GEORGES LOUIS LECLERC BUFFON

BUFFON'S NATURAL HISTORY, VOLUME I (OF 10)

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Содержание

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PREFACE

We should certainly be guilty of a gross absurdity if, in an age like the present, we were to enter into an elaborate discussion on the advantages to be derived from the study of Natural History; the ancients recommended it as useful, instructive, and entertaining; and the moderns have so far pursued and cultivated this first of sciences, that it is now admitted to be the source of universal instruction and knowledge; where every active mind may find subjects to amuse and delight, and the artist a never failing field to enrich his glowing imagination.

It would have been singular if, on such a subject, a number of authors had not submitted the produce of their observations and labour; many have written upon Natural Philosophy, but the Comte de Buffon stands eminently distinguished among them; he has entered into a minute investigation, and drawn numberless facts from unwearied observations far beyond any other, and this he has accomplished in a style fully accordant with the importance of his subject. Ray, Linnæus, Rheaumur, and other of his cotemporaries, deserve much credit for their classing of animals, vegetables, &c. but it was Buffon alone who entered into a description of their nature, habits, uses, and properties. In his Theory of the Earth he has displayed a wonderful ingenuity, and shewn the general order of Nature with a masterly hand, although he may be subject to some objections for preferring physical reasonings on general causes, rather than allowing aught to have arisen from supernatural agency, or the will of the Almighty. In this he has followed the example of all great philosophers, who seem unwilling to admit that the formation of any part of the Universe is beyond their comprehension.

As the works of this Author will best speak for themselves, we shall avoid unnecessary panegyric, hoping they will have received no material injury in the following translation; we shall therefore content ourselves with observing, that in our plan we have followed that adopted by the Comte himself in a latter edition, from which he exploded his long and minute treatises on anatomy and mensuration; though elegant and highly finished in

themselves, they appeared to us of too abstruse and confined a nature for general estimation, and which we could not have gone into without almost doubling the expence; a circumstance we had to guard against, for the advantage of those of our readers to whom that part would have been totally uninteresting.

As to this edition, we presume it is no vain boast, that every exertion has been made to do justice to a work of such acknowledged merit. In the literary part, it has been the Proprietor's chief endeavour to preserve the spirit and accuracy of the Author, as far as could be done in translating from one language into another; and it is with gratitude he acknowledges, that those endeavours have been amply supported by the engraver; for the decorative executions of Milton will remain a lasting monument of his abilities, as long as delicacy in the arts is held in estimation.

THE THEORY OF THE EARTH

Neither the figure of the earth, its motion, nor its external connections with the rest of the universe, pertain to our present investigation. It is the internal structure of the globe, its composition, form, and manner of existence which we purpose to examine. The general history of the earth should doubtless precede that of its productions, as a necessary study for those who wish to be acquainted with Nature in her variety of shapes, and the detail of facts relative to the life and manners of animals, or to the culture and vegetation of plants, belong not, perhaps, so much to Natural History, as to the general deductions drawn from the observations that have been made upon the different materials which compose the terrestrial globe: as the heights, depths, and inequalities of its form; the motion of the sea, the direction of mountains, the situation of rocks and quarries, the rapidity and effects of currents in the ocean, &c. This is the history of nature in its most ample extent, and these are the operations by which every other effect is influenced and produced. The theory of these effects constitutes what may be termed a primary science, upon which the exact knowledge of particular appearances as well as terrestrial substances entirely depends. This description of science may fairly be considered as appertaining to physics; but does not all physical knowledge, in which no system is admitted, form part of the History of Nature?

In a subject of great magnitude, whose relative connections are difficult to trace, and where some facts are but partially known, and others uncertain and obscure, it is more easy to form a visionary system, than to establish a rational theory; thus it is that the Theory of the Earth has only hitherto been treated in a vague and hypothetical manner; I shall therefore but slightly mention the singular notions of some authors who have written upon the subject.

The first hypothesis I shall allude to, deserves to be mentioned more for its ingenuity than its reasonable solidity; it is that of an English astronomer, (Whiston) versed in the system of Newton, and an enthusiastic admirer of his philosophy; convinced that every event which happens on the terrestrial globe, depends upon the motions of the stars, he endeavours to prove, by the assistance of mathematical calculations, that the tail of a comet has produced every alteration the earth has ever undergone.

The next is the formation of an heterodox theologician, (Burnet) whose brain was so heated with poetical visions, that he imagined he had seen the creation of the universe. After explaining what the earth was in its primary state, when it sprung from nothing; what changes were occasioned by the deluge; what it has been and what it is, he then assumes a prophetic style, and predicts what will be its state after the destruction of the human race.

The third comes from a writer (Woodward) certainly a better and more extensive observer of nature than the two former,

though little less irregular and confused in his ideas; he explains the principal appearances of the globe, by an immense abyss in the bowels of the earth, which in his opinion is nothing more than a thin crust that serves as a covering to the fluid it incloses.

The whole of these hypotheses are raised on unstable foundations; have given no light upon the subject, the ideas being unconnected, the facts confused, and the whole confounded with a mixture of physic and fable; and consequently have been adopted only by those who implicitly believe opinions without investigation, and who, incapable of distinguishing probability, are more impressed with the wonders of the marvellous than the relation of truth.

What we shall say on this subject will doubtless be less extraordinary, and appear unimportant, if put in comparison with the grand systems just mentioned, but it should be remembered that it is an historian's business to describe, not invent; that no suppositions should be admitted upon subjects that depend upon facts and observation; that his imagination ought only to be exercised for the purpose of combining observations, rendering facts more general, and forming one connected whole, so as to present to the mind a distinct arrangement of clear ideas and probable conjectures; I say probable, because we must not expect to give exact demonstration on this subject, that being confined to mathematical sciences, while our knowledge in physics and natural history depends solely upon experience, and is confined to reasoning upon inductions.

In the history of the Earth, we shall therefore begin with those facts that have been obtained from the experience of time, together with what we have collected by our own observations.

This immense globe exhibits upon its surface heights, depths, plains, seas, lakes, marshes, rivers, caverns, gulphs, and volcanos; and upon the first view of these objects we cannot discover in their dispositions either order or regularity. If we penetrate into its internal part, we shall there find metals, minerals, stones, bitumens, sands, earths, waters, and matters of every kind, placed as it were by chance, and without the smallest apparent design. Examining with a more strict attention, we discover sunk mountains, caverns filled, rocks split and broken, countries swallowed up, and new islands rising from the ocean; we shall also perceive heavy substances placed above light ones, hard bodies surrounded with soft; in short, we shall there find matter in every form, wet and dry, hot and cold, solid and brittle, mixed in such a sort of confusion as to leave room to compare them only to a mass of rubbish and the ruins of a wrecked world.

We inhabit these ruins however with a perfect security. The various generations of men, animals, and plants, succeed each other without interruption; the earth produces fully sufficient for their subsistence; the sea has its limits; its motions and the currents of air are regulated by fixed laws: the returns of the seasons are certain and regular; the severity of the winter being constantly succeeded by the beauties of the spring: every thing appears in order, and the earth, formerly a CHAOS, is

now a tranquil and delightful abode, where all is animated, and regulated by such an amazing display of power and intelligence as fills us with admiration, and elevates our minds with the most sublime ideas of an all-potent and wonderful Creator.

Let us not then draw any hasty conclusions upon the irregularities of the surface of the earth, nor the apparent disorders in the interior parts, for we shall soon discover the utility, and even the necessity of them; and, by considering them with a little attention, we shall, perhaps, find an order of which we had no conception, and a general connection that we could neither perceive nor comprehend, by a slight examination: but in fact, our knowledge on this subject must always be confined. There are many parts of the surface of the globe with which we are entirely unacquainted, and have but partial ideas of the bottom of the sea, which in many places we have not been able to fathom. We can only penetrate into the coat of the earth; the greatest caverns and the deepest mines do not descend above the eight thousandth part of its diameter, we can therefore judge only of the external and mere superficial part; we know, indeed, that bulk for bulk the earth weighs four times heavier than the sun, and we also know the proportion its weight bears with other planets; but this is merely a relative estimation; we have no certain standard nor proportion; we are so entirely ignorant of the real weight of the materials, that the internal part of the globe may be a void space, or composed of matter a thousand times heavier than gold; nor is there any method to make further

discoveries on this subject; and it is with the greatest difficulty any rational conjectures can be formed thereon.

We must therefore confine ourselves to a correct examination and description of the surface of the earth, and to those trifling depths to which we have been enabled to penetrate. The first object which presents itself is that immense quantity of water which covers the greatest part of the globe; this water always occupies the lowest ground, its surface always level, and constantly tending to equilibrium and rest; nevertheless it is kept in perpetual agitation by a powerful agent, which opposing its natural tranquillity, impresses it with a regular periodical motion, alternately raising and depressing its waves, producing a vibration in the total mass, by disturbing the whole body to the greatest depths. This motion we know has existed from the commencement of time, and will continue as long as the sun and moon, which are the causes of it.

By an examination of the bottom of the sea, we discover that to be fully as irregular as the surface of the earth; we there find hills and vallies, plains and cavities, rocks and soils of every kind: we there perceive that islands are only the summits of vast mountains, whose foundations are at the bottom of the Ocean; we also find other mountains whose tops are nearly on a level with the surface of the water, and rapid currents which run contrary to the general movement: they sometimes run in the same direction, at others, their motions are retrograde, but never exceeding their bounds, which appear to be as fixed and invariable as

those which confine the rivers of the earth. In one part we meet with tempestuous regions, where the winds blow with irresistible fury, where the sea and the heavens equally agitated, join in contact with each other, are mixed and confounded in the general shock: in others, violent intestine motions, tumultuous swellings, water-spouts, and extraordinary agitations, caused by volcanos, whose mouths though a considerable depth under water, yet vomit fire from the midst of the waves, and send up to the clouds a thick vapour, composed of water, sulphur, and bitumen. Further we perceive dreadful gulphs or whirlpools, which seem to attract vessels, merely to swallow them up. On the other hand, we discover immense regions, totally opposite in their natures, always calm and tranquil, yet equally dangerous; where the winds never exert their power, where the art of the mariner becomes useless, and where the becalmed voyager must remain until death relieves him from the horrors of despair. In conclusion, if we turn our eyes towards the northern or southern extremities of the globe, we there perceive enormous flakes of ice separating themselves from the polar regions, advancing like huge mountains into the more temperate climes, where they dissolve and are lost to the sight.

Exclusive of these principal objects the vast empire of the sea abounds with animated beings, almost innumerable in numbers and variety. Some of them, covered with light scales, move with astonishing celerity; others, loaded with thick shells, drag heavily along, leaving their track in the sand; on others Nature

has bestowed fins, resembling wings, with which they raise and support themselves in the air, and fly to considerable distances; while there are those to whom all motion has been denied, who live and die immoveably fixed to the same rock: every species, however, find abundance of food in this their native element. The bottom of the sea, and the shelving sides of the various rocks, produce great abundance of plants and mosses of different kinds; its soil is composed of sand, gravel, rocks, and shells; in some parts a fine clay, in others a solid earth, and in general it has a complete resemblance to the land which we inhabit.

Let us now take a view of the earth. What prodigious differences do we find in different climates? What a variety of soils? What inequalities in the surface? but upon a minute and attentive observation we shall find the greatest chain of mountains are nearer the equator than the poles; that in the Old Continent their direction is more from the east to west than from the north to south; and that, on the contrary, in the New World they extend more from north to south than from east to west; but what is still more remarkable, the form and direction of those mountains, whose appearance is so very irregular, correspond so precisely, that the prominent angles of one mountain are always opposite to the concave angles of the neighbouring mountain, and are of equal dimensions, whether they are separated by a small valley or an extensive plain. I have also observed that opposite hills are nearly of the same height, and that, in general, mountains occupy the middle of continents, islands, and promontories,

which they divide by the greatest lengths.

In following the courses of the principal rivers, I have likewise found that they are almost always perpendicular with those of the sea into which they empty themselves; and that in the greatest part of their courses they proceed nearly in the direction of the mountains from which they derive their source.

The sea shores are generally bounded with rocks, marble, and other hard stones, or by earth and sand which has accumulated by the waters from the sea, or been brought down by the rivers; and I observe that opposite coasts, separated only by an arm of the sea, are composed of similar materials, and the beds of the earth are exactly the same. Volcanos I find exist only in the highest mountains; that many of them are entirely extinct; that some are connected with others by subterraneous passages, and that their explosions frequently happen at one and the same time. There are similar correspondences between certain lakes and neighbouring seas; some rivers suddenly disappear, and seem to precipitate themselves into the earth. We also find internal, or mediterranean seas, constantly receiving an enormous quantity of water from a number of rivers without ever extending their bounds, most probably discharging by subterraneous passages all their superfluous supplies. Lands which have been long inhabited are easily distinguished from those new countries where the soil appears in a rude state, where the rivers are full of cataracts, where the earth is either overflowed with water, or parched up with drought, and where every spot upon which a tree will grow

is covered with uncultivated woods.

Pursuing our examination in a more extensive view, we find that the upper strata that surrounds the globe, is universally the same. That this substance which serves for the growth and nourishment of animals and vegetables, is nothing but a composition of decayed animal and vegetable bodies reduced into such small particles, that their former organization is not distinguishable; or penetrating a little further, we find the real earth, beds of sand, lime-stone, argol, shells, marble, gravel, chalk, &c. These beds are always parallel to each other and of the same thickness throughout their whole extent. In neighbouring hills beds of the same materials are invariably found upon the same levels, though the hills are separated by deep and extensive intervals. All beds of earth, even the most solid strata, as rocks, quarries of marble, &c. are uniformly divided by perpendicular fissures; it is the same in the largest as well as smallest depths, and appears a rule which nature invariably pursues.

In the very bowels of the earth, on the tops of mountains, and even the most remote parts from the sea, shells, skeletons of fish, marine plants, &c. are frequently found, and these shells, fish, and plants, are exactly similar to those which exist in the Ocean. There are a prodigious quantity of petrified shells to be met with in an infinity of places, not only inclosed in rocks, masses of marble, lime-stone, as well as in earth and clays, but are actually incorporated and filled with the very substance which surrounds them. In short, I find myself convinced, by repeated

observations, that marbles, stones, chalks, marls, clay, sand, and almost all terrestrial substances, wherever they may be placed, are filled with shells and other substances, the productions of the sea.

These facts being enumerated, let us now see what reasonable conclusions are to be drawn from them.

The changes and alterations which have happened to the earth, in the space of the last two or three thousand years, are very inconsiderable indeed, when compared with those important revolutions which must have taken place in those ages which immediately followed the creation; for as all terrestrial substances could only acquire solidity by the continued action of gravity, it would be easy to demonstrate that the surface of the earth was much softer at first than it is at present, and consequently the same causes which now produce but slight and almost imperceptible changes during many ages, would then effect great revolutions in a very short space. It appears to be a certain fact, that the earth which we now inhabit, and even the tops of the highest mountains, were formerly covered with the sea, for shells and other marine productions are frequently found in almost every part; it appears also that the water remained a considerable time on the surface of the earth, since in many places there have been discovered such prodigious banks of shells, that it is impossible so great a multitude of animals could exist at the same time: this fact seems likewise to prove, that although the materials which composed the surface of the earth were then

in a state of softness, that rendered them easy to be disunited, moved and transported by the waters, yet that these removals were not made at once; they must indeed have been successive, gradual, and by degrees, because these kind of sea productions are frequently met with more than a thousand feet below the surface, and such a considerable thickness of earth and stone could not have accumulated but by the length of time. If we were to suppose that at the Deluge all the shell-fish were raised from the bottom of the sea, and transported over all the earth; besides the difficulty of establishing this supposition, it is evident, that as we find shells incorporated in marble and in the rocks of the highest mountains, we must likewise suppose that all these marbles and rocks were formed at the same time, and that too at the very instant of the Deluge; and besides, that previous to this great revolution there were neither mountains, marble, nor rocks, nor clays, nor matters of any kind similar to those we are at present acquainted with, as they almost all contain shells and other productions of the sea. Besides, at the time of the Deluge, the earth must have acquired a considerable degree of solidity, from the action of gravity for more than sixteen centuries, and consequently it does not appear possible that the waters, during the short time the Deluge lasted, should have overturned and dissolved its surface to the greatest depths we have since been enabled to penetrate.

But without dwelling longer on this point, which shall hereafter be more amply discussed, I shall confine myself to

well-known observations and established facts. There is no doubt but that the waters of the sea at some period covered and remained for ages upon that part of the globe which is now known to be dry land; and consequently the whole continents of Asia, Europe, Africa, and America, were then the bottom of an ocean abounding with similar productions to those which the sea at present contains: it is equally certain that the different strata which compose the earth are parallel and horizontal, and it is evident their being in this situation is the operation of the waters which have collected and accumulated by degrees the different materials, and given them the same position as the water itself always assumes. We observe that the position of strata is almost universally horizontal: in plains it is exactly so, and it is only in the mountains that they are inclined to the horizon, from their having been originally formed by a sediment deposited upon an inclined base. Now I insist that these strata must have been formed by degrees, and not all at once, by any revolution whatever, because strata, composed of heavy materials, are very frequently found placed above light ones, which could not be, if, as some authors assert, the whole had been mixed with the waters at the time of the Deluge, and afterwards precipitated; in that case every thing must have had a very different appearance to that which now exists. The heaviest bodies would have descended first, and each particular stratum would have been arranged according to its weight and specific gravity, and we should not see solid rocks or metals placed above light sand any more than clay under coal.

We should also pay attention to another circumstance; it confirms what we have said on the formation of the strata; no other cause than the motions and sediments of water could possibly produce so regular a position of it, for the highest mountains are composed of parallel strata as well as the lowest plains, and therefore we cannot attribute the origin and formation of mountains to the shocks of earthquakes, or eruptions of volcanos. The small eminences which are sometimes raised by volcanos, or convulsive motions of the earth, are not by any means composed of parallel strata, they are a mere disordered heap of matters thrown confusedly together; but the horizontal and parallel position of the strata must necessarily proceed from the operations of a constant cause and motion, always regulated and directed in the same uniform manner.

From repeated observations, and these incontrovertible facts, we are convinced that the dry part of the globe, which is now habitable, has remained for a long time under the waters of the sea, and consequently this earth underwent the same fluctuations and changes which the bottom of the ocean is at present actually undergoing. To discover therefore what formerly passed on the earth, let us examine what now passes at the bottom of the sea, and from thence we shall soon be enabled to draw rational conclusions with regard to the external form and internal composition of that which we inhabit.

From the Creation the sea has constantly been subject to a regular flux and reflux: this motion, which raises and falls

the waters twice in every twenty-four hours, is principally occasioned by the action of the moon, and is much greater under the equator than in any other climates. The earth performs a rapid motion on its axis, and consequently has a centrifugal force, which is also the greatest at the equator; this latter, independent of actual observation, proves that the earth is not perfectly spherical, but that it must be more elevated under the equator then at the poles.

From these combined causes, the ebbing and flowing of the tides, and the motion of the earth, we may fairly conclude, that although the earth was a perfect sphere in its original form, yet its diurnal motion, together with the constant flux and reflux of the sea, must, by degrees, in the course of time, have raised the equatorial parts, by carrying mud, earth, sand, shells, &c. from other climes, and there depositing of them. Agreeable to this idea the greatest irregularities must be found, and, in fact, are found near the equator. Besides, as this motion of the tides is made by diurnal alternatives, and been repeated, without interruption, from the commencement of time, is it not natural to imagine, that each time the tide flows the water carries a small quantity of matter from one place to another, which may fall to the bottom like a sediment, and form those parallel and horizontal strata which are every where to be met with? for the whole motion of the water, in the flux and reflux, being horizontal, the matters carried away with them will naturally be deposited in the same parallel direction.

But to this it may be said, that as the flux and reflux of the waters are equal and regularly succeed, two motions would counterpoise each other, and the matters brought by the flux would be returned by the reflux, and of course this cause for the formation of the strata must be chimerical; that the bottom of the sea could not experience any material alteration by two uniform motions, wherein the effects of the one would be regularly destroyed by the other; much less could they change the original form by the production of heights and inequalities.

To which it may be answered, that the alternate motions of the waters are not equal, the sea having a constant motion from the east to the west, besides, the agitation, caused by the winds, opposes and prevents the equality of the tides. It will also be admitted, that by every motion of which the sea is susceptible, particles of earth and other matters will be carried from one place and deposited in another; and these collections will necessarily assume the form of horizontal and parallel strata, from the various combinations of the motions of the sea always tending to move the earth, and to level these materials wherever they fall, in the form of a sediment. But this objection is easily obviated by the well-known fact, that upon all coasts, bordering the sea, where the ebbing and flowing of the tide is observed, the flux constantly brings in a number of things which the reflux does not carry back. There are many places upon which the sea insensibly gains and gradually covers over, while there are others from which it recedes, narrowing as it were its limits,

by depositing earth, sands, shells, &c. which naturally take an horizontal position; these matters accumulate by degrees in the course of time, and being raised to a certain point gradually exclude the water, and so become part of the dry land for ever after.

But not to leave any doubt upon this important point, let us strictly examine into the possibility of a mountain's being formed at the bottom of the sea by the motions and sediments of the waters. It is certain that on a coast which the sea beats with violence during the agitation of its flow, that every wave must carry off some part of the earth; for wherever the sea is bounded by rocks, it is a plain fact that the water by degrees wears away those rocks, and consequently carries away small particles every time the waves retire; these particles of earth and stone will necessarily be transported to some distance, and being arrived where the agitation of the water is abated, and left to their own weight, they precipitate to the bottom in form of a sediment, and there form a first stratum, either horizontal or inclined, according to the position of the surface upon which they fall; this will shortly be covered by a similar stratum produced by the same cause, and thus will a considerable quantity of matter be almost insensibly collected together, and the strata of which will be placed, parallel to each other.

This mass will continue to increase by new sediments, and by gradually accumulating, in the course of time become a mountain at the bottom of the sea, exactly similar to those we see

on dry land, both as to outward form and internal composition. If there happen to be shells in this part of the sea, where we have supposed this deposit to be made, they will be filled and covered with the sediment, and incorporated in the deposited matter, making a part of the whole mass, and they will be found situated in the parts of the mountain according to the time they had been there deposited; those that lay at the bottom, previous to the formation of the first stratum, will be found in the lowest, and so according to the time of their being deposited, the latest in the most elevated parts.

So likewise, when the bottom of the sea, at particular places, is troubled by the agitation of the water, there will necessarily ensue, in the same manner, a removal of earth, shells, and other matters, from the troubled to other parts; for we are assumed by all divers, that at the greatest depths they descend, i. e. twenty fathoms, the bottom of the sea is so troubled by the agitation of the waters, that the mud and shells are carried to considerable distances, consequently transportations of this kind are made in every part of the sea, and this matter falling must form eminences, composed like our mountains, and in every respect similar; therefore the flux and reflux, by the winds, the currents, and all the motions of the water, must inevitably create inequalities at the bottom of the sea.

Nor must we imagine that these matters cannot be transported to great distances, because we daily see grain, and other productions of the East and West Indies, arriving on our own

coasts.[1] It is true these bodies are specifically lighter than water, whereas the substances of which we have been speaking are specifically heavier; but, however, being reduced to an impalpable powder, they may be sustained a long time in the water so as to be conveyed to considerable distances.

It has been supposed that the sea is not troubled at the bottom, especially if it is very deep, by the agitations produced by the winds and tides; but it should be recollected that the whole mass, however deep, is put in motion by the tides, and that in a liquid globe this motion would be communicated to the very centre; that the power which produces the flux and reflux is a penetrating force, which acts proportionably upon every particle of its mass, so that we can determine by calculation the quantity of its force at different depths; but, in short, this point is so certain, that it cannot be contested but by refusing the evidence of reason.

Therefore, we cannot possibly have the least doubt that the tides, the winds, and every other cause which agitates the sea, must produce eminences and inequalities at the bottom, and those heights must ever be composed of horizontal or equally inclined strata. These eminences will gradually encrease until they become hills, which will rise in situations similar to the waves that produce them; and if there is a long extent of soil, they will continue to augment by degrees; so that in course of time they will form a vast chain of mountains. Being formed into mountains, they become an obstacle to and interrupt the common

[1] Particularly Scotland and Ireland.

motion of the sea, producing at the same time other motions, which are generally called currents. Between two neighbouring heights at the bottom of the sea a current will necessarily be formed, which will follow their common direction, and, like a river, form a channel, whose angles will be alternately opposite during the whole extent of its course. These heights will be continually increasing, being subject only to the motion of the flux, for the waters during the flow will leave the common sediment upon their ridges; and those waters which are impelled by the current will force along with them, to great distances, those matters which would be deposited between both, at the same time hollowing out a valley with corresponding angles at their foundation. By the effects of these motions and sediments the bottom of the sea, although originally smooth, must become unequal, and abounding with hills and chains of mountains, as we find it at present. The soft materials of which the eminences are originally composed will harden by degrees with their own weight; some forming parts, purely angular, produce hills of clay; others, consisting of sandy and crystalline particles, compose those enormous masses of rock and flint from whence crystal and other precious stones are extracted; those formed with stony particles, mixed with shells, form those of lime-stone and marble, wherein we daily meet with shells incorporated; and others, compounded of matter more shelly, united with pure earth, compose all our beds of marle and chalk. All these substances are placed in regular beds, and all contain

heterogeneous matter; marine productions are found among them in abundance, and nearly according to the relation of their specific weights; the lightest shells in chalk, and the heaviest in clay and lime-stone; these shells are invariably filled with the matter in which they have been inclosed, whether stones or earth; an incontestible proof that they have been transported with the matter that fills and surrounds them, and that this matter was at that time in an impalpable powder. In short, all those substances whose horizontal situations have been established by the level of the waters of the sea, will constantly preserve their original position.

But here it may be observed, that most hills, whose summits consist of solid rocks, stone, or marble, are formed upon small eminences of much lighter materials, such for instance as clay, or strata of sand, which we commonly find extended over the neighbouring plains, upon which it may be asked, how, if the foregoing theory be just, this seemingly contradictory arrangement happens? To me this phenomenon appears to be very easy and naturally explained. The water at first acts upon the upper stratum of coasts, or bottom of the sea, which commonly consists of clay or sand, and having transported this, and deposited the sediment, it of course composes small eminences, which form a base for the more heavy particles to rest upon. Having removed the lighter substances, it operates upon the more heavy, and by constant attrition reduces them to an impalpable powder; which it conveys to the same spot, and

where, being deposited, these stony particles, in the course of time, form those solid rocks and quarries which we now find upon the tops of hills and mountains. It is not unlikely that as these particles are much heavier than sand or clay, that they were formerly a considerable depth under a strata of that kind, and now owe their high situations to having been last raised up and transported by the motion of the water.

To confirm what we here assert, let us more closely investigate the situation of those materials which compose the superficial outer part of the globe, indeed the only part with which we have any knowledge. The different beds of strata in stone quarries are almost all horizontal, or regularly inclined; those whose foundations are on clays or other solid matters are clearly horizontal, especially in plains. The quarries wherein we find flint, or brownish grey free-stone, in detached portions, have a less regular position, but even in those the uniformity of nature plainly appears, for the horizontal or regularly inclined strata are apparent in quarries where these stones are found in great masses. This position is universal, except in quarries where flint and brown free-stone are found in small detached portions, the formation of which we shall prove to have been posterior to those we have just been treating of; for granite, vitrifiable sand, argol, marble, calcareous stone, chalk, and marles, are always deposited in parallel strata, horizontally or equally inclined; the original formation of these are easily discovered, for the strata are exactly horizontal and very thin, and are arranged above each other like

the leaves of a book. Beds of sand, soft and hard clay, chalk, and shells, are also either horizontal or regularly inclined. Strata of every kind preserves the same thickness throughout its whole extent, which often occupies the space of many miles, and may be traced still farther by close and exact observations. In a word, the materials of the globe, as far as mankind have been enabled to penetrate, are arranged in an uniform position, and are exactly similar.

The strata of sand and gravel which have been washed down from mountains must in some measure be excepted; in vallies they are sometimes of a considerable extent, and are generally placed under the first strata of the earth; in plains, they are as even as the most ancient and interior strata, but near the bottom and upon the ridges of hills they are inclined, and follow the inclination of the ground upon which they have flowed. These being formed by rivers and rivulets, which are constantly in vallies changing their beds, and dragging these sands and gravel with them, they are of course very numerous. A small rivulet flowing from the neighbouring heights, in the course of time will be sufficient to cover a very spacious valley with a strata of sand and gravel, and I have often observed in hilly countries, whose base, as well as the upper stratum, was hard clay, that above the source of the rivulet the clay is found immediately under the vegetable soil, and below it there is the thickness of a foot of sand upon the clay, and which extends itself to a considerable distance. These strata formed by rivers are not very ancient, and

are easily discovered by the inequality of their thickness, which is constantly varying, while the ancient strata preserves the same dimensions throughout; they are also to be known by the matter itself, which bears evident marks of having been smoothed and rounded by the motions of the water. The same may be said of the turf and perished vegetables which are found below the first stratum of earth in marshy grounds; they cannot be considered as ancient, but entirely produced by successive heaps of decayed trees and other plants. Nor are the strata of slime and mud, which are found in many countries, to be considered as ancient productions, having been formed by stagnated waters or inundations of rivers, and are neither so horizontal, nor equally inclined, as the strata anciently produced by the regular motions of the sea. In the strata formed by rivers we constantly meet with river, but scarcely ever sea shells, and the few that are found are broken and irregularly placed; whereas in the ancient strata there are no river shells; the sea shells are in great quantities, well preserved, and all placed in the same manner, having been transported at the same time and by the same cause. How are we to account for this astonishing regularity? Instead of regular strata, why do we not meet with the matters that compose the earth jumbled together, without any kind of order? Why are not rocks, marbles, clays, marles, &c. variously dispersed, or joined by irregular or vertical strata? Why are not the heaviest bodies uniformly found placed beneath the lightest? It is easy to perceive that this uniformity of nature, this organization of

earth, this connection of different materials, by parallel strata, without respect to their weights, could only be produced by a cause as powerful and constant as the motion of the sea, whether occasioned by the regular winds or by that of the flux and reflux, &c.

These causes act with greater force under the equator than in other climates, for there the winds are more regular and the tides run higher; the most extensive chains of mountains are also near the equator. The mountains of Africa and Peru are the highest known, they frequently extend themselves through whole provinces, and stretch, to considerable distances under the ocean. The mountains of Europe and Asia, which extend from Spain to China, are not so high as those of South America and Africa. The mountains of the North, according to the relation of travellers, are only hills in comparison with those of the Southern countries. Besides, there are very few islands in the Northern Seas, whereas in the torrid zone they are almost innumerable, and as islands are only the summits of mountains, it is evident that the surface of the earth has many more inequalities towards the equator than in the northerly climes.

It is therefore evident that the prodigious chain of mountains which run from the West to the East in the old continent, and from the North to the South in the new, must have been produced by the general motion of the tides; but the origin of all the inferior mountains must be attributed to the particular motions of currents, occasioned by the winds and other irregular

agitations of the sea: they may probably have been produced by a combination of all those motions, which must be capable of infinite variations, since the winds and different positions of islands and coasts change the regular course of the tides, and compel them to flow in every possible direction: it is, therefore, not in the least astonishing that we should see considerable eminences, whose courses have no determined direction. But it is sufficient for our present purpose to have demonstrated that mountains are not the produce of earthquakes, or other accidental causes, but that they are the effects resulting from the general order of nature, both as to their organization and the position of the materials of which they are composed.

But how has it happened that this earth which we and our ancestors have inhabited for ages, which, from time immemorial, has been an immense continent, dry and removed from the reach of the waters, should, if formerly the bottom of the ocean, be actually larger than all the waters, and raised to such a height as to be distinctly separated from them? Having remained so long on the earth, why have the waters now abandoned it? What accident, what cause could produce so great a change? Is it possible to conceive one possessed of sufficient power to produce such an amazing effect?

These questions are difficult to be resolved, but as the facts are certain and incontrovertible, the exact manner in which they happened may remain unknown, without prejudicing the conclusions that may be drawn from them; nevertheless, by a

little reflection, we shall find at least plausible reasons for these changes. We daily observe the sea gaining ground on some coasts and losing it on others; we know that the ocean has a continued regular motion from East to West; that it makes loud and violent efforts against the low lands and rocks which confine it; that there are whole provinces which human industry can hardly secure from the rage of the sea; that there are instances of islands rising above, and others being sunk under the waters. History speaks of much greater deluges and inundations. Ought not this to incline us to believe that the surface of the earth has undergone great revolutions, and that the sea may have quitted the greatest part of the earth which it formerly covered? Let us but suppose that the old and new worlds were formerly but one continent, and that the Atlantis of Plato was sunk by a violent earthquake; the natural consequence would be, that the sea would necessarily have flowed in from all sides, and formed what is now called the Atlantic Ocean, leaving vast continents dry, and possibly those which we now inhabit. This revolution, therefore, might be made of a sudden by the opening of some vast cavern in the interior part of the globe, which an universal deluge must inevitably succeed; or possibly this change was not effected at once, but required a length of time, which I am rather inclined to think; however these conjectures may be, it is certain the revolution has occurred, and in my opinion very naturally; for to judge of the future, as well as the past, we must carefully attend to what daily happens before our eyes. It is a fact clearly established by repeated observations

of travellers, that the ocean has a constant motion from the East to West; this motion, like the trade winds, is not only felt between the tropics, but also throughout the temperate climates, and as near the poles as navigators have gone; of course the Pacific Ocean makes a continual effort against the coasts of Tartary, China, and India; the Indian Ocean acts against the east coast of Africa; and the Atlantic in like manner against all the eastern coasts of America; therefore the sea must have always and still continues to gain land on the east and lose it on the west; and this alone is sufficient to prove the possibility of the change Of earth into sea, and sea into land. If, in fact, such are the effects of the sea's motion from east to west, may we not very reasonably suppose that Asia and the eastern continent is the oldest country in the world, and that Europe and part of Africa, especially the western coasts of these continents, as Great Britain, France, Spain, Muratania, &c. are of a more modern date? Both history and physics agree in confirming this conjecture.

There are, however, many other causes which concur with the continual motion of the sea from east to west, in producing these effects.

In many places there are lands lower than the level of the sea, and which are only defended from it by an isthmus of rocks, or by banks and dykes of still weaker materials; these barriers must gradually be destroyed by the constant action of the sea, when the lands will be overflowed, and constantly make part of the ocean. Besides, are not mountains daily decreasing by the rains,

which loosen the earth, and carry it down into the vallies? It is also well known that floods wash the earth from the plains and high grounds into the small brooks and rivers, which in their turn convey it into the sea. By these means the bottom of the sea is filling up by degrees, the surface of the earth lowering to a level, and nothing but time is necessary for the sea's successively changing places with the earth.

I speak not here of those remote causes which stand above our comprehension; of those convulsions of nature, whose least effects would be fatal to the world; the near approach of a comet, the absence of the moon, the introduction of a new planet, &c. are suppositions on which it is easy to give scope to the imagination. Such causes would produce any effects we chose, and from a single hypothesis of this nature, a thousand physical romances might be drawn, and which the authors might term, THE THEORY OF THE EARTH. As historians we reject these vain speculations; they are mere possibilities which suppose the destruction of the universe, in which our globe, like a particle of forsaken matter, escapes our observation, and is no longer an object worthy regard; but to preserve consistency, we must take the earth as it is, closely observing every part, and by inductions judge of the future from what exists at present; in other respects we ought not to be affected by causes which seldom happen, and whose effects are always sudden and violent; they do not occur in the common course of nature; but effects which are daily repeated, motions which succeed each other

without interruption, and operations that are constant, ought alone to be the ground of our reasoning.

We will add some examples thereto; we will combine particular effects with general causes, and give a detail of facts which will render apparent, and explain the different changes that the earth has undergone, whether by the eruption of the sea upon the land, or by retiring from that which it had formerly covered.

The greatest eruption was certainly that which gave rise to the Mediterranean sea. The ocean flows through a narrow channel between two promontories with great rapidity, and then forms a vast sea, which, without including the Black sea, is about seven times larger than the kingdom of France. Its motion through the straits of Gibraltar is contrary to all other straits, for the general motion of the sea is from east to west, but in that alone it is from the west to the east, which proves that the Mediterranean sea is not an ancient gulph, but that it has been formed by an eruption, produced by some accidental cause; as an earthquake which might swallow up the earth in the strait, or by a violent effort of the ocean, caused by the wind, which might have forced its way through the banks between the promontories of Gibraltar and Ceuta. This opinion is authorised by the testimony of the ancients, who declare in their writings, that the Mediterranean sea did not formerly exist; and confirmed by natural history and observations made on the opposite coasts of Spain, where similar beds of stones and earth are found upon the same levels, in like manner as they are in two mountains, separated by a small valley.

The ocean having forced this passage, it ran at first through the straits with much greater rapidity than at present, and overflowed the continent that joined Europe to Africa. The waters covered all the low countries, of which we can only now perceive the tops of some of the considerable mountains, such as parts of Italy, the islands of Sicily, Malta, Corsica, Sardinia, Cyprus, Rhodes, and those of the Archipelago.

In this eruption I have not included the Black sea, because the quantity of water it receives from the Danube, Nieper, Don, and various other rivers, is fully sufficient to form and support it; and besides, it flows with great rapidity through the Bosphorus into the Mediterranean. It might also be presumed that the Black and Caspian seas were formerly only two large lakes, joined by a narrow communication, or by a morass, or small lake, which united the Don and the Wolga near Tria, where these two rivers flow near each other; nor is it improbable that these two seas or lakes were then of much greater extent, for the immense rivers which fall into the Black and Caspian seas may have brought down a sufficient quantity of earth to shut up the communication, and form that neck of land by which they are now separated; for we know great rivers, in the course of time, fill up seas and form new land, as the province at the mouth of the Yellow river in China; Louisania at the mouth of the Mississippi, and the northern part of Egypt, which owes its existence to the inundations of the Nile; the rapidity of which brings down such quantities of earth from the internal parts of Africa, as to deposit

on the shores, during the inundations, a body of slime and mud of more than fifty feet in depth. The province of the Yellow river and Louisania have, in like manner, been formed by the soil from the rivers.

The Caspian sea is actually a real lake; having no communication with other seas, not even with the lake Aral, which seems to have been a part of it, being only separated from it by a large track of sand, in which neither rivers nor canals for communication the waters have as yet been found. This sea, therefore, has no external communication with any other; and I do not know that we are authorised to suspect that it has an internal one with the Black sea, or with the Gulph of Persia. It is true the Caspian sea receives the Wolga and many other rivers, which seem to furnish it with more water than is lost by evaporation; but independent of the difficulty of such calculation, if it had a communication with any other sea, a constant and rapid current towards the opening would have marked its course, and I never heard of any such discovery being made; travellers of the best credit affirm to the contrary, and consequently the Caspian sea must lose by evaporation just as much water as it receives from the Wolga and other rivers.

Nor is it any improbable conjecture that the Black sea will at some period be separated from the Mediterranean; and that the Bosphorus will be shut up, whenever the great rivers shall have accumulated a sufficient quantity of earth to answer that effect; this may be the case in the course of time by the successive

diminution of waters in rivers, in proportion as the mountains from whence they draw their sources are lowered by the rains, and those other causes we have just alluded to.

The Caspian and Black seas must therefore be looked upon rather as lakes than gulphs of the ocean, for they resemble other lakes which receive a number of rivers without any apparent outlet, such as the Dead sea, many lakes in Africa and other places. These two seas are not near so salt as the Mediterranean or the ocean; and all voyagers affirm that the navigation in the Black and Caspian seas, upon account of its shallowness and quantity of rocks and quicksands, is so extremely dangerous, that only small vessels can be used with safety which farther proves they must not be looked upon as gulphs of the ocean, but as immense bodies of water collected from great rivers.

A considerable eruption of the sea would doubtless take place upon the earth, if the isthmus which separates Africa from Asia was divided, as the Kings of Egypt, and afterwards the Caliphs projected; and I do not know that the communication between the Red sea and Mediterranean is sufficiently established, as the former must be higher than the latter. The Red sea is a narrow branch of the ocean, and does not receive into it a single river on the side of Egypt, and very few on the opposite coast; it will not therefore be subject to diminution, like those seas and lakes which are constantly receiving slime and sand from those rivers that flow into them. The ocean supplies the Red sea with all its water, and the motion of the tides is very evident

in it, of course it must be affected by every movement of the ocean. But the Mediterranean must be lower than the ocean, because the current passes with great rapidity through the straits; besides, it receives the Nile, which flows parallel to the west coast of the Red sea, and which divides Egypt, a very low country; from all which it appears probable, that the Red sea is higher than the Mediterranean, and that if the isthmus of Suez was cut through, there Would be a great inundation, and a considerable augmentation of the Mediterranean would ensue; at least if the waters were not restrained by dykes and sluices placed at proper distances, and which was most likely the case if the ancient canal of communication ever had existence.

Without dwelling longer upon conjectures, which, although well founded, may appear hazardous and rash, we shall give some recent and certain examples of the change of the sea into land, and the land into sea. At Venice the bottom of the Adriatic is daily rising, and if great care had not been taken to clean and empty the canals, the whole would long since have formed part of the continent; the same may be said of most ports, bays, and mouths of rivers. In Holland the bottom of the sea has risen in many places; the gulph of Zuyderzee and the strait of the Texel cannot receive such large vessels as formerly. At the mouth of all rivers we find small islands, and banks of sand and earth brought down by the waters, and it is certain the sea will be filled up in every part where great rivers empty themselves. The Rhine is lost in the sands which itself accumulated. The Danube and the Nile,

and all great rivers, after bringing down much sand and earth, no longer come to the sea by a single channel; they divide into different branches, and the intervals are filled up by the materials they have themselves brought thither. Morasses daily dry up; lands forsaken by the sea are cultivated; we navigate countries now covered by waters; in short, we see so many instances of land changing into water, and water into land, that we must be convinced of these alterations having, and will continue to take place; so that in time gulphs will become continents; isthmusses, straits; morasses, dry lands; and the tops of our mountains, the shoals of the sea.

Since then the waters have covered, and may successively cover, every part of the present dry land, our surprise must cease at finding every where marine productions and compositions, which could only be the works of the waters. We have already explained how the horizontal strata of the earth were formed, but the perpendicular divisions that are commonly found in rocks, clays, and all matters of which the globe is composed, still remain to be considered. These perpendicular stratas are, in fact, placed much farther from each other than the horizontal, and the softer the matter the greater the distance; in marble and hard earths they are frequently found only a few feet; but if the mass of rock be very extensive, then these fissures are at some fathoms distant; sometimes they descend from the top of the rock to the bottom, and sometimes terminate at an horizontal fissure. They are always perpendicular in the strata of calcinable matters, as

chalk, marle, marble, &c. but are more oblique and irregularly placed in vitrifiable substances, brown freestone, and rocks of flint, where they are frequently adorned with chrystals, and other minerals. In quarries of marble or calcinable stone, the divisions are filled with spar, gypsum, gravel, and an earthy sand, which contains a great quantity of chalk. In clay, marls, and every other kind of earth, excepting turf, these perpendicular divisions are either empty or filled with such matters as the water has transported thither.

We need seek very little farther for the cause and origin of those perpendicular cracks. The materials by which the different strata are composed being carried by the water, and deposited as a kind of sediment, must necessarily, at first, contain a considerable share of water, the which, as they began to harden, they would part with by degrees, and, as they must necessarily lessen in the course of drying, that decrease would occasion them to split at irregular distances. They naturally split in a perpendicular direction, because in that direction the action of gravity of one particle upon another has no actual effect, while, on the contrary, it is directly opposite in a horizontal situation; the diminution of bulk therefore could have no sensible effect but in a vertical line. I say it is the diminution of drying, and not the contained water forcing a place to issue, is the cause of these perpendicular fissures, for I have often observed that the two sides of those fissures answer throughout their whole height, as exactly as two sides of a split piece of wood; their insides

are rough and irregular, whereas if they had been made by the motion of the water, they would have been smooth and polished; therefore these cracks must be produced suddenly and at once or by degrees in drying, like the flaws in wood, and the greatest part of the water they contained evaporated through the pores. The divisions of these perpendicular cracks vary greatly as to the extent of their openings; some of them being not more than half an inch, others increasing to one or two feet; there are some many fathoms, and which form those precipices so often met with in the Alps and other high mountains. The small ones are produced by drying alone, but those which extend to several feet are the effects of other causes; for instance, the sinking of the foundation on one side while the other remains unmoved; if the base sinks but a line or two, it is sufficient to produce openings of many feet in a rock of considerable height. Sometimes rocks, which are founded on clay or sand, incline to one side, by which motion the perpendicular cracks become extended.

I have not yet mentioned those large openings which are found in rocks and mountains; they must have been produced by great sinkings, as of immense caverns, unable longer to support the weight with which they were encumbered, but these intervals are very different from perpendicular fissures; they appear to be vacancies opened by the hand of Nature for the communication of nations. In this manner all vacancies in large mountains and divisions, by straits in the sea, seem to present themselves; such as the straits of Thermopylæ, the ports of Caucasus, the Cordeliers,

the extremity of the straits of Gibraltar, the entrance of the Hellespont, &c. These could not have been occasioned by the simple separation by drying of matter, but by considerable parts of the lands themselves being sunk, swallowed up, or overturned.

These great sinkings, though produced by accidental causes, hold a first place in the principal circumstances in the History of the Earth, and not a little contributed to change the face of the Globe; the greatest part of them have been produced by subterraneous fires, whose explosions cause earthquakes and volcanos; the force of these inflamed and confined matters in the bowels of the earth is beyond compare; by it cities have been swallowed up, provinces overturned, and mountains overthrown. But however great this force may be, and prodigious as the effects appear, we cannot assent to the opinion of those authors who suppose these subterraneous fires proceed from an immense abyss of flame in the centre of the earth, neither give we credit to the common notion that they proceed from a great depth below the surface of the earth, air being absolutely necessary for the support of inflammation. In examining the materials which issue from volcanos, even in the most violent eruptions, it appears very plain, that the furnace of the inflamed matters is not at any great depth, as they are similar to those found in mountains, disfigured only by the calcination, and the melting of the metallic parts which they contain; and to be convinced that the matters cast out by volcanos do not come from any great depth, we have only to consider of the height of the mountain, and judge of the immense

force that would be necessary to cast up stones and minerals to the height of half a league; for Ætna, Hecla, and many other volcanos have at least that elevation from the plains. Now it is perfectly well known that the action of fire is equal in every direction; it cannot therefore act upwards, with a force capable of throwing large stones half a league high, without an equal re-action downwards, and on the sides, and which re-action must very soon pierce and destroy the mountain on every side, because the materials which compose it are not more dense and firm than those thrown out; how then can it be imagined that the cavity, which must be considered as the type or cannon, could resist so great a force as would be necessary to raise those bodies to the mouth of the volcano? Besides, if this cavity was deeper, as the external orifice is not great, it would be impossible for so large a quantity of inflamed and liquid matter to issue out at once, without clashing against each other, and against the sides of the tube, and by passing through so long a space they would run the chance of being extinguished and hardened. We often see rivers of bitumen and melted sulphur, thrown out of the volcanos with stones and minerals, flow from the tops of the mountains into the plains; is it natural to imagine that matters so fluid, and so little able to resist violent action, should be elevated from any great depth? All the observations that can be made on this subject will prove that the fire of the volcano is not far from the summit of the mountain, and that it never descends to the level of the plain.

This idea of volcanos does not, however, render it inconsistent

that they are the cause of earthquakes, and that their shocks may be felt on the plains to very considerable distances; nor that one volcano may not communicate with another by means of subterraneous passages; but it is of the depth of the fire's confinement that we now speak, and which can only be at a small distance from the mouth of the volcano. It is not necessary to produce an earthquake on a plain, that the bottom of the volcano should be below the level of that plain; nor that there should be internal cavities filled with the same combustible matter, for a violent explosion, such as generally attends an eruption, may, like that of a powder magazine give so great a shock by its re-action, as to produce an earthquake that might be felt at a considerable distance.

I do not mean to say that there are no earthquakes produced by subterraneous fires, but merely that there are some which proceed only from the explosion of volcanos. In confirmation of what has been advanced on this subject, it is certain that volcanos are seldom met with on plains; on the contrary, they are constantly found in the highest mountains, and their mouths at the very summit of them. If the internal fires of the volcanos extended below the plains, would not passages be opened in them during violent eruptions? In the first eruption would not these fires rather have pierced the plains, where, by comparison, the resistance must be infinitely weaker, than force their way through a mountain more than half a league in height.

The reason why volcanos appear alone in mountains, is,

because much greater quantities of minerals, sulphur, and pyrites, are contained in mountains, and more exposed than in the plains; besides which, those high places are more subject to the impressions of air, and receive greater quantities of rain and damps, by which mineral substances are capable of being heated and fermented into an absolute state of inflammation.

In short, it has often been observed, that, after violent eruptions, the mountains have shrunk and diminished in proportion to the quantity of matter which has been thrown out; another proof that the volcanos are not situated at the bottom of the mountain, but rather at no great distance from the summit itself.

In many places earthquakes have formed considerable hollows, and even separations in mountains; all other inequalities have been produced at the same time with the mountains themselves by the currents of the sea, for in every place where there has not been a violent convulsion, the strata of the mountains are parallel, and their angles exactly correspond. Those subterraneous caverns which have been produced by volcanos are easily to be distinguished from those formed by water; for the water, having washed away the sand and clay with which they are filled, leaves only the stones and rocks, and this is the origin of caverns upon hills; while those found upon the plains are commonly nothing but ancient pits and quarries, such as the salt quarries of Maestricht, the mines of Poland, &c. But natural caverns belong to mountains: they receive the water from the

summit and its environs, from whence it issues over the surface wherever it can obtain a passage; and these are the sources of springs and rivers, and whenever a cavern is filled by any part falling in, an inundation generally ensues.

From what we have related, it is easy to be seen how much subterraneous fires contribute to change the surface and internal part of the globe. This cause is sufficiently powerful to produce very great effects: but it is difficult to conceive how the winds should occasion any sensible alterations upon the earth. The sea appears to be their empire, and indeed, excepting the tides, nothing has so powerful an influence upon the ocean; even the flux and reflux move in an uniform manner, and their effects are regularly the same; but the action of the winds is capricious and violent; they sometimes rush on with such impetuosity, and agitate the sea with such violence, that from a calm, smooth, and tranquil plain, it becomes furrowed with waves rolling mountains high, and dashing themselves to pieces against the rocks and shores. The winds cause constant alterations on the surface of the sea, but the surface of the land, which has so solid an appearance, we should suppose would not be subject to similar effects; by experience, however, it is known that the winds raise mountains of sand in Arabia and Africa; and that they cover plains with it; they frequently transport sand to great distances, and many miles into the sea, where they accumulate in such quantities as to form banks, downs, and even islands. It is also known that hurricanes are the scourge of the Antilles, Madagascar, and other countries,

where they act with such fury, as to sweep away trees, plants, and animals, together with the soil which gave them subsistence: they cause rivers to ascend and descend, and produce new ones; they overthrow rocks and mountains; they make holes and gulphs on the earth, and entirely change the face of those unfortunate countries where they exist. Happily there are but few climates exposed to the impetuosity of those dreadful agitations of the air.

But the greatest and most general changes in the surface of the earth are produced by rains, floods, and torrents from the high lands. Their origins proceed from the vapours which the sun raises above the surface of the ocean, and which the wind transports through every climate. These vapours, which are sustained in the air, and conveyed at the will of the winds, are stopped in their progress by the tops of the hills which they encounter, where they accumulate until they become clouds and fall in the form of rain, dew, or snow. These waters at first descend upon the plains without any fixed course, but by degrees hollow out a bed for themselves; by their natural bent they run to the bottom of mountains, and penetrating or dissolving the land easiest to divide, they carry earth and sand away with them, cut deep channels in the plains, form themselves into rivers, and open a passage into the sea, which constantly receives as much water from the land rivers as it loses by evaporation. The windings in the channels of rivers have sinuosities, whose angles are correspondent to each other, so that where the waves form a saliant angle on one side, the other has an exactly opposite

one; and as hills and mountains, which may be considered as the banks of the vallies which separate them, have also sinuosities in corresponding angles, it seems to demonstrate that the vallies have been formed, by degrees, by the currents of the sea, in the same manner as the rivers have hollowed out their beds on the earth.

The waters which run on the surface of the earth, and support its verdure and fertility, are not perhaps one half of those which the vapours produce; for there are many veins of water which sink to great depths in the internal part of the earth. In some places we are certain to meet with water by digging; in others, not any can be found. In almost all vallies and low grounds water is certain to be met with at moderate depths; but, on the contrary, in all high places it cannot be extracted from the bowels of the earth, but must be collected from the heavens. There are countries of great extent where a spring cannot be found, and where all the water which supplies the inhabitants and animals with drink is contained in pools and cisterns. In the east, especially in Arabia, Egypt, and Persia, wells are extremely scarce, and the people have been obliged to make reservoirs of a considerable extent to collect the waters as it falls from the heavens. These works, projected and executed from public necessity, are the most beautiful and magnificent monuments of the eastern nations; some of the reservoirs occupy a space of two square miles, and serve to fertilize whole provinces, by means of baths and small rivulets that let it out on every side. But in low

countries, where the greatest rivers flow, we cannot dig far from the surface, without meeting with water, and in fields situate in the environs of rivers it is often obtained by a few strokes with a pick-axe.

The water, found in such quantities in low grounds, comes principally from the neighbouring hills and eminences; at the time of great rains or sudden melting of snow, a part of the water flows on the surface, but most of it penetrates through the small cracks and crevices it finds in the earth and rocks. This water springs up again to the surface wherever it can find vent; but it often filters through the sand until it comes to a bottom of clay or solid earth, where it forms subterraneous lakes, rivulets, and perhaps rivers, whose courses are entirely unknown; they must, however, follow the general laws of nature, and constantly flow from the higher grounds to the lower, and consequently these subterraneous waters must, in the end, fall into the sea, or collect in some low place, either on the surface or in the interior part of the earth; for there are several lakes into which no rivers enter, nor from which there are not any issue; and a much greater number, which do not receive any considerable river, that are the sources of the greatest rivers on earth; such as the lake of St. Laurence; the lake Chiamè, from whence spring two great rivers that water the kingdoms of Asam and Pegu; the lake of Assiniboil in America; those of Ozera in Muscovy, that give rise to the river Irtis, and a great number of others. These lakes, it is evident, must be produced by the waters from the high lands passing through

subterraneous passages, and collecting in the lowest places. Some indeed have asserted that lakes are to be found on the summit of the highest mountains; but to this no credit can be given, for those found on the Alps, and other elevated places, are all surrounded by much more lofty mountains, and derive their origin from the waters which run down the sides, or are filtered through those eminences in the same manner as the lakes in the plains obtain their sources from the neighbouring hills which overtop them.

It is apparent, therefore, that lakes have existence in the bowels of the earth, especially under large plains and extensive vallies. Mountains, hills, and all eminences have either a perpendicular or inclined situation, and are exposed on all sides; the waters which fall on their summits, after having penetrated into the earth, cannot fail, from the declivity of the ground, of finding issue in many places, and breaking in forms out of springs and fountains, and consequently there will be little, if any water, remain in the mountains. On the contrary, in plains, as the water which filters through the earth can find no vent, it must collect in subterraneous caverns, or be dispersed and divided among sand and gravel. It is these waters which are so universally diffused through low grounds. The bottom of a pit or well is nothing else but a kind of bason into which the waters that issue from the adjoining lands insinuate themselves, at first falling drop by drop, but afterwards, as the passages are opened, it receives supplies from greater distances, and then continually runs in little streams or rills; from which circumstance, although we can find water

in any part of a plain, yet we can obtain a supply but for a certain number of wells, proportionate to the quantity of water dispersed, or rather to the extent of the higher lands from whence they come.

It is unnecessary to dig below the level of the river to find water; it is generally met with at much less depths, and there is no appearance that waters of rivers filter far through the earth. The origin of waters found in the earth below the level of rivers is not to be attributed to them; for in rivers or torrents which are dried up, or whose courses have been turned, we find no greater quantity of water by digging in their beds than in the neighbouring lands at an equal depth.

A piece of land of five or six feet in thickness is sufficient to contain water, and prevent it from escaping; and I have often observed that the banks of brooks and pools are not sensibly wet at six inches distance from the water.

It is true that the extent of the filtration is in proportion as the soil is more or less penetrable; but if we examine the standing pools with sandy bottoms, we shall perceive the water confined in the small compass it had hollowed itself, and the moisture spread but a very few inches; even in vegetable earth it has no great extent, which must be more porous than sand or hard soil. It is a certain fact, that in a garden we may almost inundate one bed without those nearly adjoining feeling any moisture from it[2]. I

[2] These facts are so easily demonstrated, that the smallest observation will prove their veracity.

have examined pieces of garden ground, eight or ten feet thick, which had not been stirred for many years, and whose surface was nearly level, and found that the rain water never penetrated deeper than three or four feet; and on turning it up in the spring, after a wet winter, I found it as dry as when first heaped together.

I made the same observation on earth which had laid in ridges two hundred years; below three or four feet it was as dry as dust; from which it is plain that water does not extend so far by filtration as has been generally imagined.

By this means, therefore, the internal part of the earth can be supplied with a very small part; but water by its own weight descends from the surface to the greatest depths; it sinks through natural conduits, or penetrates small passages for itself; it follows the roots of trees, the cracks in rocks, the interstices in the earth, and divides and extends on all sides into an infinity of small branches and rills, always descending until its passage is opposed by clay or some solid body, where it continues collecting, and at length breaks out in form of springs upon the surface.

It would be very difficult to make an exact calculation of the quantity of subterraneous waters which have no apparent vent. Many have pretended that it greatly surpasses all the waters that are on the surface of the earth.

Without mentioning those who have advanced that the interior part of the globe is entirely filled with water, there are some who believe there are an infinity of floods, rivulets, and lakes in the bowels of the earth. But this opinion does not seem to

be properly founded, and it is more probable that the quantity of subterraneous water, which never appears on the surface, is not very considerable; for if these subterraneous rivers are so very numerous, why do we never see any of their mouths forcing their way through the surface? Besides, rivers, and all running waters, produce great alterations on the surface of the earth; they transport the soil, wear away the most solid rocks, and displace all matters which oppose their passage. It would certainly be the same in subterraneous rivers; the same effects would be produced; but no such alterations have ever as yet been observed; the different strata remains parallel, and every where preserves its original position; and it is but in a very few places that any considerable subterraneous veins of water have been discovered. Thus water in the internal part of the earth, though great, acts but in a small degree, as it is divided in an infinity of little streams, and retained by a number of obstacles; and being so generally dispersed, it gives rise to many substances totally different from primitive matters, both in form and organization.

From all these observations we may fairly conclude, that it is the continual motion of the flux and reflux of the sea which has produced mountains, vallies, and other inequalities on the surface of the earth; that it is the currents of the ocean which have hollowed vallies, raised hills, and given them corresponding directions; that it is those waters of the sea which, by transporting earth, &c. and depositing them in horizontal layers, have formed the parallel strata; that it is the waters from heaven, which by

degrees destroy the effects of the sea, by continually lowering the summit of mountains, filling up vallies, and stopping the mouths of gulphs and rivers, and which, by bringing all to a level, will, in the course of time, return this earth to the sea, which, by its natural operations, will again form new continents, containing vallies and mountains exactly similar to those which we at present inhabit.

PROOF
OF
THE THEORY OF THE EARTH

ARTICLE I.
ON THE FORMATION OF THE PLANETS

Our subject being Natural History, we would willingly dispense with astronomical observations; but as the nature of the earth is so closely connected with the heavenly bodies, and such observations being calculated to illustrate more fully what has been said, it is necessary to give some general ideas of the formation, motion, figure of the earth and other planets.

The earth is a globe of about three thousand leagues diameter; it is situate one thousand millions of leagues from the sun, around which it makes its revolution in three hundred and sixty-five days. This revolution is the result of two forces; the one may be considered as an impulse from right to left, or from left to right, and the other an attraction from above downwards, or beneath upwards, to a common centre. The direction of these two forces, and their quantities, are so nicely combined and proportioned,

that they produce an almost uniform motion in an ellipse, very near to a circle. Like the other planets the earth is opaque, it throws out a shadow; it receives and reflects the light of the sun, round which it revolves in a space of time proportioned to its relative distance and density. It also turns round its own axis once in twenty-four hours, and its axis is inclined 66-1/4 degrees on the plane of the orbit. Its figure is spheroidical, the two axes of which differ about 160th part from each other, and the smallest axis is that round which the revolution is made.

These are the principal phenomena of the earth, the result of discoveries made by means of geometry, astronomy, and navigation. We shall not here enter into the detail of the proofs and observations by which those facts have been ascertained, but only make a few remarks to clear up what is still doubtful, and at the same time give our ideas respecting the formation of the planets, and the different changes thro' which it is possible they have passed before they arrived at the state we at present see them.

There have been so many systems and hypotheses framed upon the formation of the terrestrial globe, and the changes which it has undergone, that we may presume to add our conjectures to those who have written upon the subject, especially as we mean to support them with a greater degree of probability than has hitherto been done: and we are the more inclined to deliver our opinion upon this subject, from the hope that we shall enable the reader to pronounce on the difference

between an hypothesis drawn from possibilities, and a theory founded in facts; between a system, such as we are here about to present, on the formation and original state of the earth, and a physical history of its real condition, which has been given in the preceding discourse.

Galileo having found the laws of falling bodies, and Kepler having observed that the area described by the principal planets in moving round the sun, and those of the satellites round the planets to which they belong, are proportionable to the time of their revolutions, and that such periods were also in proportion to the square roots of the cubes of their distances from the sun, or principal planets. Newton found that the force which caused heavy bodies to fall on the surface of the earth, extended to the moon, and retained it in its orbit; that this force diminished in the same proportion as the square of the distance increased, and consequently that the moon is attracted by the earth; that the earth and planets are attracted by the sun; and that in general all bodies which revolve round a centre, and describe areas proportioned to the times of their revolution, are attracted towards that point. This power, known by the name of GRAVITY, is therefore diffused throughout all matter; planets, comets, the sun, the earth, and all nature, is subject to its laws, and it serves as a basis to the general harmony which reigns in the universe. Nothing is better proved in physics than the actual existence of this power in every material substance. Observation has confirmed the effects of this power,

and geometrical calculations have determined the quantity and relations of it.

This general cause being known, the effects would easily be deduced from it, if the action of the powers which produce it were not too complicated. A single moment's reflection upon the solar system will fully demonstrate the difficulties that have attended this subject; the principal planets are attracted by the sun, and the sun by the planets; the satellites are also attracted by their principal planets, and each planet attracts all the rest, and is attracted by them. All these actions and reactions vary according to the quantities of matter and the distances, and produce great inequalities and irregularities. How is so great a number of connections to be combined and estimated? It appears almost impossible in such a crowd of objects to follow any particular one; nevertheless those difficulties have been surmounted, and calculation has confirmed the suppositions of them, each observation is become a new demonstration, and the systematic order of the universe is laid open to the eyes of all those who can distinguish truth from error.

We feel some little stop, by the force of impulsion remaining unknown; but this, however, does not by any means affect the general theory. We evidently see the force of attraction always draws the planets towards the sun, they would fall in a perpendicular line, on that planet, if they were not repelled by some other power that obliges them to move in a straight line, and which impulsive force would compel them to fly off the tangents

of their respective orbits, if the force of attraction ceased one moment. The force of impulsion was certainly communicated to the planets by the hand of the Almighty, when he gave motion to the universe; but we ought as much as possible to abstain in physics from having recourse to supernatural causes; and it appears that a probable reason may be given for this impulsive force, perfectly accordant with the law of mechanics, and not by any means more astonishing than the changes and revolutions which may and must happen in the universe.

The sphere of the sun's attraction does not confine itself to the orbs of the planets, but extends to a remote distance, always decreasing in the same ratio as the square of the distance increases; it is demonstrated that the comets which are lost to our sight, in the regions of the sky, obey this power, and by it their motions, like that of the planets, are regulated. All these stars, whose tracts are so different, move round the sun, and describe areas proportioned to the time; the planets in ellipses more or less approaching a circle, and the comets in narrow ellipses of a great extent. Comets and planets move, therefore, by virtue of the force of attraction and impulsion, which continually acting at one time obliges them to describe these courses; but it must be remarked that comets pass over the solar system in all directions, and that the inclinations of their orbits are very different, insomuch that, although subject like the planets to the force of attraction, they have nothing in common with respect to their progressive or impulsive motions, but appear in this respect

independent of each other: the planets, on the contrary, move round the sun in the same direction, and almost in the same plane, never exceeding 7-1/2 degrees of inclination in their planes, the most distant from their orbits. This conformity of position and direction in the motion of the planets, necessarily implies that their impulsive force has been communicated to them by one and the same cause.

May it not be imagined, with some degree of probability, that a comet falling into the body of the sun, will displace and separate some parts from the surface, and communicate to them a motion of impulsion, insomuch that the planets may formerly have belonged to the body of the sun, and been detached therefrom by an impulsive force, and which they still preserve.

This supposition appears to be at least as well founded as the opinion of Leibnitz, who supposes that the earth and planets had formerly been suns; and his system, of which an account will be given in the fifth article, would have been more comprehensive and more agreeable to probability, if he had raised himself to this idea. We agree with him in thinking that this effect was produced at the time when Moses said that God divided light from darkness; for, according to Leibnitz, light was divided from darkness when the planets were extinguished; but in our supposition there was a real physical separation, since the opaque bodies of the planets were divided from the luminous matter which composes the sun.

This idea of the cause of the impulsive force of the planets will

be found much less objectionable, when an estimation is made of the analogies and degrees of probability, by which it may be supported. In the first place, the motion of the planets are in the same direction, from West to East, and therefore, according to calculation, it is sixty-four to one that such would not have been the case, if they had not been indebted to the same cause for their impulsive forces.

This, probably, will be considerably augmented by the second analogy, viz. that the inclination of the planes of the orbits do not exceed 7-1/2 degrees; for, by comparing the spaces, we shall find there is twenty-four to one, that two planets are found in their most distant places at the same time, and consequently ^{5}, or 7,692,624 to one, that all six would by chance be thus placed; or, what amounts to the same, there is a great degree of probability that the planets have been impressed with one common moving force, and which has given them this position. But what can have bestowed this common impulsive motion, but the force and direction of the bodies by which it was originally communicated? It may therefore be concluded, with great probability, that the planets received their impulsive motion by one single stroke. This likelihood, which is almost equivalent to a certainty, being established, I seek to know what moving bodies could produce this effect, and I find nothing but comets capable of communicating a motion to such vast bodies.

By examining the course of comets, we shall be easily persuaded, that it is almost necessary for some of them

occasionally to fall into the sun. That of 1680 approached so near, that at its perihelium it was not more distant from the sun than a sixteenth part of its diameter, and if it returns, as there is every appearance it will, in 2255, it may then possibly fall into the sun; that must depend on the rencounters it will meet with in its road, and of the retardment it suffers in passing through the atmosphere of the sun[3].

We may, therefore, presume with the great Newton, that comets sometimes fall into the sun; but this fall may be made in different directions. If they fall perpendicular, or in a direction not very oblique, they will remain in the sun, and serve for food to the fire which that luminary consumes, and the motion of impulsion which they will have communicated to the sun, will produce no other effect than that of removing it more or less, according as the mass of the comet will be more or less considerable; but if the fall of the comet is in a very oblique direction, which will most frequently happen, then the comet will only graze the surface of the sun, or slightly furrow it; and in this case it may drive out some parts of matter to which it will communicate a common motion of impulsion, and these parts so forced out of the body of the sun, and even the comet itself, may then become planets, and turn round this luminary in the same direction, and in almost the same plane. We might perhaps calculate what quantity of matter, velocity, and direction a comet should have, to impel from the sun an equal quantity of matter

[3] Vide Newton, 2d edit. page 525.

to that which the six planets and their satellites contain; but it will be sufficient to observe here, that all the planets, with their satellites, do not make the 650th part of the mass of the sun,[4]

[4] Vid. Newton, page 405.

Конец ознакомительного фрагмента.