namely the final adaptation of the Earth for the dwelling place of the human race and its contemporaneous tribes.

Since it has been found in Europe that the various ridges which have the same or parallel directions, belong to the same epoch of elevation; analogy would justify a similar inference respecting all parts of the globe, and we should naturally conclude that parallelism of direction and contemporaneity of formation are mutual indications of each other. Examining the principal chains of the globe from this point of view; we find that the direction of the system of the Pyrenees extends from the Alleghanies in North America to the Indian peninsula by the Carpatian mount Caucasus, the Mountains of Persia and the Ghauts in India. To the south of this line there are several parallel ridges, such as those which run from Cape Ortegal in Asturias to Cape Creux in Catalonia. Also the little range of Granada the mountains which surround the southern side of the desert of Sahara, intersecting the direction of the Atlas and in fine the Appennines, the Julian Alps and the mountains of Croatia and Roumelia, extending to those of the Morea.

The system of Ballons, so closely related in direction to that of the Pyrenees, is also represented in the Alleghanies.

"The direction of the System of the western Alps is observed from Morocco to New Holland, passing along the Eastern coast of Spain, the South of France and a great part of the Scandinavian peninsula. Parallel ridges are found in the cordilleras of Brazil, in the regency of Tunis, in Sicily, at the point of Italy and in Asia Minor. All the littoral range of the old continent, from the northern cape of Lapland to Cape blanc in Affrica, partakes of this direction.

"The direction of the principal Alps is in accordance with numerous other ridges. Chains parallel to this direction are found in the Atlas in Spain, and across the old continent to the sea of China, including mount Olympus, the Balkans the Taurus, the central chain of the Caucasus between the Black sea and the Caspian; in the long series of Mountains which extend through Persia and Cabul, including the Parapamisan mountains in Afghanistan and Eastern Persia, the range of the Hindoo Koosh and in fine the Himalayas, which include the most lofty Mountains in the World

Parallel to the Corsican System are the chains of Syria and Palestine - Parallel to that of Monte Viso, those of Pindus -

Parallel to the Thüringerwald are the mountains of Attica and Negropont - Parallel to the Cote d' Or, and perhaps to the Hundsruck are the Altaï range and so on

Ages, Periods
Stages

In the preceding extracts we have seen how the terrestrial globe has been the theatre of numerous catastrophes succeding each other at certain intervals of time: the exact length of these intervals cannot be ascertained; it is admitted however to have analogy more or less close to that which will have elapsed between the creation of the present animal and vegetable kingdoms and the end of it effected by a future catastrophe whenever it may arrive. It may be stated moreover that taking for unity one of these intervals this unity is of much greater length than years and centuries which are the chronological measure of human hystory. We may besides obtain some approximate measure of their duration from the analysis of the strata respecting their constituent elements animal vegetable and mineral and their thickness with other circumstances concurring to their formation.

This analysis carried on with much labour and no less sagacity has brought out a great number of secrets highly instructive and interesting, some of which will form the subject of the remaining pages. Before however giving this rapid view, we must resume somewhat more orderly and in detail the subiect concerning ages and periods.

The duration of time between convulsion and convulsion is called geological period: the mineral strata deposited by the waters during such periods are called geological stages, which evidently are as numerous as the periods. The analysis of the strata has presented certain features upon which geologists have formed a classification of the same stages into six groups denominated as follows I Azoic formation II Palaeozoic formation III Triassic formation IV Jurassic formation V Cretaceous formation VI Tertiary formation This formations do not differ from the rocks already mentioned in the article on stratification, the grouping however of the strata is different here as are also the names: and the igneous rocks do not enter in this classification which commences with the Azoic group the lowest stratum of which reposes upon the igneous rocks i.e. the Azoic group coincides with the metamorphic rocks. The Paleozoic formation rests upon the uppermost strata of the Azoic group: in it, as its name implies, are found the first traces of organic life. The Triassic formation is so called from tria because it contains three principal parts of what it has in common with other formations. The Jurassic formation derives its name from the Jura mountains, which being formed by it have often times served as a term of comparison. The group of strata deposited upon the Jurassic group has been called Cretaceous or chalk formation on account of chalk being its prominent although non exclusive character. The tertiary formation is so called in reference to the division of the terrestrial crust into three concentric shels of which this formation is the uppermost and last in order of time. Or also in reference to another threefold partition from the Azoic formation exclusively upwards. This partition divides the crust of the earth, which contains organic deposits in three sections the lowest of which is called Primary or Paleozoic, the next Secondary or Mesozoic and the last Tertiary or Cainozoic.

Resuming the six formations, the second of them or Palaeozoic consists of five distinct stages each containing its own peculiar organic deposits. In like manner the Triassic formation consists of two such stages the Jurassic of ten, the Cretaceous of seven and in fine the tertiary of five; so that the whole fossiliferous portion of the Earth's crust may be considered as consisting of twenty-nine stages, each stage being a catacomb in which the remains of the preceding creation are buried. The intervals of time during which each of the six formations were deposited are called Geological Ages. Azoic age, Palaeozoic age &c. Thus the Palaeozoic age consists of five periods, denominated in their numerical order from the earliest to the last. The first Palaeozoic period, the second Palaeozoic period and so on. Adopting this chronological order and classification, Geologists have examined in detail each one of the stages from which some general inferences have been deduced and some remarkable features of the terrestrial crust have been discovered of which we will pass to see a rapid sketch.

Mineral Character of The Terrestrial crust

The constituents of the crust of the earth are divided into three classes or, as they are called, kingdoms, mineral botanical and zoological; the mineral embracing all unorganised substances, the remaining two divide the organic form into vegetable and animal. Following this division we may epitomise with some lucidity the results obtained from geological researches as much namely as compatible with a strictly synoptical view which, in the present extract must be limited to a few vulcanic productions.

All the circumstances and characters which attend basaltic rocks conspire to show that they have issued from openings in the crust of the earth in a state of fusion much more complete than that of vulcanic lava and in the process of cooling have in many cases been crystallised so as to assume remarkable varieties of columnar form, so conspicuously developed in the north of Ireland, the Scottish Islands and in many other parts of the world.

The basaltic rocks are characterised by a dark colour and a compact base of the mineral called Labradorite, including black pyroxene, generally the magnetic oxide of iron, frequently peridote and sometimes crystallised feldspar, to which they owe their porphyritic structure.

The basalt often assumes the form of prismatic columns in the process of crystallisation, consequent upon slow cooling. M. Gregory Watt imitated it artificially and obtained regular columns resembling in all respects those of natural basalt.

In some places basalt forms vast plateaux of considerable thickness, in others it is found in detached sheets of less extent, at points of mountains more or less distant one from the other, and at the same level, as if it had originally been a single sheet and had been disrupted by the convulsions of which the mountains have been the result. In some cases the basalt forms insulated masses or mounds rising in the midst of plains, altogether removed from all similar formations. It is also often found in veins in the strata. Again it presents itself in the form of extensive walls or in a series of separate mounds having a common direction.

Basaltic deposits are much more extensive than those of ordinary vulcanic origin but the tendency of these rocks to form themselves into prismatic columns has more especially attracted the attention of observers. In some cases all the prisms converge to the summit of a mound, which thus assumes a sheaf-like structure: in others thei take the form of close columns with the most picturesque aspect: in others these columns, cut off at a certain level, form a sort of mosaic pavement, to which the name of causeway has been given. One of the most magnificent examples of this kind is presented in the case of the Giant's causeway in the north of Ireland. Other examples of similar formations are presented in different parts of Europe especially in the Vivarais in France. Basaltic rocks with all the prismatic characteristics above described are frequently present in the form of mineral veins: examples of this are found in the central parts of France and on the borders of the Rhine. Most commonly the matter composing the vein is compact or divided by irregular cleavage but when it exhibits the prismatic form, the axes of the prisms are horizontal.

Grottoes, caves and tunnels are often found in the midst of basaltic masses, and in those of trap rocks, which have a close analogy to them. Examples of this may be seen in the Vivarais, on the borders of the Rhine, near Bentrick - Baden, where the columns forming the grotto consist of rounded blocks resembling a pile of cheeses, from whence the grotto has received the name of Käse-Grotte. But by far the most magnificent of these Basaltic grottoes is the celebrated cave of Fingal in the Island of Staffa.

Another eruptive production of the terrestrial crust, still more extensive than the basalt is that of the trachytic rocks, which form the celebrated Puy-de-dome in Auvergne, the Mont d'or, the Cantal De Merene and the Megal, upon the borders of the Velay and the Vivarais. They prevail also on the right bank of the Rhine and the Siebengebirge: they form immense groups in Hungary and Transylvania; in the Caucasus: in Greece, where their continuation appears in the Islands of Milo in Argentiera and extends to the centre of Santorin. They reappear in the Lipari islands: in the Campania: in the Euganian mountains: in the Azores: in the Canaries: in South America, where the loftiest heights of the Cordilleras are composed of them: in central Asia and in many of the Islands extending along its coast to Kamschatka.

The trachytic formation presents itself

also in narrow bands and sheets scattered over the surface of the globe like those of the basalt. The vast mountains it forms, generally assembled in large groups, are covered with terrific asperities and their flanks are torn by precipitous valleys and deep gorges.

But as the genus of this vulcanic production is abundant in the formation of the terrestrial crust, so the species, are extremely various. In some instances they present a compact porphyric structure but more commonly they are minutely porous or present cavities or scoriaceous and pomiceous character. Their colour also is various, now gray, now red or dark and black interspersed with wite crystals: there are examples of light colours, to which class the name of Domites is given from the Puy-de-Dome which is composed of them. The base of all these rocks is Albite and results from an agglomeration of microscopical crystals

Besides the granite with its various classes, the basalt and trachytes, there are rocks the constituents of which are not sufficiently known. They are called Trappitic rocks and frequently form prisms like basalts. Another kind of rocks consists of those called Phonolites from their ringing character. They are found in trachytic as well as in basaltic soil.

Feldspar, as we have seen elsewhere, constitutes the base of granitic rocks in a pasty form. Feldspar besides enters as a constituent of this kind of rocks in a crystallised form. Now there are instances in which instead of definite crystals imbedded in the feldspatic mass, nucleuses are found in it of a crystalline nature, frequently radiated from their centres to the surface. This kind of rocks is called variolites

Other rocks, as the diorites, a formation analogous to granite and some basalts contain similar nucleuses of different substances which have been compared to almonds; hence the appellation of Amygdaloides given to these rocks

The veins formed by the central liquid matter forced upwards through fissures and cracks, often contain earthy matter such as carbonate of lime, sulphate of baryta and quartz, in which case they offer but little interest. They are however more frequently filled either wholly or partially with metalliferous substances in which case they acquire great importance. Concerning these formations we must remark that they are found in vertical fissures as well as between layers or in small masses either insulated or connected by filaments of the same substance. Commonly however they form systems of veins in a direction somewhat parallel: it often happens also that one system of such veins is intersected by another presenting mineral contents totally different from the former: these are called cross veins.

Every thing conspire to show the igneous origin of metallic minerals. Let it suffice to mention some circumstances evincing the common origin of metallic veins and volcanic rocks. Roks in a state of fusion and ejected by the interior force assume themselves the form of veins piercing, as it were, the terrestrial crust. Now the rocky threads are occasionally found closely connected with the metallic ones, thus sometimes the same veins are now granitic now metallic or the metallic threads accompany porphyric or basaltic threads as in Bohemia, and the two substances intermingle mutually with alternate prevalence.

To the transition rocks has been given the name of metamorphic rocks on account of their being a transformation of the primitive rocks: although, as we have observed, the change is so slight as to have remained unnoticed for a long time. Other changes more perceptible and various are effected the action of the fused matter issuing from the interior of the globe on the rocks and strata through which it passes and which it affects. These changes are designated by the appellation of metamorphism and the rocks or deposits thus modified form a peculiar class of mineral substances. To give some idea of the origin and character of these rocks it is enough to mention some examples. Calcarious deposits, with which granitic rocks in a state of fusion have come at contact, have been transformed into calcarious saccaroid masses in which the vestiges of organic remains have ordinarily disappeared. they have taken a variety of vivid colours and have been filled with crystalline substances. Some clay deposits or sandy masses have likewise been filled with the same crystalline substances and have been changed into shistous form or even into Jaspers.

But the granites themselves which by their action metamorphise so admirably other formations have been greatly altered when their solid masses have been traversed by basaltic veins. These changes and many others similar to them are of very frequent occurrence although generally they belong to ancient action. We may refer to the same class of phenomena the effects produced by gaseous eruptions which appear to have been prodigiously abundant at earlier epochs. Carbonic acid, for instance, entering into combination with lime, transformed this substance into lime-stone and into rocks of different kinds including every variety of marbles

Botanical character of the terrestrial crust

Mineralogical effects are not the only ones produced by the abundant eruption of carbonic acid. This gas, together with the great quantity of aqueous vapours always suspended in the air, was at those earlier epochs, eminently favorable to the production of a vegetation exuberant to a degree of which there is now no existing parallel. Hence arose those vast forests and other large collection of vegetable matter, which being fossilised in succeeding revolutions of the globe, have supplied inexhaustible stores of mineral fuel which, through the application of science, have become mechanical agents of indefinite power as well as sources of light and heat; another evidence of the benevolent purpose of the Creator in adapting the earth for the habitation of man. But let us examine the subject a little more in detail.

No doubt can be intertained concerning the origin of carboniferous deposits. They are produced by an accummulation of vegetable substances. In fact by an accurate analysis of the structure of the materials composing these deposits, the microscope has detected the fibrous texture and other circumstances which qualify vegetable substances, just as a like examination finds similar qualities in the combustible called peat or turf, the formation of which we know to be nothing but the accumulation of vegetable substances formed in the bed of our present marshes. The same analysis has besides discovered stocks and roots and leaves in abundance. Geologists therefore agree unanimously on this subject. The same agreement is not to be found concerning the mode in which the coal deposits are formed; some are of opinion that they are the result of long continued buring of rafts transported by rivers or by sea-currents: others think their formation to be like that of modern turfs. The depression of the ground, of which there are so numerous examples, is sufficient to explain the fact of the formation of a coal bed resulting from the vegetation of the ground itself and from that of the surrounding land conveyed by streams flowing towards the cavity. This opinion is better supported by the circumstances observable in the analysis of carboniferous strata. The other however is not destitute of a good foundation

The qualities of the plants fossilised in the deposit of coal are such that compared with our present vegetation or, as it is called, the present Flora they give clear evidence of uniform tropical temperature on the whole surface of the globe: this accords remarkably well with other geological evidences of the same fact. There exists, for instance, in England, in the Island of Portland, as well as elsewhere and on various parts of the continent a stratum called by miners dirt-bed. and, among the fossil plants found in the stratum, there are some analogous to the modern tropical plants Cycas and Zamia. The uniformity of climate over the entire surface of the globe is a fact constantly evinced by botanical deposits and also by zoological fossils: from which we see that in all former ages and periods, including those which immediately preceded the present, the earth' surface was not divided as it is now into climatological zones each zone having its peculiar animals and

flora plants
fauna animals

plants: or, as they say, its peculiar Fauna and Flora.

Coal deposits give moreover some approximate idea of the length of the periods of their formation. The analysis of the constituents of these deposits shows that their actual volume compared with the original one is in a ratio between from 4 and 22 to 100. Hence the great length of the period required for the formation of certain carboniferous deposits whatever be the process. According to the estimate of Mr de Beaumont, from the coal which our present forests would annually produce, one century would not suffice to add one inch of thickness to the deposits of coal that are known. Supposing even, as we must, a much more rapid and exuberant vegetation than that of the present period; carboniferous deposits, especially those of 60 feet of thickness necessarily require periods of enormous length for their formation.

The strata of coal, like those of other substaces, have been metamorphised by the action of fused volcanic matter: they have lost their bituminous constituents they have assumed the character of coke and have even been reduced to ashes.

The analysis of fossilised vegetation

is no less interesting than that of the other constituents of the terrestrial crust. As the science of comparative anatomy has enabled the geologist to reproduce the forms and determine the habits and functions of the animal tribes which peopled the earth at former periods; in like manner the principles of botanical science have enabled him, basing his conclusion upon the visible structure of vegetable remains found in the coal beds, to reproduce, as it were the vast forests of the same periods. For instance those of palms and arborescent ferns, the groves of conifers and the rest of the exuberant vegetation which flourished during the second, third and fourth Palaiozoic periods eminently carboniferous

In the layers of pure coal, which consist altogether of carbonised vegetable, the leaves often possess such tenacity as to be separable from the stone: these and the seed-vessels, which are found in iron-stone, have in many cases undergone metallic impregnation, which has in no degree impaired the delicacy of their structure. The coal plants have been determined to the number of nearly a thousand species, two-thirds of which are related to the Ferns and the higher tribes of Cryptogamia, the remainder consisting of conifers and some flowering monocotyledonous (having only one seed lobe) and dicotyledonous (having two seed lobes) trees; numerous species however are still undescribed and new forms are continually discovered. It is worthy of note that identical fossil plants have been found on opposite sides of the earth.

The fourth palaeozoic period is, on account of its abundant vegetation, antonomastically called the carboniferous period. The prominent character of the vegetable kingdom during this period is the immense predominance of the vascular and higher tribes of Cryptogamic plants with which were associated palms, conifers, cicadae and other plants approaching to the character of Cacteae and Euphorbiaceae. Plants analogous to the tribes of Ductulosae abounded, differing however both in genera and species from those which at present exist. Thus fossil calamites are found which measure eighteen inches in circumference and thirty and forty feet in length, while the recent analogous species, seldom exceed an inch in diameter and two feet in height. The arborescent ferns called sigillaria sometimes measure fifty feet in height having their summits covered with a splendid canopy of foliage. The foliage of the herbaceous species is extremely elegant, presenting endless varieties in their forms and in the skeletons of their leaves. The arborescent club-mosses, called lepidodendria or scaly tree frequently attained an elevation of from sixty to seventy feet. Some of these trees have been found entire from their roots to their top-most branches. their foliage consisted of simply linear leaves, spirally arranged round the stem. The leaves had in many cases shed from the tree, the marks of their points of attachment never having been obliterated. In their external forms the mode of ramification and the disposition of their foliage, they closely resemble the existing Lycopodiaceae or club-mosses: and notwithstanding the enormous disparity of magnitude between these latter and the fossil Lepidodendra; Brongniart has shown that both belong to the same family. The magnitude of Lepidodendra reaches that of the largest existing pines: and during the Carboniferous period they formed extensive forests beneath whose shade flourished the lesser ferns and associated plants now found with them in the same coal-strata.

Zoological Character of the terrestrial crust

The rapid sketch we have given of the mineralogical and botanical character of the terrestrial crust, shows sufficiently that each of the two kingdoms offers abundant subject for the sciences of botany and mineralogy. A still larger field is presented to the science of Zoology by the analysis of the same crust: the strata of which are most abundant zoological museums of past creation.

Naturalists to render more accessible the study of this section of Geology have endeavoured to classify the numerous tribes which through a long series of periods have successively tenanted the surface of the globe or have inhabited the seas, a task not easy to be accomplished on account of the great number and varieties and of the periods of the existence of the same tribes. Hence the confusion prevailing among the classifications adopted by different naturalists

The most common of these classifications divides all the various forms of animal life, from the first animalisation of the globe to the existing tribes inclusively into four sections denominated from their peculiar structure I Vertebrata, II Annulata, III Mollusca, and IV Radiata.

Each of these primary divisions is resolved into a certain number of Classes and each class is again resolved into Orders, each order into Genera each genus into Species and each species into Varieties.

The four primary divisions are resolved into classes as follows:— The Vertebrata into four, the annulata into six, the mollusca into five and the radiata also into five making altogether twenty classes.

The vertebrate division is characterised by an internal skeleton and a cerebro-spinal nervous system. It takes its name from the vertebral or spinal column, to which all the subordinate parts of the skeleton are attached. The four classes of this division are Mammifers, Birds, Reptiles and Fishes.

The Annulata have no internal skeleton but in its stead a tegumentary covering, composed of movable rings, which gives them their characteristic form. Their nervous system consists of two long cords running longitudinally through the abdomen, twisted at intervals in knots called ganglions. The tegumentary covering, which is always annular, is sometimes hard and calcareous. The six classes of this division are Insects as the Bee; Miriapods (thousands of feet); Arachnides, as the spider and scorpion: Crustacea, as the crab: Cirrhipeds as the anatifa (animals which attach themselves to the bottom of ships) and Annelides, as the earth-worm.

The mollusca have neither internal skeleton nor articulated envelope. Their bodies are sometimes naked, but often protected by a shell. The five classes of this division are Cephalopods and Gastropods (kinds of snails): Lamellibranchia called also Acephala, as oysters: Brachipods, another kind of shelled animals, and Bryozoa. To this class belong the reticulipora

The radiata include the lowest form of animal organic life. The numerous and heterogeneous groups of this class have in general no articulated skeleton, either internal or external, and scarcely exhibit the rudiments of a nervous system. Those to which the name of radiata is more properly applied are composed of organs disposed radially around a centre or axis. Some naturalists have given to this division the name of Zoophites being as a link between animals and vegetables others have confined this name to Polyparia which is one of the classes of the division. Corals and Astreas are examples of polyparia. The remaining classes are Echinodermata, as star fish: Foraminifera (microscopical cased animals): Amorphozea, as sponges and fungi and Infusoria (also microscopical animals) so called to imply the existence of this class of animals in vegetable and other infusions.

The vastness of the subject and its endless variety, renders extremely difficult if not even impossible a synoptical and clear exposition of the same. We must therefore confine ourselves to elucidate some few scattered points. Let us first observe that organic remains offer an excellent test to distinguish periods from periods.

Geologists have ascertained the existence of organic remains of about twenty-four thousand species of the different orders of animals, which they have assigned to upwards of fourteen hundred and seventy genera. Of these numerous species none survive; but we find in the existing animal kingdom about five hundred and fifty of the genera the remainder being extinct.

It was supposed until very recently that those twenty-four thousand fossil species of the different orders of animals were distributed through the strata of the crust of the earth, in such a manner that the great majority of them is common to strata of very different dates of deposition and that comparatively few were found exclusively in strata of particular dates; these few being consequently called Characteristic Species in as much as they supplied to Geologists certain tests, by which the dates of strata, left uncertain from their mineralogical constituents, could be fixed. But the elaborate researches of M. D'Orbigny, who has catalogued, described and located a vast number of species of mollusca and radiata alone, have demonstrated that all the species found in strata of the same date, with extremely rare exceptions, are characteristic of these strata.

There is therefore in the crust of the earth a sort of organic stratification and, comparing stage with stage a distinct and unmistakeble line of separation between their respective faunas; and as the preceding fauna disappears by the effect of some catastrophe, so the next fauna appears not gradually but suddenly and simultaneously over the whole extent of the globe, so far as geological observations have extended and demonstrate. The fauna therefore is a most valuable test to geologists. The twenty-nine organic stages point out the number of universal cataclysms; the character of the species determines the periods and their corresponding strata. The sudden and simultaneous apparition of successive faunas shows that Almighty power has called at once into existence entire tribes to inhabit the globe and finally the identity of species, from the equator to the poles, is a manifest indication of the equality of climate over the whole surface of the globe.

Another fact well ascertained by geological researches is that the four principal sections in which the animal kingdom has been divided have been uninterruptedly represented by the inhabitants of the globe from the primitive creation to the present period. There is however a progressive increase of them according to their order of organisation — the mammalia, which are the first in this order are the most recent in date and the zoophytes and mollusca, which are the last, are the earliest. That is the first forms of animal life where chiefly zoophytes and other classes of the lowest organisation, the only vertebrates then existing being fishes and those in very limited numbers

The first appearance of birds was manifested during the cretaceous period but they were very limited in number until the tertiary period. It was not until the last tertiary period, which immediately preceded the present epoch, that mammalia were created, during which period birds, reptiles and fishes augmented in number and variety as did also various others inferior classes. It must be observed however, that foot-prints of mammalia have been discovered in the oolitic strata and marks supposed of birds in the triassic.

The progressive increase of animal tribes does not seem to be attended by an equal progress of organisation. No döbt can be certainly intertained concerning the specific perfection of each division; but the diligent study of the remains of animals of the different periods has besides convinced geologists that there have been always specimens of organisation as complete and exquisite as at present; a circumstance which has also led them to the conclusion that the external conditions in which animals exist have undergone no essential change and that the medium in which birds and reptiles, breathing by lungs, lived was little, if at all, different from the medium in which similar classes now live. An example of exquisite organisation is offered by the ocular structure of Trilobites a family of aquatic crustacea, almost exclusively limited to the Silurian period. Their eyes consists, like those of some insects, of a large number of minute lenses of octagonal form, set in the ends of tubes arranged side by side so as to produce a radiating mass, enabling the animal to look at the same time in every direction. As many as four hundred of these lenses have been found set in a single cornea. From such a structure we infer again that the properties of light and of the transparent media constituting the atmosphere and water, were at remote epochs what they are now.

There is another division of the animal creation of remote geological periods which, besides concurring with the rest of the zoological Kingdom to trace out the history of the globe, likewise gives a striking geological feature to the crust of the earth. It is wonderful indeed to see the enormous extent of matter which various species of microscopical animals have elaborated, from the gaseous or liquid elements around them, by vital action.

Whole islands and even larg tracts of continents have been produced by the secretive functions and other vital agencies of countless myriads of living instruments. Ehrenberg, the celebrated prussian microscopist and naturalist, mentions a stratum in Germany, not less than 14 feet in thickness composed exclusively of the shells of animalcules, so minute that fourty-thousand millions of them would not fill a space greater than a cubic inch. Mountains hundreds and even thousands of feet in height are also found to be composed of organic animal matter.

During the first tertiary period in which a prodigious number of such minute creatures abounded; the Nummulites which, among others, prominently characterise that period and which have been so called on account of the round flat form of their shell resembling that of a coin; living far from the coast left their shells deposited in layers of great thickness upon the deepest bottom of the sea. At subsequent periods geological convulsions occurred by which these conchiferous strata were forced upwards so as to form mountain ranges. An example of such chains is presented in the Pyrenees where entire mountains are found consisting of little else than the fossilised remains of these minute animals. It is a striking fact also that it was of the like materials that the pyramids of Egypt were built.

A similar example is offered by the so called Miliolae, which prevailed among the Zoophytes and Foraminifera of the second tertiary period. They are characterised by their multilocular shells and take the name from Milium the latin word for millet seed. Their multitude is so enormous, as to form those strata of which nearly the whole city of Paris is built. Thus one of the greatest cities of the world owes its fabrication to the original industry of minute animals, which lived so long before the creation of man. The prodigious multitude of these minute beings concurring to produce the quarries of Paris, may be imagined when it is stated that, taking into account the weight of these shells, it has been calculated that a cubic inch of stone must be composed of no less than two thousand millions of them.

Numerous other similar examples of calcareous deposits to be met with in every part of the world might be added all formed by microscopic shells, of which from seven to eight hundred fossil species have been discovered, the principal of which are the foraminifera and the infusoria. The foraminifera derive their name from the structure of the shell, which consists of one or more series of chambers, separated from one another, by septa or partitions in each of which there is a small perforation. The polishing slate of Biling in Bohemia is almost exclusively formed by them. The infusoria present a still greater variety than the foraminifera. Mr Ehrenberg has described numerous fossil genera and species of them found in all parts of the world and in different strata.

Among the zoophites which have largely contributed and do also at present contribute to the formation of the crust of the earth the coralline or madreporic reefs cannot be left altogether unnoticed. At present they exist only in intertropical regions, but not so in former periods on account of the uniform temperature. Madreporic formations until 1599 have been supposed to be plants and not animal productions. Ferrante Imperato discovered discovered the animal character of this production, which imitates the form of trees and flowering shrubs and although they have the compactness and rigidity of stones, they rival plants in gracefulness, delicacy and brillancy of colours. The miriads of animalcules who build up these admirable structures live and die in them cased in proportional cavities which they never abandon, but stretch temselves out of their holes to take from the sea nurishment to live and materials to build. Upon the old dead bodies and preceding structure the new continue to grow, adding to the mass and gradually form important members of the earth' surface.

The polyps, which have contributed most to the construction of coralline reefs are the *Astreas*; the *Madrepora*: the *Meandrinas*: the *Porites*: the *Caryophilleas* and the *Oculinas*. Some species, remarks Prof. Dana, grow up in the form of large, leaves rolled around one another like an open cabbage: another foliated kind consists of leaves more crisped and of a more delicate structure irregularly clustered — Clustered leaves of acantus and oak are at once called to mind by other species — a sprouting asparagus bed by others

In the present period the great theatre of the formation of coral reefs is, as we have observed, within the tropics and especially in the indian ocean and in that part of the Pacific called Polynesia: comprising altogether a space of about the extent of Asia. The numerous groups of low Islands and reefs forming unbroken barriers for hundred of miles (frequently circular and enclosing a sheet of water) which are to be met with in those seas; owe their existence to the work of coralline zoophites.

Periodical Geography

It is a highily interesting problem for the geologist to determine the geographical condition of the surface of the earth defined by the relative extent and outlines of land and water, during each of the periods in which the strata of the actual terrestrial crust have been formed. But the solution of this problem besides requiring a larger and more accurate survey of the dry land than the one possessed at present, meets with an insurmontable difficulty with the larger portion of the terrestrial shell covered by the waters. Nevertheless, although the problem taken in its total extent is an insoluble one; it admits yet of a partial and approximate resolution concerning the series of geographical changes, which that part of the earth, at present dry land, has undergone since the earliest geological periods.

To keep this last article within limits proportionate to the preceding extracts, it will be enough for us to point out the criteria which indicate the limits of land and water in past ages or what is called Geological horizon of the different periods; a term, perhaps not very properly, adopted to indicate the layer of the crust extending over the whole globe and which was contemporaneously deposited.

The first criterion, which indicates dry land is the absence of the geological horizon of the period. This absence in fact indicates that the subjacent deposits were above the level of the sea, and formed an island or continent during the period in which the absent deposit was formed. Thus the extensive plateau which, we have already said to be in the centre of France, gives evidence of having been dry land from the most remote epochs and at the epoch of the formation of the deposit which constitutes the present Paris basin the greatest part of Europe gives evidence of having been dry land.

If the constituent of the different strata belonged exclusively to them, so that those of one stratum would never been found in another stratum of different formation and the constituents of the same stratum were the same everywhere; the determination of the outlines of land and water at different epochs would be rendered much easier. It would be enough in such a case to ascertain the presence or absence of such characteristic constituents to decide at once whether the part of the land examined was above or below the water at the epoch of the deposit in question. Mineral constituents vary from place to place in strata of simultaneous deposits, hence they are not a good criterion to decide promptly the presence or absence of water over the land. A better test for this purpose is offered by fossil zoology: for although it be true that many of the genera of animals and plants deposited in strata of different dates are common, this is not the case with the species which, with rare exceptions are peculiar to each period.

The aid afforded by organic remains supplies the means to determines other details besides the outlines of land and water.

It is known, for instance, that certain genera of animals can live only in the tranquil bottoms of deep seas; there they live and die and there their remains are buried. Hence where such remains are found in the strata of the crust of the earth, such strata must have been at the epoch of their deposition at the bottom of a deep sea.

The outlines of land and water are moreover determined and with great precision by the accumulation of organic deposits. The bodies of certain animals when dead and not dismembered float upon water. The remains of such would necessarily be washed upon the shore and cast upon the coasts between high and low water-mark. There, upon the successive returns of the tide, they would be gradually covered with sand or mud and would thus be buried in the strata to become future fossils. Where such remains are found, an indication is given of a limit between land and water.

As there are remains which indicate the deep sea and some which indicate the sea shores; so other organic remains determine the bottom of shallow seas. There are marine animals that live neither on the very coasts of the sea nor in very deep water, but frequent the littoral sections of the seas and in the bottom of these sections their remains are accordingly found. Thus the zoological test offers indications to determine the undulations of the land when in former periods it was covered by the sea

We must add to the preceding remarks that the bodies of dead animals and vegetables which are carried away by the currents of rivers to their embouchures; there they are deposited, mixed with certain species of marine animals. Thus the combination of fresh-water shells, land animals and plants with the remains of marine animals are a sure indication of the embouchure of rivers and estuaries

We owe to the labours of the eminent geologists Mr Elie de Beaumont and Mr D'Orbigny the construction of various maps showing the outlines of land and water of different periods. The configuration and extent of land and water in western Europe during the Silurian period: the map of western Europe in the carboniferous period: the map of France in the Triassic age: The map of western Europe in the Jurassic age: that also of the western and central Europe in the Cretaceous age: the map of France and England in the Tertiary age and others. Further investigations will afford materials to enable naturalists to extend the same graphical description to other parts of the globe.

The sketch we have given of the stupendous works of God manifested in the history of the globe from the beginning to the present period, rapid and incomplete as it is; shows however sufficiently well, the boundless benevolence of purpose and equally boundless power and wisdom in adapting the habitation for man. A benevolence which manifestly requires on the part of man a gratitude and dependence without limits