Columbus himſelf remarked, that, on the weſt coaſts, certain winds blew for ſome days, which he was perſuaded proceeded from land. But, though he poſſeſſed all theſe advantages over the ancients, and likewiſe the compaſs, the difficulties to be encountered were ſo great, that nothing leſs than ſucceſs could have juſtified the enterpriſe. Suppoſe, for a moment, that the continent of America had been 1000 or 1500 leagues more diſtant, a circumſtance which Columbus could not foreſee, he never would have arrived, and perhaps this vaſt country might ſtill have remained undiſcovered. This conjecture receives additional force, when it is conſidered, that Columbus, though the ableſt navigator of his age, was ſeized with terror and aſtoniſhment in his ſecond voyage to the New World: As, in his firſt voyage, he found nothing but iſlands, he directed his courſe more to the ſouth in queſt of a continent; but found himſelf ſtopped by currents, the great extent of which, and their uniform oppoſition to his courſe, obliged him to direct his ſearch more to the weſt. He imagined, that it was not currents which prevented him from advancing to the ſouth, but that the ſea was riſing to the heavens, and that both perhaps touched each other in the ſouthern parts: Thus, in great undertakings, the moſt trifling difficulty may ſometimes turn a man's brain, and extinguiſh his courage.

PROOFS

OF THE

THEORY OF THE EARTH.

ARTICLE VII.

Of the Formation of Strata, or Beds, in the Earth.

WE have demonſtrated, in the firſt article, that the earth, in conſequence of the mutual attraction between the particles of matter, and of the centrifugal force that reſults from its diurnal revolution, muſt have aſſumed the figure of a ſpheroid, the two diameters of which differ about a 230th part; and that nothing but the changes made on the earth's ſurface, by the motions of the air and of the waters, could augment this difference, in the manner alleged by thoſe who meaſured a degree under the equator, and another within the polar circle. This figure of the earth, which agrees ſo well with the laws of hydroſtatics and with our theory, indicates

cates that, at the time it aſſumed its figure, it was in a ſtate of fluidity. We have alſo proved, that the projectile motion, and the motion of rotation, were impreſſed at the ſame time, and by the ſame impulſe. It will more readily be admitted, that the earth was originally in a ſtate of liquefaction, when it is conſidered, that the greateſt part of the materials of which this globe is compoſed are either vitrifications, or vitrifiable by fire. The impoſſibility of rendering the earth fluid by the operation of waters confirms this hypotheſis; becauſe there is infinitely more earth than water, and the water is not able to diſſolve ſand, rocks, and hard minerals.

It is, therefore, evident, that the earth aſſumed its figure when in a fluid ſtate: And, to purſue our theory, it is natural to think, that the earth, when it iſſued from the ſun, had no other form but that of a torrent of melted and inflamed matter; that this torrent, by the mutual attraction of its parts, aſſumed a globular figure, which its diurnal motion changed into a ſpheroid; that, when the earth cooled, the vapours which were expanded like the tail of a comet, gradually condenſed, fell down in the form of water upon the ſurface, depoſiting, at the ſame time, a ſlimy ſubſtance, mixed with ſulphur and ſalts, part of which was carried, by the motion of the waters, into the perpendicular fiſſures of the ſtrata, and produced metals, and the reſt remained on the ſurface, and gave riſe

riſe to the vegetable mould, which abounds, in different places, with more or leſs of animal and vegetable particles, whoſe organization is not obvious to the ſenſes.

Thus the interior parts of the globe were originally compoſed of vitrified matter; and, I believe, they continue ſo at preſent. Above this vitrified matter were placed thoſe bodies which the fire had reduced into the ſmalleſt particles, as ſands, which are only portions of glaſs; and, above theſe, pumice ſtones, and the ſcoriæ of melted matter, which gave riſe to the different clays. The whole was covered with water to the depth of 500 or 600 feet*, which originated from the condenſation of the vapours, when the earth began to cool. This water depoſited a ſtratum of mud, mixed with all thoſe matters that are capable of being ſublimed or exhaled by fire; and the air was formed of the moſt ſubtile vapours, which, from their levity, roſe above the water.

Such was the condition of the earth, when the tides, the winds, and the heat of the ſun, began to introduce changes on its ſurface. The

* This opinion, that the earth was entirely covered with water, correſponds with the ſentiments of ſeveral ancient philoſophers, and likewiſe with thoſe of many of the fathers of the church. In mundi primordio, aqua in omnem terram ſtagnabat, ſays St. John of Damaſcus, lib. 2. cap. 9. Terra erat inviſibilis, quia exundabat aqua et operiebat terram; St. Ambroſe, lib. 1. cap. 8. Submerſa tellus cum eſſet, faciem ejus, inundante aqua, non erat adſpectabilis; St. Baſile, Hom. 2. See likewiſe St. Auguſtine, lib. i. cap. 12.

diurnal

diurnal motion of the earth, and that of the tides, elevated the waters in the equatorial regions, and neceſſarily tranſported thither great quantities of ſlime, clay, and ſand, and, by thus elevating theſe parts of the earth, they perhaps ſank thoſe under the poles about two leagues, as was formerly remarked: For the waters would eaſily reduce into powder pumice-ſtones, and other ſpungy parts of the vitrified matter upon the ſurface, and, by this means, excavate ſome places, and elevate others, which, in time, would produce iſlands and continents, and all thoſe inequalities on the ſurface, that are more conſiderable towards the equator than the poles. The higheſt mountains lie between the Tropics and the middle of the Temperate Zones, and the loweſt from the polar circles towards the poles. Between the Tropics are the Cordeliers, moſt of the mountains of Mexico and the Brazils, the great and leſſer Atlas, the mountains of the Moon, &c. Beſides, both the land and the ſea have moſt inequalities between the tropics, as is evident from the incredible number of iſlands peculiar to theſe regions.

However independent of my general theory, this hypotheſis, concerning the original ſtate of the globe, may be, I have choſen to refer to it in this article, with a view to ſhow the connection and poſſibility of the ſyſtem endeavoured to be eſtabliſhed in the firſt article. It may only be remarked, that my theory is not oppoſed

ed by the facts; that I take the earth nearly as it ſtands at preſent; and that I lay hold of none of thoſe ſuppoſitions which are often uſed in reaſoning concerning the former condition of the earth. But, as I here offer a new idea upon this ſubject of the ſediments depoſited by the waters that, in my opinion, gave riſe to the upper ſtratum of the earth, it will not be improper to exhibit the reaſons upon which it is founded.

The vapours exhaled from the earth produce rain, dews, thunder, lightning, and other meteors. Theſe vapours, therefore, are mixed with particles of water, air, ſulphur, earth, &c.; and it is the ſolid earthy particles which conſtitute the ſlime or mud under conſideration. The pureſt rain-water depoſits a quantity of this mud; and, when a quantity of dew is collected, and allowed to corrupt, it produces a greater proportional quantity of mud, which is fat, unctuous, and of a reddiſh colour.

The upper ſtratum of the earth is compoſed of this mud, mixed with particles of animal and vegetable ſubſtances, or rather with particles of ſtone and ſand. It is worthy of remark, that moſt arable land is reddiſh, and more or leſs blended with heterogeneous matters. The particles of ſtone or of ſand found in the upper ſtratum, are of two kinds; the one is groſs and heavy, the other fine, and ſometimes impalpable. The groſs is detached from the inferior ſtratum by labouring the ground; or, rather,

the upper ſtratum, by penetrating the inferior which is compoſed of ſand or gravel, forms what is called *fat*, or *fertile ſand*. The finer ſpecies proceeds from the air, falls down with the dew or rain, and intimately incorporates with the vegetable mould, or upper ſtratum. This laſt is nothing more than the duſt, tranſported by the air, and again depoſited by rain or a moiſt atmoſphere. When the quantity of this mud is great in proportion to the particles of ſtone or ſand, the ſoil is red and fertile; if it be conſiderably mixed with animal and vegetable ſubſtances, it is blackiſh; but if the quantity of mud and of vegetable and animal ſubſtances be ſmall, the ſoil is white and barren; and even when the particles of ſand, ſtone, or chalk, which compoſe theſe barren ſoils, are mixed with a conſiderable quantity of animal and vegetable ſubſtances, they become black and light, but have very little fertility. According, therefore, to the different proportions of theſe three ingredients, the ſoil is more or leſs fertile, and differently coloured.

In order to acquire diſtinct ideas concerning the ſtrata of the earth, we ſhall take for an example the pits at Marly-la-Ville, which are exceedingly deep. This place is ſituated in a high, but flat and fertile country, and its ſtrata lie horizontally. I procured ſpecimens of all theſe ſtrata in their order from M. Dalibard, an eminent botaniſt, and a man of ſcience; and, after having

having proved, with aqua fortis, the nature of the matters they reſpectively conſiſt of, I arranged them in the following table.

Table of the different beds of earth at Marly-la-Ville, to the depth of 100 *feet.*

	Feet.	Inch.
1. A free reddiſh earth, mixed with a large quantity of mud, a little vitrifiable ſand, and a greater proportion of calcinable ſand, or gravel - - -	13	
2. A free earth mixed with gravel and with more vitrifiable ſand -	2	6
3. Mud mixed with a large quantity of vitrifiable ſand, which made but a ſmall effervеſcence with aqua fortis - - -	3	
4. Hard marl, which effervеſced violently with aqua fortis -	2	
5. A marly ſtone very hard -	4	
6. Marl in powder, mixed with vitrifiable ſand - -	5	
7. Fine vitrifiable ſand - -	1	6
8. Marl reſembling earth, mixed with a little vitrifiable ſand -	3	6
9. Hard marl, in which was found genuine flint - -	3	6
10. Gravel, or marl in powder -	1	
Carried over	39	

	Feet.	Inch.
Brought over	39	
11. Eglantine, a hard ringing ſtone, of the grain of marble -	1	6
12. Marly gravel - -	1	6
13. Marl in the form of hard ſtone, with a fine grain -	1	6
14. Marl like ſtone, with a coarſer grain - - -	1	6
15. Marl ſtill more groſs -	2	6
16. Fine vitrifiable ſand, mixed with foſſil ſea-ſhells, which had no coheſion with the ſand, and which ſtill preſerve their natural colours	1	6
17. Fine gravel, or marl-duſt -	2	
18. Marl in the form of a hard ſtone	3	6
19. Marl in the form of coarſe powder	1	6
20. Hard ſtone, calcinable like marble	1	
21. A gray vitrifiable ſand, mixed with foſſil ſhells, particularly with oyſters and ſpondyles, which had no coheſion with the ſand, and were not petrified - -	3	
22. A white vitrifiable ſand, mixed with the ſame ſhells -	2	
23. A vitrifiable ſand with red and white ſtreaks, and mixed with he ſame ſhells - -	1	
24. A coarſer vitrifiable ſand, mixed with the ſame ſhells -	1	
Carried over	64	

	Feet.	Inch.
Brought over	64	
25. A fine, gray, vitrifiable ſand, mixed with the ſame ſhells -	8	6
26. A fine unctuous ſand, with very few ſhells - -	3	
27. Brown free ſtone - -	3	
28. Vitrifiable ſand, ſtriped with red and white - -	4	
29. A white vitrifiable ſand -	3	6
30. A reddiſh vitrifiable ſand -	15	
Total depth of the pit	101	

I formerly mentioned, that I had examined all theſe ſubſtances with aqua fortis, becauſe no other teſt can enable us to make real diſtinctions between earthy bodies of the ſame or of different appearances. Thoſe which effervesce and ſuddenly diſſolve, on the application of the aqua fortis, are generally calcinable. Thoſe, on the other hand, upon which that acid makes no impreſſion, are vitrifiable.

From this enumeration of ſtrata it is evident, that the land at Mary-la-Ville was formerly covered with the ſea, to the depth of 75 feet, ſince ſhells are found 75 feet below the ſurface. Thoſe ſhells have been collected and depoſited by the water, together with the ſand, which contains them; and the whole ſuperior ſtrata, except the uppermoſt, have been tranſported

thither by the motion of the waters, and depoſited in the form of ſediment, as is apparent from their horizontal poſition, from the mixture of ſand, ſhells, and marl, which laſt is compoſed of decayed ſhells; and even the upper ſtratum has been almoſt wholly formed of ſlime or mud, with a ſmall mixture of marl.

I have choſen this example, becauſe it is leaſt favourable to my theory; for it appears, at firſt view, difficult to conceive how the mud depoſited by the dew and rains ſhould produce a bed of vegetable ſoil 13 feet thick. But it ought to be remarked, that a ſoil of this thickneſs is rarely to be found, eſpecially in high countries. The general run of ſoils are from three to four feet, and often they exceed not one foot. The ſoil is thickeſt in plains ſurrounded with hills; becauſe the rains daily bring freſh ſupplies from the higher grounds. But, abſtracting from this ſuppoſition, it is plain, that the upper ſtrata formed by the ſea are thick beds of marl. It is natural to think, that the upper ſtratum was originally much thicker, and that, beſide the 13 feet, the ſea would leave a conſiderable quantity of marl. But this marl, being expoſed to the action of the air, of rains, and of the rays of the ſun, would ſoon be reduced into a fine powder. The ſea would not leave this land ſuddenly, but would continue for ſome time occaſionally to cover it, either by the motion of the tides, or by extraordinary

dinary ſwells during great ſtorms; and, of courſe, the upper ſtratum would be mixed with mud, clay, and other ſlimy bodies. After being entirely above the reach of the waves, plants would begin to grow, and the ſoil would conſtantly accumulate, and be tinged with a reddiſh colour by the mud depoſited by dews and rain. Culture would ſtill farther increaſe both its fertility and its thickneſs, and, by allowing the dews and rains to penetrate deeper, would in proceſs of time produce this ſoil of 13 feet.

I ſhall not here examine, whether the reddiſh colour of vegetable mould proceeds from a quantity of iron contained in the mud depoſited by rain and dews. This point, which is of ſome importance, ſhall be diſcuſſed when we come to treat of minerals. It is ſufficient to have given a view of the manner in which the upper ſtratum has been formed: We ſhall now prove, by other examples, that the formation of the interior ſtrata of the earth muſt likewiſe have originated from the operation of the waters.

The upper ſtratum of the globe, ſays Woodward, that magazine for the formation and ſupport of animals and vegetables, is moſtly compoſed of vegetable and animal matter, and is in perpetual fluctuation. All the animals and vegetables which have exiſted ſince the creation, have ſucceſſively extracted from this ſtratum the materials of which their bodies are conſtructed; theſe they again reſtore at their diſſolution, where

they remain prepared for the ſucceſſive formation of new bodies of the ſame ſpecies; the matter which forms one body being naturally diſpoſed to make another of the ſame kind*. In uninhabited countries, where the woods are never cut, nor the herbs brouſed by cattle, the ſoil is conſtantly augmenting. The ſoil, in all woods, even in thoſe which are occaſionally cut, is from 6 to 8 feet thick, and has originated from the leaves, and other decayed parts of vegetables. I have often remarked, that, upon an old Roman way which runs acroſs Burgundy, the ſtones with which it was conſtructed are covered with a black mould of more than a foot thick, and that it nouriſhes trees of a conſiderable ſize. This ſoil could only be produced by the gradual and ſucceſſive deſtruction of vegetable bodies. As vegetables derive more of their ſubſtance from the air and water than from the earth, when they decay, they add more to the ſoil than they extracted from it. Beſides, foreſts collect and retain vapours and moiſture; and, of courſe, in old woods, the ſoil is greatly augmented. But, as animals reſtore much leſs to the earth than they take from it; and, as men conſume vaſt quantities of wood and herbs for fewel and other purpoſes, it follows, that the vegetable ſoil of populous countries muſt continually diminiſh, and become, in time, like thoſe of Arabia Petrea and other eaſtern countries, which were firſt inhabited, where nothing is now

* See Woodward's Eſſay, p. 136.

to

to be found but ſand and ſalts; for the fixed ſalts of plants and of animals remain, while all the other parts volatilize, and are carried off by the air.

Let us next examine the poſition and formation of the interior ſtrata. The earth, ſays Woodward, wherever it has been dug, is compoſed of beds or ſtrata, one above another, in the ſame manner as if they had proceeded from ſucceſſive ſediments depoſited by water. The beds which lie deepeſt are thicker than thoſe immediately above them, and they are gradually thinner till they arrive at the ſurface. Sea-ſhells, teeth, and bones of fiſhes, are found in theſe beds, and not only in thoſe which are ſoft, as chalk, clay, and marl, but even in beds of hard ſtone, marble, &c. Theſe productions of the ſea are incorporated with the ſtone, and, when ſeparated, leave in the ſtone the figure of their ſurface exactly delineated. 'I was abundantly aſſured,' ſays this author, 'that the circumſtances of theſe things in remoter countries were much the ſame with thoſe of ours here: That the ſtone, and other terreſtrial matter, in France, Flanders, Holland, Spain, Italy, Germany, Denmark, Norway, and Sweden, was diſtinguiſhed into ſtrata, or layers, as it is in England: That thoſe ſtrata were divided by parallel fiſſures: That there were incloſed in the ſtone, and all the other denſer kinds of terreſtrial matter, great numbers of ſhells, and

other

'other productions of the ſea; in the ſame manner as in that of this iſland. To be ſhort, by the ſame means I got ſufficient intelligence that theſe things were found in like manner in Barbary, in Egypt, in Guiney, and other parts of Africa: In Arabia, Syria, Perſia, Malabar, China, and other Aſiatic provinces: In Jamaica, Barbadoes, Virginia, New England, Braſil, Peru, and other parts of America.' p. 6. 41, 42, &c.

Woodward gives no authority for his aſſertion, that ſhells are found in the ſtrata of Peru. But as, in general, his facts are true, I doubt not but his information has been good; and I am perſuaded that ſhells exiſt in the ſtrata of Peru, as well as every where elſe. I make this remark on account of a doubt which has been entertained, and which ſhall afterwards be conſidered.

In digging a well at Amſterdam, 232 feet deep, the ſtrata were arranged in the following order: 7 feet of vegetable ſoil; 9 feet of turf; 9 feet of ſoft clay; 8 feet of ſand; 4 of earth; 10 of clay; 4 of earth; 10 of ſand; 2 of clay; 4 of ſmall white ſand; 5 of dry earth; 1 of ſoft earth; 14 of ſand; 8 of clay mixed with ſand; 4 of ſand mixed with ſhells; then 102 feet of clay; and, *laſtly*, 31 feet of ſand*.

It is uncommon to dig ſo deep before we find water: But this fact is remarkable in

* See Varenii Geograph. gen. p. 46.

many

many other reſpects. 1*ſt*, It demonſtrates that the ſea communicates not with the interior parts of the earth by means of filtration: 2*d*, That ſhells are found 100 feet below the ſurface in a country extremely low; and, conſequently, that the land of Holland has been elevated 100 feet by the ſediments of the ocean: 3*d*, It may be concluded, that the bed of clay of 102 feet, and the bed of ſand, 31 feet of which only had been dug, and whoſe actual thickneſs is unknown, lie near to the ancient and original earth that exiſted before the motion of the waters began to change its ſurface. In the firſt article, it was remarked, that, in order to diſcover the ancient earth, we muſt dig in the northern, rather than in the ſouthern regions; and in the low and plain, rather than in the elevated countries. Theſe circumſtances nearly concurred in the preſent caſe. We only wiſh that the pit had been dug deeper, and that the author had informed us, whether ſhells, or other ſea-bodies, were intermixed with the laſt ſtrata of clay and of ſand. This experiment confirms what was formerly advanced, that the ſtrata are always thicker in proportion to their depth.

The earth conſiſts of parallel and horizontal ſtrata, not in the plains only, but, in general, the hills and mountains have the ſame ſtructure. The ſtrata of the mountains are even more conſpicuous than thoſe of the plains; for the plains are commonly covered with great quantities of

ſand

ſand and earth brought from the higher grounds by the waters; and, therefore, to find the ancient ſtrata, we muſt dig deeper in the plains than in the mountains.

I have often remarked, that, when the top of a mountain is level, its ſtrata are likewiſe level; but, when the top is not horizontal, the ſtrata follow the direction of its declivity. It has frequently been alleged, that the beds of quarries incline to the eaſt. But in all the chains of rocks which I have examined, I found, that theſe beds always follow the declivity of the hill, whether its direction be eaſt, weſt, ſouth, or north. In raiſing ſtones from the quarry, they are always ſeparated according to their natural poſition; and, if cut in a contrary direction, it is impoſſible to raiſe them of any conſiderable ſize. In all good maſonry, the workmen place the ſtones in the direction in which they lay in the quarry. If laid in an oppoſite poſition, they will ſplit, and be unable to reſiſt the weight of the incumbent building. Hence we may conclude, that ſtones have been originally formed in horizontal beds; that theſe beds have been ſucceſſively accumulated above each other, and have been compoſed of materials, the reſiſtance of which is ſtronger in that than in any other direction.

Every ſtratum, of whatever kind, whether it be horizontal or inclined, is of an equal thickneſs through its whole extent. In the quarries round Paris, the ſtratum of good ſtone is but about

about 18 or 20 inches thick throughout. In the quarries of Burgundy, the ſtone is much thicker. The ſame inequalities take place in marbles. The white and black marbles are thicker than thoſe that are coloured; and there is a hard ſtone with which the people of Burgundy cover their houſes, that exceeds not an inch in thickneſs. Thus, different ſtrata differ much with regard to thickneſs; but each ſtratum uniformly preſerves the ſame thickneſs through its whole extent. This difference is ſo great, that ſtrata are to be found, from leſs than a line, to 1, 10, 20, 30, and 100 feet thick. Both ancient and modern quarries, which are dug horizontally, the ſhafts of mines, and the working of lead, either longitudinally or tranſverſely, prove that ſtrata extend a great way on all ſides. 'It is well known,' as the hiſtorian of the academy obſerves, 'that 'all ſtones have originally been a ſoft paſte, and 'that, as ſtones are almoſt every where to be 'met with, the ſurface of the earth, in all theſe 'places, at leaſt to a certain depth, muſt have 'conſiſted of mud and ſlime. The ſhells found 'in moſt quarries demonſtrate, that this mud 'was an earth diluted by the water of the ſea; 'and, conſequently, that the ſea once covered 'all theſe places; but the ſea could not cover 'them, without, at the ſame time, covering all 'places that were lower, or on the ſame level. 'Now, it is impoſſible that the ſea could cover 'all thoſe places where there are quarries, with-

'out

'out covering the whole ſurface of the globe. 'If the mountains were then formed, the ſea 'muſt alſo have covered them; for they are full 'of rocks and quarries, and ſhells are often 'found in them.

'The ſea, then,' continues he, 'covered the 'whole earth; and hence all the beds of ſtone 'in the plains are horizontal and parallel: The 'fiſhes, therefore, were the moſt ancient inha- 'bitants of the globe; for neither land-animals 'nor birds could exiſt. But how has the ſea 'retired into thoſe vaſt baſons which it now oc- 'cupies? The moſt natural ſuppoſition is, that 'the earth, at leaſt to a certain depth, was not 'all equally ſolid, but interſperſed with vaſt 'vaults or caverns, the arches of which would 'remain for a time, and at laſt ſuddenly fall in. 'The waters would then ruſh into theſe hollows, 'fill them up, and leave a part of the ſurface 'dry, which would become a convenient habi- 'tation for land-animals and birds. The ſhells 'found in quarries ſtrongly confirm this idea; 'for nothing but the bony parts of fiſhes could 'be preſerved ſo long in the earth. Beſides, 'ſhells commonly lie in vaſt maſſes in certain 'parts of the ſea, where they remain immove- 'able, and form a ſpecies of rocks or banks; 'they could not, therefore, follow the ſea, which 'ſuddenly abandoned them. It is for this laſt 'reaſon that we find ſuch numbers of foſſil- 'ſhells, and ſo few veſtiges of other fiſhes, which

'is a farther proof that the waters retired with 'rapidity into their preſent baſons. When the 'vaults ſunk down, it is very probable that 'mountains were elevated by the ſame cauſe, 'and placed upon the ſurface with rocks and 'quarries already formed. But the beds of theſe 'quarries could not preſerve their original ho- 'rizontal poſition, unleſs they were raiſed exact- 'ly perpendicular to the ſurface, which would 'rarely happen. Thus, as we formerly remark- 'ed *, the beds of ſtone in mountains are all 'inclined to the horizon, though they be paral- 'lel to each other; for they changed not their 'poſition with regard to one another, but with 'regard only to the ſurface of the earth †.'

Theſe parallel beds of earth or of ſtone, which have been formed by ſediments of the ocean, often extend to conſiderable diſtances. We even find, in hills ſeparated by valleys, beds of the ſame materials upon equal levels. This obſervation has a perfect correſpondence with the equal altitudes of oppoſite hills. The truth of this fact may be eaſily eſtabliſhed; for, in all hills ſeparated by narrow valleys, where ſtone or marble is found on one hill, we uniformly find theſe very ſubſtances, at the ſame level, on the oppoſite hill. I have traced a quarry of marble 12 leagues in length; its breadth is alſo conſiderable, though I have not been able to aſcertain it with preciſion. I have often obſerved,

* See Mem. de l'Acad. ann. 1705, p. 30.
† Ibid. ann. 1716, p. 14.

that this bed of marble has every where the ſame thickneſs; and that, in hills ſeparated by a valley of 100 feet deep, the ſame bed always appeared at the ſame altitude. I am firmly perſuaded, that this obſervation holds with regard to all quarries of ſtone or of marble which contain ſhells; but it applies not to beds of free-ſtone. We ſhall afterwards explain why free-ſtone is not diſperſed, like other matters, in horizontal beds, but in blocks, irregular both in form and poſition.

It has likewiſe been remarked, that, on the oppoſite ſides of ſtraits of the ſea, the ſtrata are the ſame. This obſervation is important, and may lead to the diſcovery of thoſe necks of land, or iſlands, which have been ſeparated from the Continent. It proves, for example, that England has been ſeparated from France, Spain from Africa, and Sicily from Italy: And it is to be regretted, that the ſame obſervation has not been made upon all ſtraits. I have no doubt but it will hold univerſally. We know not, whether, in the ſtraits of Magellan, the longeſt we are acquainted with, the ſame ſtrata are to be found at the ſame latitude. But we perceive, from very exact charts, that the oppoſite coaſts, which are high, have correſponding angles like thoſe obſervable in our inland mountains; and this farther proves Terra del Fuego to have been formerly a part of the Continent of America. The ſame remark has been made with regard to the ſtrait

ſtrait of Frobiſher; and the iſland of Frieſland appears to have been ſeparated from the continent of Greenland.

The Maldivia iſlands are ſeparated from each other by ſmall branches of the ſea; and, on each ſide of the oppoſite iſlands, the ſtrata of rocks, &c. are the ſame. Theſe iſlands, which, when taken together, extend about 200 leagues in length, were formerly one. They are divided into 13 provinces, called *Cluſters*. Every Cluſter contains a great number of ſmall iſlands, moſt of which will ſoon be under water. It is remarkable, that each of theſe 13 Cluſters is ſurrounded with a chain of rocks of the ſame ſtone, and that there are only three or four ſmall and dangerous openings, through which each of them can be approached. They are all placed in a line, with their ends to each other, and appear evidently to have been once a long mountain crowned with rock *.

Several authors, as Verſtegan, Twine, Sommer, but particularly Campbell, in his deſcription of the county of Kent, give ſtriking proofs that England was formerly joined to France, and that the neck of land that divides them had been carried off by the ſea, which retired, and left a great quantity of low marſhy ground along the ſouthern coaſts of England. As a farther proof of this fact, Dr. Wallis has attempted to ſhow an affinity between the an-

* See Voyag. de Franc. Pyrard, vol. i. p. 107.

cient language of the Gauls and that of the Britains; and he adds ſeveral other remarks, which ſhall be related in the following articles.

If travellers obſerved the figure of lands, the poſition of mountains, and the windings of rivers, they would perceive that oppoſite hills are not only compoſed of the ſame materials at the ſame altitudes, but that they are alſo nearly of an equal height. In all the places where I have travelled, I uniformly remarked this equality in the height of oppoſite hills, eſpecially when they are ſeparated by valleys not above a fourth or a third of a league wide. In valleys of greater width, it is difficult to judge of the height or equality of hills; for, on looking over a level and extenſive plain, it appears to riſe; and diſtant hills ſeem to ſink. But this is not the place to account for theſe phænomena. Beſides, it is not eaſy to determine by the eye the middle of a large valley, unleſs it be traverſed by a river. But, in narrow valleys, the judgment of the eye is more certain. That diſtrict of Burgundy comprehended between Auxerre, Dijon, Autun, and Bar-ſur-ſeine, of which a conſiderable portion is called *le Bailliage de la Montagne*, is one of the moſt elevated parts of France. From one ſide of theſe mountains, which are only of the ſecond order, the water runs to the ocean, and, from the other, to the Mediterranean. There are points of partition, as at Sombernon, Pouilli in Auxois, &c. where the

the water may be turned at pleaſure, either to the ocean or the Mediterranean. This high country is interſected with a number of ſmall valleys, and moſt of them are watered with rivulets. Here I have a thouſand times obſerved the correſponding angles of the hills, and their equality as to height; and I can with confidence affirm, that the ſalient or prominent angles are uniformly oppoſed to the concave ones, and that the heights of the two ſides are nearly the ſame. The farther we advance in this high country, where are the points of partition mentioned above, the mountains riſe the higher. But this height is always the ſame on the oppoſite ſides of the valleys, and the hills riſe or fall equally. The ſame obſervation I have repeatedly made in ſeveral other provinces of France; but they extend not to very high mountains; for theſe are more irregular as to height, and often terminate in unequal points or peaks. In frequently traverſing the Alps and Appennines, I obſerved, that the angles, in effect, correſponded; but that it is almoſt impoſſible to judge, by the eye, concerning the equality or inequality in the heights of oppoſite mountains; becauſe their tops are loſt in the clouds.

The different ſtrata compoſing the earth are not arranged according to their ſpecific gravities. Beds of heavy matter are frequently placed above thoſe of lighter. Solid rocks are often ſupported by beds of earth, clay, or ſand, which

are greatly inferior in ſpecific gravity. This is the caſe with moſt hills, and is eaſily perceived. But, in high mountains, the ſummits are not only rocks, but theſe rocks are ſupported by others; and this ſtructure runs through ſuch an extent of country, where one mountain riſes out of another, that it is difficult to determine whether they are founded on earth, or of what nature this earth is. I have ſeen rocks cut perpendicularly for ſome hundreds of feet; but theſe rocks reſted upon other rocks, without my being able to perceive where they ended. May we not, however, be allowed to conclude from the leſs to the greater? Since the rocks of ſmall mountains, the baſes of which are viſible, reſt upon earths leſs heavy and leſs ſolid than ſtone, is it not reaſonable to think, that earth is likewiſe the baſis of high mountains? Beſides, all I have here advanced tends to prove, that heavy bodies might be accumulated, by the motion of the waters, above light ones; and, if this really takes place in moſt hills, it is probable that it has happened in the manner pointed out by my theory. But, ſhould it be objected, that I had no reaſon to ſuppoſe, that, prior to the formation of mountains, the heavier matter was below the lighter; I anſwer, that I affirm nothing with regard to this article; becauſe there are many ways by which this effect might be produced, whether the heavy matter was above or below, or placed indiſcriminately: For, in order to conceive

conceive how the ſea could firſt form a mountain of clay, and then crown it with rocks, we have only to conſider, that the ſediments might be tranſported from different places, and that they might conſiſt of different materials. The ſea might tranſport from one place ſeveral ſediments of clay, and afterwards depoſit ſediments of ſtony matter; either becauſe all the clay at the bottom, or on the coaſts, was exhauſted, and then the waves would attack the rocks; or, rather, becauſe the firſt ſediments were tranſported from one place, and the laſt from a different one. Beſides, the latter correſponds exactly with experience; for, it is a known fact, that beds of earth, ſtone, gravel, ſand, &c. follow no rule of arrangement, but are placed indifferently, and, as it were, by chance, one above another.

This chance, however, ought to have ſome rules, which can only be diſcovered by analogy and probable conjecture. We have ſeen, that, according to my theory of the formation of the globe, its interior parts ſhould conſiſt of vitrified matter, ſimilar to vitrified ſand, which is only the fragments of glaſs, and of which the clays are the ſcoriæ, or decompoſed parts. Agreeable to this ſuppoſition, the centre of the earth, and even near the ſurface itſelf, ſhould be compoſed of glaſs or vitrified matter, and above this ſhould be found ſand, clay, and other ſcoriæ. Thus, the earth, in its original ſtate,

was a nucleus of glaſs, or of vitrified matter, either compact like glaſs, or divided like ſand, (for that circumſtance depends on the degree of heat applied); above this matter was ſand; and, laſtly, clay. The ſoil, or external covering, was produced from the air, and the mud of water; and it is more or leſs thick according to the ſituation of the ground; more or leſs coloured, according to the different mixtures of mud, ſand, clay, and the parts of decayed animals and vegetables; and more or leſs fertile, according to the abundance or deficiency of theſe parts. To ſhow that this account of the formation of ſand and clay is not altogether imaginary, I ſhall add a few remarks.

I ſuppoſe the earth, in its firſt ſtate, to have been a ſpheroid of compact glaſs, covered with a thin cruſt of pumice-ſtone, and other ſcoriæ of melted matter. The agitation of the air and of the water would ſoon reduce this cruſt of pumice into powder or ſand, which, by uniting into maſſes, would give riſe to free-ſtone and flints, the varieties of which, with regard to colour and denſity, depend upon the different degrees of fineneſs of the ſand that compoſed them.

The conſtituent parts of ſand unite by the application of fire, become very hard, compact, and more or leſs tranſparent, according to the purity of the ſand: But, on the other hand, when expoſed to the action of the air, it exfoliates,

liates, falls down in the form of earth, and may thus produce clays of different kinds. This duſt, which is ſometimes yellow, ſometimes brilliant, and is uſed to dry writings, is nothing elſe than a fine ſand, ſomewhat corrupted, and nearly reduced to an elementary ſtate. Its particles, in time, become ſo attenuated and divided, that they loſe the power of reflecting light, and acquire all the properties of clay. On examining a piece of clay, many of theſe ſhining or talky particles appear; becauſe they have not yet entirely loſt their original form. Sand, therefore, in proceſs of time, may produce clay; and this clay, by a farther diviſion, acquires the qualities of mud or ſlime, a vitrifiable matter of the ſame nature with clay.

This theory is confirmed by daily experience. In waſhing ſand, the water becomes impregnated with a black, ſoft, fatty earth, which is a genuine clay. The mud ſwept from ſtreets paved with free-ſtone, is black and very fat, and, when dried, it diſcovers itſelf to be an earth of the ſame nature with clay. Clay, taken from places where there is neither flint nor free-ſtone, and diluted with water, always precipitates a great quantity of vitrifiable ſand.

But, what clearly demonſtrates the exiſtence of ſand, and even of flint and glaſs, in clay, is, that the re-union of its parts, by the action of fire, reſtores it to its original form. Clay, when heated to the degree of calcination, is covered

with a hard coat of enamel; if its internal parts are not vitrified, they become ſo extremely hard as to reſiſt the file; they ſtrike fire with the hammer, and acquire all the properties of flint: A great degree of heat melts and converts them into real glaſs.

Clay and ſand, therefore, are ſubſtances perfectly analogous, and of the ſame kind. If clay can be condenſed to flint, and even to glaſs, why may not ſand, by reſolution, become clay? Glaſs appears to be the true elementary earth, and all mixed bodies are only glaſs in diſguiſe. Metals, minerals, ſalts, &c. are only a vitrifiable earth: Common ſtone, and other analogous bodies, teſtaceous and cruſtaceous ſhells, &c. are the only ſubſtances which cannot be vitrified, and which ſeem to form a diſtinct claſs. The former, by the action of fire, may be converted into a homogeneous, hard, and tranſparent ſubſtance, without any diminution of its weight, and upon which no farther change can be made. The latter, on the contrary, which conſiſt of more active and volatile principles, calcine in the fire, loſe more than a third of their weight, and reſume the form of ſimple earth, without any other change than the reſolution of their conſtituent parts. If theſe bodies be excepted, which are few in number, and of which the combinations produce few varieties in nature, all other ſubſtances, and particularly clay, may be converted into glaſs, and, conſequently, are only

only glaſs in a decompoſed ſtate. If fire quickly vitrifies theſe ſubſtances, glaſs itſelf, whether ſimple, or in the form of ſand or flint, naturally, but by a ſlow and inſenſible progreſs, reſolves into clay.

In countries where flint is the predominant ſtone, the fields are commonly ſtrewed with its fragments: If the place be uncultivated, and if the flints have remained long expoſed to the air without being moved, their upper ſurface is always white; but the ſurface next the ground preſerves its natural colour, which is very brown. When theſe flints are broken, the whiteneſs appears to be not ſuperficial only, but penetrates more or leſs into their internal parts, and forms a belt, which in ſome is not very deep, but, in others occupies nearly the whole ſtone. This white part is ſomewhat granulated, perfectly opaque, as tender as free-ſtone, and adheres to the tongue like the boles. But the other portion of the flint is ſmooth and poliſhed, has neither thread nor grain, and preſerves its original colour, its tranſparency, and its hardneſs. When this half decompoſed flint is put into a furnace, the white part becomes red like a brick, and the brown part becomes exceedingly white. Why ſhall we conclude, with a famous naturaliſt, that flints of this kind are imperfect, and that they are not old enough to have acquired their perfect ſtate? For why ſhould they be all imperfect? And why ſhould they be uniformly

imperfect

imperfect on the ſide only that is expoſed to the air? It is, on the contrary, much more probable, that they are changed from the original ſtate, and partly decompoſed, and that they are gradually reſolved into clay or bole. If this reaſoning ſhould appear to be unſatisfactory, expoſe to the air the hardeſt and blackeſt flint, in leſs than a year the colour of its ſurface will be changed; and, if the experiment be farther proſecuted, the flint will be found gradually to loſe its hardneſs, its tranſparency, and its other ſpecific characters, and make daily approaches to the nature of clay.

Sand undergoes the ſame changes as flint. Every grain of ſand may, perhaps, be conſidered as a ſmall flint, and every piece of flint as a collection of fine ſand cemented together. The firſt example of the decompoſition of ſand is exhibited in that ſhining, but opaque powder, called *mica*, with which clay and ſlate are always impregnated. The quartz, or perfectly tranſparent flints, in decompoſing, produce fat and ſoft talks, ſuch as thoſe of Venice and Ruſſia, which are as ductile and vitrifiable as clay; and it appears, that talk is the mean between glaſs, or tranſparent flint, and clay; but that the groſs and impure flints, in decompoſing, are converted into clay without any intermediate ſtate.

Our made glaſs undergoes the ſame change; when long expoſed to the air, it decompoſes, and, as it were, corrupts. At firſt, it aſſumes a number

number of colours, then it exfoliates, and, in handling it, we perceive that many ſhining particles fall off. But, when its decompoſition is farther advanced, it bruiſes between the fingers, and is reduced to a very white, talky, and impalpable powder. Art alſo imitates nature in the decompoſition of glaſs and flint. 'Eſt etiam 'certa methodus, ſolius aquæ communis ope, 'ſilices et arenam in liquorem viſcoſum, eun-'demque in ſal viride convertendi, et hoc in ole-'um rubicundum, &c. Solius ignis et aquæ 'ope, ſpeciali experimento, duriſſimos quoſque 'lapides in mucorem reſolvo, qui diſtillans ſub-'tilem ſpiritum exhibet, et oleum nullis laudi-'bus prædicabile*.'

Theſe matters ſhall be more fully conſidered when we treat of metals. We ſhall here only add, that the different ſtrata of the globe conſiſt either of materials which may be conſidered as actual vitrifications, or analogous to glaſs, and poſſeſſing its moſt eſſential qualities. It is alſo evident, that, from the decompoſition of glaſs and flint, which daily takes place, there reſults a genuine clay. Hence we may conclude, with a high degree of probability, that ſand and clays have originally been the ſcoriæ of burnt matter, eſpecially when we join to the above circumſtances, the proofs *a priori* which have been employed to ſhow that the earth was formerly in a ſtate of liquefaction occaſioned by the operation of fire.

* Vid. Becher. Phyſ. Subterr.