PROOFS

OF THE

THEORY OF THE EARTH.

ARTICLE XVII.

Of New Islands, Caverns, perpendicular Fissures, &c.

NEW islands are produced either suddenly by the operation of subterraneous fires, or slowly by the accumulated sediments of water. Upon this subject we are furnished with indubitable facts, both by ancient historians, and by modern voyagers. Seneca tells us, that, in his time, the island of Therasia* suddenly emerged from the sea, to the astonishment of many spectators. Pliny relates, that 13 islands formerly arose all at once from the bottom of the Mediterranean, and that Rhodes and Delos are the chief of them. According to Ammianus Marcellinus, Philo, Pliny, &c. these 13 islands were

* Now called Santorini.

not

not formed by an earthquake or by a subterraneous explosion, but were formerly concealed under the water, which sunk and uncovered them. Delos was even distinguished by the name of Pelagia, because it formerly belonged to the sea. Whether these 13 new islands were produced by the action of subterraneous fire, or by any other cause which diminished the quantity of water in the Mediterranean, it is not easy to determine. But we are informed by Pliny himself, that the island of Hiera, in the neighbourhood of Therasia, is composed of ferruginous masses, and of earth which had been thrown up from the bottom of the sea; and, in another place, he mentions several other islands which had been formed in the same manner. Upon this subject, however, we have facts more recent, and less involved in obscurity.

On the 23d day of May 1707, at sun-rising, there appeared, at the distance of two or three miles from the island of Therasia or Santorini, something which had the resemblance of a floating rock. Some men, stimulated by curiosity, approached it, and discovered that it had arisen from the bottom of the sea; that it increased under their feet; that oysters and other shells still adhered to the rocks; and that many pumice-stones lay on its surface. Two days before this rock appeared, there had been a slight earthquake in Santorini. This island continued to augment considerably, without any accident, till the 14th

of

of June. It was then about half a mile in circumference, and 20 or 30 feet high, and the earth was white and mixed with clay. After this time, the fea began to be more and more agitated; vapours arofe from it which infefted the ifland of Santorini, and on the 16th of July, 17 or 18 rocks rofe all at once from the bottom of the fea, and united into one mafs. Thefe phænomena were attended with a frightful noife, which continued two months; and flames iffued from the new ifland, which ftill augmented both in circumference and height; and the explofions were fo violent, that they drove large ftones to more than 7 miles diftance. The ifland of Santorini itfelf was regarded by the ancients as a recent production; and, in 726, 1427, and 1573, it received confiderable additions, befide the fmall iflands formed in its neighbourhood*. The fame volcano, which, in the days of Seneca, raifed the ifland of Santorini, produced, in Pliny's time, that of Hiera or Volcanella, and, in our days, the rock above defcribed.

On the 10th of October 1720, a great fire was feen to arife from the fea near the ifland of Tercera. Navigators being fent, by order of government, to examine it, they perceived, on the 19th of the fame month, an ifland covered with fire and fmoke; and a prodigious quantity of afhes was thrown to a great diftance, as from a volcano, and accompanied with a noife fimilar to that

* See l'Hift. de l'Acad. des Sciences, 1708, p. 23.

of

of thunder. The earth was alfo perceived to fhake in the neighbourhood; and a vaft number of pumice-ftones were found floating on the fea all round the new ifland: This laft phænomenon has fometimes been remarked in the open fea*.

The hiftorian of the French academy†, in relating this event, remarks, that, after an earthquake in the ifland of St. Michael, one of the Azores, there appeared a torrent of fire between this ifland and that of Tercera, which gave rife to two new rocks: And, in the fubfequent year, the fame hiftorian gives the following detail:

'M. de l'Ifle has informed the academy of 'feveral particulars concerning the new ifland 'among the Azores, which he received in a 'letter from M. de Montagnac conful at Lif'bon. On the 18th of September 1721, M. de 'Montagnac's veffel was moored off the fortrefs 'of St. Michael; and he learned the following 'particulars from the pilot of the port.

'During the night of the 7th or 8th of De'cember 1720, there was a great earthquake in 'Tercera and St. Michael, which iflands are dif'tant from each other about 28 leagues, and a 'new ifland rofe from the fea. It was, at the 'fame time, remarked, that the point of the 'ifland of Peak, at the diftance of 30 leagues,

* See Philofophical Tranfact. Abridg. vol. vi. part 2. p. 154.
† Ann. 1721, p. 26.

'which

'which formerly threw out flames, was extinguiſhed. But a continual thick ſmoke iſſued 'from the new iſland, which was diſtinctly perceived by M. de Montagnac, as long as he 'continued in that part. The pilot aſſured him, 'that he had ſailed round the iſland, and approached it as near as he could with ſafety. 'He ſounded on the ſouth ſide of it with a rope 'of 60 fathoms; but found no bottom. On the 'weſt ſide, the water was much changed: It appeared to be mixed with white, blue, and 'green; and, at the diſtance of two miles, it 'ſeemed to be ſhallow and boiling. On the 'north-weſt, the ſide from which the ſmoke 'iſſued, he found, at 15 fathoms, a bottom of 'coarſe ſand. He threw a ſtone into the ſea, 'and, at the place where it fell, he obſerved the 'water boil, and mount into the air with great 'impetuoſity. The bottom was ſo hot, that, at 'two different times, it melted a piece of ſuet 'which had been faſtened to the end of the 'plumb-line. The pilot likewiſe remarked, 'that ſmoke iſſued from a ſmall lake, in the 'midſt of a ſandy plain. This iſland is nearly 'round, and high enough to be perceived, in 'clear weather, at the diſtance of ſeven or eight 'leagues.

'We have ſince learned, by a letter from M. 'Adrien, French conſul at St. Michael, dated 'in March 1722, that the new iſland is conſiderably diminiſhed; that it is nearly on a 'level with the water; and that it will probably 'ſoon diſappear.'

From theſe, and many other facts of a ſimilar nature, it is apparent, that inflammable bodies exiſt under the bottom of the ſea, and that they ſometimes produce violent exploſions. The places where they happen may be conſidered as ſubmarine volcano's, which differ from common volcano's only in the ſhorter duration of their effects; for, after the fire opens a paſſage to itſelf, the water ruſhes in, and extinguiſhes them. The elevation of new iſlands neceſſarily leaves caverns, which are ſoon filled by the waters; and the new ground, which conſiſts of matter thrown out by the ſubmarine volcano, muſt, in every reſpect, reſemble that of the Monti di Cinere, and other eminences which have been raiſed by terreſtrial volcano's. It is on account of the waters ruſhing into the voids and fiſſures produced by exploſions, that ſubmarine volcano's exhibit their effects leſs frequently than common volcano's, though both derive their origin from the ſame cauſe.

To ſubterraneous, or rather ſubmarine, fires, muſt be aſcribed all thoſe ebullitions of the ſea, and water-ſpouts, which have been remarked in different places by mariners: They alſo produce ſtorms and earthquakes, the effects of which are felt equally at ſea as upon land. The iſlands raiſed by ſubmarine volcano's are generally compoſed of pumice-ſtones and calcined rocks.

Fire

Fire has frequently been obferved to iffue out of the waters of the fea. Pliny tells us, that the whole furface of the Thrafymen lake has appeared to be inflamed; and Agricola informs us, that, when a ftone was thrown into the lake of Denftat in Thuringia, its defcent was marked by a train of fire.

Laftly, The great quantities of pumice-ftones difcovered by voyagers in different parts of the ocean, as well as in the Mediterranean, evince the exiftence of volcano's in the bottom of the fea, which differ not from thofe upon land, either in the violence of their explofions, or in the matter they throw out, but only in their rarity, and in the fhortnefs of their duration. Hence it may be remarked, that the bottom of the fea every way refembles the furface of the earth, not admitting even the exception of volcano's.

Between fea and land volcano's there are many relations. Both of them exift on the tops of mountains. The Azore iflands, and thofe of the Archipelago, are only the points of mountains, fome of which are above, and others under, the furface of the water. From the account of the new iflands among the Azores, it appears, that the place where the fmoke iffued was only 15 fathoms deep, which, when compared with the ordinary depth of the ocean, demonftrates this place to be the top of a pretty high mountain. The fame remark may be made

made with regard to the new ifland near Santorini. Its depth muft have been inconfiderable, fince oyfters were found attached to the rocks which rofe above the furface of the water. It likewife appears, that fea-volcano's, as well as thofe upon land, have fubterraneous communications; for, at the very time that the new ifland among the Azores arofe, the fummit of the volcano of St. George, in the ifland of Peak, funk. It alfo merits obfervation, that new iflands never appear but in the neighbourhood of old ones; and that there are no examples of new iflands in open feas: They ought, therefore, to be regarded as continuations of the ancient iflands; and, when volcano's happen to exift in the latter, it is not furprifing that the former fhould contain the fame materials, which may be kindled either by fermentation alone, or by the action of fubterraneous winds.

Befides, new iflands produced by earthquakes, or by fubterraneous fires, are few in number. But the number of thofe formed by flime, fand, and earth, tranfported by rivers, or by the motions of the fea, is almoft infinite. At the mouths of rivers, fuch quantities of earth and fand are amaffed, as frequently give rife to iflands of confiderable extent. The fea, by retiring from certain coafts, leaves uncovered the higheft parts of the bottom, and thefe parts conftitute fo many new iflands. In the fame manner, when the fea encroaches upon the land, it covers

covers the plains, and the more elevated grounds appear in the form of iſlands. It is for this reaſon that there are few iſlands in the open ſeas, and that they are ſo numerous near the coaſts.

Fire and water, though of very oppoſite natures, exhibit many effects ſo ſimilar, that the one may often be miſtaken for the other. Beſide the productions peculiar to theſe elements, as cryſtal, glaſs, &c. they give riſe to many great phænomena, which have ſuch ſtrong reſemblances, that they can hardly be diſtinguiſhed. Water, as we have ſeen, elevates mountains, and forms the greateſt number of iſlands: Some mountains and iſlands likewiſe derive their origin from fire. The ſame obſervation is applicable to caverns, fiſſures, gulfs, &c. Some of them are the effects of fire, and others of water.

Caverns are, in a great meaſure, peculiar to mountains: They are ſeldom or never found in plains. They are frequent in the Archipelago, and other iſlands; becauſe iſlands are generally nothing but the tops of mountains. Caverns, like precipices, are formed by the ſinking or mouldering of rocks, or, like abyſſes, by the action of fire; for, to make a cavern form a precipice or an abyſs, nothing farther is neceſſary than that the tops of the oppoſite rocks ſhould come together and form an arch, which muſt frequently happen when they are looſened at the root, and ſhaken by earthquakes, or by the operation of time and of the weather. Caverns may be produced by the ſame cauſes which give riſe to gulfs, apertures, or ſinkings of the earth; and theſe cauſes are exploſions of volcano's, the action of ſubterraneous vapours, and earthquakes, which create ſuch commotions in the earth, as muſt neceſſarily produce caverns, fiſſures, and hollows of every kind.

The cavern of St. Patrick in Ireland is not ſo conſiderable as it is famous: The ſame remark may be made with regard to the Grotto del Cane in Italy, and to that of Mount Beni-guazeval, in the kingdom of Fez, which throws out fire. There is a very large cavern in the county of Derby in England. It is much larger than the celebrated cavern of Bauman, near the Black Foreſt of Brunſwick. I was informed by the Earl of Morton, a philoſopher more reſpectable for his merit than his high rank, that the entrance to this cavern, called the *Devil's-hole*, is larger than the door of any church; that a ſmall river runs through it; that, after advancing ſome way, the vault of the cavern ſinks down ſo low, that, in order to proceed farther, it is neceſſary to lie flat in a boat, and to be puſhed through this narrow paſſage by people accuſtomed to the buſineſs; and that, after getting through, the roof, or arch of the cavern, riſes to a great height; and, after walking a conſiderable way on the ſide of the river, the arch ſinks again ſo low as to touch the ſurface of the water. Here the cavern terminates. The river, which

which feems to have its fource in this part of the cavern, fwells occafionally, and tranfports heaps of fand, which, by accumulating, forms a kind of blind alley, whofe direction is different from that of the principal cavern.

In Carniola, near Potpechio, there is a large cavern, in which is a pretty confiderable lake. Near Adelfperg, we meet with a cavern in which a man may travel two German miles. It contains feveral tremendous and deep precipices*. The Mendip hills in Somerfetfhire likewife prefent us with extenfive caverns, and very fine grottos. Near thefe caverns we find veins of lead, and fometimes large oak-trees, buried 15 fathoms deep. In the county of Gloucefter, there is a large cavern called *Pen-park-hole*, at the bottom of which we meet with 32 fathoms of water. Here are alfo veins of lead.

It is apparent, that the Devil's-hole, and other caverns, from which large fprings or brooks iffue, have been gradually formed by the operation of the water, and their origin cannot be afcribed to earthquakes or volcano's.

One of the largeft and moft fingular caverns we are acquainted with, is that of Antiparos, of which M. Tournefort has given a complete defcription. We firft find a ruftic cave about 30 feet wide, divided by fome natural pillars. Between two pillars on the right, the ground flopes gently, and then more precipitately for about

* See Acta erud. Lipf. anno 1689, p. 558.

20 paces

20 paces to the bottom of the cavern. This is the paffage to the grotto or interior cave, and is nothing but a dark hole, through which a man cannot pafs without ftooping, and the affiftance of lights. We then defcend, by means of a rope fixed at the entrance, a horrible precipice, and arrive on the borders of another ftill more tremendous, with correfponding abyffes on the left. By a ladder placed on the margin of thefe gulfs, we get over a vaft perpendicular rock. We then continue to flip through places lefs dangerous. But, when we think ourfelves in the greateft fafety, we are fuddenly ftopped by a frightful pafs; to efcape through which, we are obliged to glide on our backs along a large rock, and to defcend by means of a ladder. When we arrive at the bottom of the ladder, we ftumble for fome time among irregular rocks, and then the famous grotto prefents itfelf. This grotto is about 300 fathoms below the furface of the earth, and it appears to be about 40 fathoms high, and 50 wide. It is full of large and beautiful ftalactites, which both depend from the roof of the vault and cover the floor*.

In that part of Greece called Achaia by the ancients, now Livadia, there is a large cavern in a mountain which was formerly famous for the oracles of Trophonius: It is fituated between the Lake of Livadia and the fea, from which, at the neareft part, it is diftant about four miles; and

* See Tournefort's voyage to the Levant.

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there are no lefs than 40 fubterranneous paffages through which the waters run under the mountain*.

In all countries which are fubject to earthquakes or volcano's, caverns are frequent. The ftructure of moft of the iflands of the Archipelago is exceedingly cavernous. The iflands in the Indian Ocean, and particularly the Moluccas, appear to be chiefly fupported upon vaults. The land of the Azores, of the Canaries, of the Cape de Verd iflands, and, in general, of almoft all fmall iflands, is, in many places, hollow and full of caverns; becaufe thefe iflands, as formerly remarked, are only the tops of mountains, which have fuffered great convulfions either from volcano's, or by the action of the waters, of frofts, and of other injuries of the weather. In the Cordelieres, where volcano's and earthquakes are frequent, there are many caverns, precipices, and abyffes.

The famous labyrinth in the ifland of Crete is not the work of nature alone. We are affured by M. Tournefort, that, in many parts of it, the operation of men is evident; and, it is probable, that this is not the only cavern which has been augmented by art. Mines and quarries are conftantly digging; and, after thefe have been long deferted, it is not eafy to determine whether fuch excavations have been the effects of nature or of art. Some quarries are amazingly extenfive.

* See Gordon's Geography, p. 179.

five. That of Maeftricht, for inftance, is fufficient to fhelter 50,000 men, and is fupported by more than 1000 pillars of 20 feet high; and the earth and rock above is 25 fathoms thick*. The falt mines of Poland exhibit excavations ftill more extenfive. Near large cities, quarries and artificial hollows are common. But we muft proceed no farther in detail. Befides, the operations of men, however great, will always make but an inconfiderable figure in the hiftory of nature.

Volcano's and water, which form caverns in the bowels of the earth, produce likewife on its furface fiffures, precipices, and abyffes. At Cajeta in Italy, there is a mountain which had been formerly fplit by an earthquake in fuch a manner, that the feparation feems to have been made by the hands of men. We have already mentioned the *Wheel-track*, or great fiffure in the ifland of Machian, the abyfs of Mount Ararat, the port or gap in the Cordelieres, that of Thermopylæ, &c. To thefe we might add the gap in the mountain of the Troglodites in Arabia, and that of the *Ladders* in Savoy, which was begun by nature, and finifhed by Victor-Amadæus. Confiderable finkings in the earth, the fall of rocks, and the fubverfion of mountains, are frequently produced by the waters, as well as by fubterraneous fires. Of this many examples might be given.

* See Phil. Tranf. Abridg. vol. ii. p. 463.

'In the month of June 1714, a part of the 'mountain of Diableret in Valois fell fudden-'ly, and, in a few hours, the fky being ferene, 'it appeared to have affumed a conical figure. 'It deftroyed 55 houfes, befides feveral men, and 'a great many cattle; and it covered a league 'fquare with its ruins. The fky was darkened 'with the duft: The collection of ftones and 'earth which were amaffed on the plain, exceed-'ed 30 Rhenifh perches in height, dammed up 'the waters, and gave rife to new lakes of con-'fiderable depths. But this phænomenon was 'not accompanied with the leaft veftige of bitu-'men, fulphur, or calcined lime-ftone; nor, con-'fequently, of fubterraneous fire: The bafe of 'this great rock appeared to be rotten, and re-'duced to powder*.'

There is a remarkable example of thefe fink-ings near Folkftone in the county of Kent. The hills in the neighbourhood funk infenfibly, with-out any earthquake or other commotion. The interior parts of thefe hills confift of rocks and chalk; and, by their finking, they have pufhed part of the adjacent land into the fea. A well attefted relation of this fact may be feen in the Philofophical Tranfactions †.

In 1618, the town of Pleurs was buried un-der the rocks at the foot of which it had been fituated. In 1678, a great inundation was oc-

* Hift. de l'Acad. des Sciences, annee 1715, p. 4.
† Abridg. vol. iv. p. 250.

cafioned,

cafioned, in Gafcony, by the finking of fome portions of one of the Pyrennees, which forced out the water that had been pent up in the fub-terraneous caverns of thefe mountains. In the year 1680, a ftill greater inundation was pro-duced in Ireland, by the finking of a mountain into caverns which had been full of water. It is not difficult to inveftigate the caufe of thefe ef-fects. It is well known, that fubterraneous wa-ters are every where frequent. Thefe waters gradually work away fand and earth in their paffages; and, confequently, they may, in the courfe of time, deftroy the ftratum of earth which ferves as a bafis to the mountain: If this ftratum fail more on one fide than on another, the mountain muft, of neceffity, be overturned; or, if the bafe waftes gradually and equally throughout, the mountain will fink, without be-ing overturned.

Having mentioned a few of thofe convulfions and changes produced in the earth by what may be called the accidents of nature, we muft not pafs over in filence the perpendicular fiffures in the different ftrata. Thefe fiffures are obvious, not only in all rocks and quarries, but in clays, and in every fpecies of earth which has never been removed from its natural pofition. They are called perpendicular fiffures; becaufe, like the horizontal ftrata, they are never oblique, but from fome accidental change. Woodward and Ray talk of fiffures, but in a general and confufed

manner,

manner, and they never mention them under the appellation of perpendicular fiffures, becaufe they imagined that they might be indifferently either oblique or perpendicular. No author has hitherto attempted to explain their origin, tho' it is apparent, as remarked in a former article, that they have been occafioned by the drying of the materials which compofe the horizontal ftrata. In whatever manner this drying fhould happen, perpendicular fiffures muft have been a neceffary confequence; for the matter of the horizontal ftrata could not be diminifhed in fize, without fplitting, at different diftances, in a direction perpendicular to the ftrata themfelves. Under perpendicular fiffures, I comprehend, not only the natural cracks in rocks, but all thofe feparations which have been effected by convulfive accidents. When a mafs of rock has fuffered any confiderable motion, the fiffures are fometimes placed obliquely; but it is becaufe the mafs itfelf is oblique; and the fmalleft attention to quarries of marble and lime-ftone, or to great chains of rocks, will convince us, that the general direction of fiffures is perpendicular to the ftrata in which they are found.

The bowels of mountains are chiefly compofed of parallel ftrata of ftones and rocks. Between the parallel ftrata, we often meet with beds of matter fofter than ftone; and the perpendicular fiffures are filled with fand, cryftals, metals, &c. The formation of thefe laft bodies

dies is more recent than that of the horizontal ftrata in which fea-fhells are found. The rains have gradually detached the fand and earth from the tops of mountains, and left the ftones and rocks bare, which afford an opportunity of diftinguifhing with eafe both the parallel ftrata and the perpendicular fiffures. On the other hand, the rains and rivers have fucceffively covered the plains with confiderable quantities of earth, fand, gravel, and other bodies which are either foluble in, or eafily divifible by water. Of thefe have been formed beds of tufa, of foft ftone, of fand, of rounded gravel, and of earth mixed with vegetable fubftances. But thefe beds contain no fea-fhells, or at moft, but fragments of them, which have been detached from the mountains along with the earth and gravel. Thefe recent beds fhould be carefully diftinguifhed from the ancient and original ftrata, in which we almoft univerfally find a greater number of entire fhells placed in their natural fituation.

In examining the internal order and diftribution of the materials of a mountain, compofed of common ftone or calcinable lapidific matter, we generally find, after removing the vegetable foil, a bed of gravel, of the fame nature and colour with the ftones which predominate in the mountain; and, under the gravel, we meet with the folid rock. When the mountain is cut by a deep trench or *ravine*, the different banks or ftrata are eafily diftinguifhable. Each horizontal

tal ſtratum is ſeparated by a kind of joint or ſuture, which is likewiſe horizontal. Theſe ſtrata generally augment in thickneſs, in proportion to their depth or diſtance from the top of the mountain; and they are all divided, vertically, by perpendicular fiſſures. In general, the firſt ſtratum under the gravel, and even the ſecond, are not only thinner than thoſe which form the baſe of the mountain, but ſo much cut by perpendicular fiſſures, that ſmall portions of them only have any coherence. Moſt of theſe fiſſures, which exactly reſemble the cracks in earth that has been dried, gradually diſappear as they deſcend, and, at the baſe of the mountain, where they cut the larger ſtrata in a more regular and more perpendicular manner than thoſe near the ſurface, their number is much ſmaller.

Theſe ſtrata of rock often extend, without interruption, to great diſtances. Stones of the ſame ſpecies likewiſe are almoſt uniformly found in oppoſite mountains, whether they be ſeparated by a narrow neck or a valley; and the ſtrata never entirely diſappear, unleſs when the mountain terminates in a large and level plain. Sometimes we find, between the vegetable ſoil and the gravel, a ſtratum of marl, which communicates its colour, and other qualities, to the neighbouring beds: The perpendicular fiſſures in the inferior rocks are, in this caſe, filled with marl, where it acquires a hardneſs equal, in appearance, to that of the ſurrounding ſtone; but,

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when expoſed to the air, it ſplits, and becomes ſoft and ductile.

The beds of ſtone which compoſe the tops of mountains are generally ſoft and tender, but thoſe near the baſe are exceedingly hard. The firſt is commonly white, and of a grain ſo fine as to be hardly perceptible. In proportion as they deſcend, the rocks become more compact, and have a better grain; and the loweſt beds are not only harder than the ſuperior ones, but are alſo more compact and heavy. Their grain is fine and brilliant; and they are often ſo brittle as to break as purely and neatly as flint.

The heart of a mountain, then, is compoſed of different ſtrata of ſtones, which are harder or ſofter in proportion to their diſtance from the ſummit; and they are broad at the baſe, and ſharp and narrow at the top. The laſt is, indeed, a neceſſary reſult of the firſt: For, as the ſtones grow harder as they deſcend, it is natural to think, that the currents, and other motions of the water, which ſcooped out the valleys, and formed the contours of the mountains, muſt have gradually conſumed, by their lateral friction, the materials of which the mountains are compoſed; and that this conſumption would be proportioned to the hardneſs or ſoftneſs of the matter acted upon. But, as the upper ſtrata are known to be ſofteſt, and as their denſity increaſes according as they approach the baſe, the moun-

tains

tains muft, of neceffity, have affumed their prefent inclined, and fomewhat conical figure. This is one great caufe of the declivity of mountains; and it muft always become more gentle, in proportion as the earth and gravel are brought down by the rain from their fummits. For thefe reafons, the declivity of hills and mountains, compofed of calcinable bodies, is lefs than that of thofe which confift of granite, or of flint in large maffes. The latter generally rife almoft perpendicularly to very great heights; becaufe in thefe maffes of vitrifiable matter, the fuperior, as well as the inferior ftrata, are extremely hard, and have prefented nearly an equal refiftance to the operation of the waters.

Though, in the tops of fome hills which are flat, and pretty extenfive, we find hard ftone immediately under the vegetable foil; yet it fhould be remarked, that, in every example of this kind, what appears to be the fummit of a hill is only a continuation of fome more elevated hill in the neighbourhood, the upper ftrata of which confift of foft, and the inferior ftrata of hard ftone; and the hard ftone found on the top of the firft hill is only a continuation of the under ftrata of the higher hill.

Still, however, on the tops of hills which are not furmounted by higher grounds, the ftone is moftly of a foft and friable nature; and hard ftone cannot be had without digging to a confiderable depth. It is between thefe layers of hard

hard ftone only that marble is to be found; and it is variegated with different colours by metallic fubftances carried down by rain-water, and filtrated through the ftrata: And it is probable that, in every country which furnifhes ftones, marble would be found, if pits were dug to a fufficient depth: *Quoto enim*, fays Pliny, *loco non fuum marmor invenitur?* It is, in fact, a more common ftone than is generally imagined, and differs from other ftones only in the finenefs of its grain, which renders it compact, and fufceptible of a fine and brilliant polifh.

Both the perpendicular fiffures, and the horizontal joints of quarries, are often filled, or encrufted, with concretions, which are fometimes tranfparent, and of regular figures, as cryftals, and fometimes earthy and opaque. Water runs through the perpendicular fiffures, and even penetrates the clofe texture of the ftone itfelf. Stones which are porous imbibe water fo copioufly, that froft fplits them in pieces. The rain-waters, by filtrating through different ftrata, are impregnated with a great variety of fubftances. They firft fink through the perpendicular fiffures; they then penetrate the ftrata of ftone, and depofite in the horizontal joints, as well as in the perpendicular fiffures, fuch matter as they collect in their courfe, and give rife to different concretions, according to the nature of thefe fubftances. For example, when the water filtrates through marl, clay, or foft ftone, the matter

ter which it depofites is nothing but a fine pure marl, and commonly appears in the perpendicular fiffures under the form of a porous, foft, white, light fubftance, known among naturalifts under the name of *Lac Lunæ, or Medulla Saxi.*

When veins of water, charged with ftony matter, run along the horizontal joints of foft ftone or chalk, this matter adheres to the furface of the ftones, and forms a white, fcaly, light, and fpongy cruft, which, from its refemblance to the agaric, has been called *mineral agaric*. But, if the ftrata through which the water penetrates be hard ftone, the filter being clofer, the water it allows to pafs will be impregnated with a ftony matter more pure and homogeneous; and, confequently, the particles being capable of a more compact and intimate union, will form concretions, nearly of equal denfity with the ftone itfelf, and fomewhat tranfparent. In quarries of this kind, the furface of the ftones are encrufted with undulated concretions, which entirely fill up the horizontal joints.

In grottos and cavities of rocks, which may be regarded as the bafins or common fewers of the perpendicular fiffures, the different directions of the veins of water give different forms to the concretions that refult from them. Thefe forms are generally wreathed, or refemble an inverted cone, attached to the roof of the cavern; or, rather, they are white, hollow cylinders, compofed

pofed of concentric coats. The impregnated waters fometimes fall in drops upon the floor of the cavern, and form columns, and a thoufand whimfical figures, to which naturalifts have given the different appellations of *ftalactites, ftelegmites, ofteocollæ*, &c.

Laftly, When the concreting juices iffue immediately from marble, or very hard ftone, the lapidific matter is rather diffolved than fufpended in the water, and it forms a kind of columns with triangular points, which are tranfparent, and confift of oblique coats. This fubftance is diftinguifhed by the name of *fpar* or *fpalt*. It is tranfparent and colourlefs, except when the ftone or marble through which it filtrates contains metallic particles. This fpar is of equal hardnefs with the ftone itfelf, and it diffolves in acids, and calcines with the fame degree of heat. Hence it is evident, that fpar is a true ftone, and perfectly homogeneous. It may even be confidered as a pure and elementary ftone.

Moft naturalifts, however, confider this as a diftinct fubftance, exifting independent of ftone: It is the lapidific or cryftalline juice, which, in their eftimation, not only cements the particles of common ftone, but even thofe of flint. This juice, they allege, daily augments the denfity of ftones by reiterated filtrations, and at laft converts them into flint: When concreted into fpar, it perpetually receives frefh fupplies of ftill purer juice, which increafes both its hardnefs and

and its denfity, till it changes to the confiftence of glafs, then to that of cryftal, and at laft it is converted into genuine diamond.

But, on this fuppofition, Why does the lapidific juice produce ftone in fome provinces only, and nothing but flint in others? It may be faid, that the one province is lefs ancient than the other, and that the juice has not had time fufficient to complete its natural operations. But in this there is not the fhadow of probability. Befides, from whence does this juice proceed? If it gives rife to ftones and flints, from whence does it derive its own origin? It is obvious, that it has no exiftence independent of thofe fubftances which alone can impart to the water that penetrates them, a petrifying quality that uniformly correfponds with their nature and peculiar properties. Thus, when it filtrates through ftone, it produces fpar; when it iffues from flint, it forms cryftal; and there are as many fpecies of this juice as of bodies from which it proceeds. Experience confirms this account of the matter. The waters, which filtrate through quarries of common ftone, form tender and calcinable concretions fimilar to the ftones themfelves. On the other hand, the waters which exude from granite or from flint, produce concretions hard and vitrifiable, and they have all the other properties of flint, as the former had all thofe of ftone. In the fame manner, the waters, which filtrate through mineral and metallic fubftances, give

give rife to pyrites, marcafites, and metallic grains.

It was formerly remarked, that all matter might be divided into the two great claffes of Vitrifiable and Calcinable. Clay and flint, marl and ftone, may be regarded as the two extremes of each clafs, the intervals between which are filled with an almoft infinite variety of mixts, that have always one or other of thefe fubftances for their bafis.

The fubftances belonging to the firft clafs can never acquire the properties of thofe of the latter. Stone, however ancient, will for ever be equally removed from the nature of flint, as clay is from that of marl. No known agent can ever force them from the circle of combinations peculiar to their nature. Places which produce marble and ftone will always continue to do fo, as infallibly as thofe that produce only fandftone, flint, and granite, will never produce limeftone or marble.

If we examine the order and diftribution of the materials of a hill compofed of vitrifiable fubftances, we fhall generally find, under the vegetable foil, a ftratum of clay, which is likewife a vitrifiable fubftance analogous to flint, and which, as already remarked, is only a decompofition of vitrifiable fand; or rather, we fhall find, under the foil, a ftratum of vitrifiable fand. This ftratum of clay or of fand correfponds with the bed of gravel in hills confifting of calcinable

 matters.

matters. Below the ſtratum of clay or of ſand, we meet with ſome beds of free-ſtone, which ſeldom exceed half a foot in thickneſs, and they are divided into ſmall portions by perpendicular fiſſures. Under theſe are ſeveral ſtrata of the ſame matter, and likewiſe beds of vitrifiable ſand. In proportion as we deſcend, the free-ſtone is more denſe, and its thickneſs increaſes. Below theſe, we find what I call *live-rock*, or *flint in large maſſes*, a ſubſtance ſo hard as to reſiſt the file, and all kinds of acids, more powerfully than vitrifiable ſand or powder of glaſs, upon which aquafortis ſeems to have ſome effect. When ſtruck with another hard body, it throws out ſparks of fire, and exhales a penetrating ſulphureous vapour. This flinty ſubſtance is commonly found along with beds of clay, of ſlate, of pit-coal, of vitrifiable ſand; and it correſponds to the ſtrata of hard ſtone and marble, which ſerve as the baſes of hills that conſiſt of calcinable matter.

The waters, in paſſing through the perpendicular fiſſures, and in penetrating the ſtrata of vitrifiable ſand, of free-ſtone, of clay, and of ſlate, are impregnated with the fineſt and moſt homogeneous particles of theſe ſubſtances, and produce various concretions, ſuch as talc, aſbeſtos, and other bodies which owe their exiſtence to diſtillation through vitrifiable matter.

Flint, notwithſtanding its hardneſs and denſity, has, like marble and common ſtone, its exudations,

dations, from which reſult ſtalactites of different ſpecies, varying in tranſparency, colour, and configuration, according to the nature of the flint that produces them, and to the different metallic or heterogeneous particles it contains. Rock-cryſtal, all the precious ſtones, and even the diamond itſelf, may be regarded as ſtalactites of this kind. The flints in ſmall maſſes, the ſtrata or coats of which are generally concentric, are only ſtalactites or paraſitical ſtones from the flints in large maſſes; and moſt of the fine opaque ſtones are nothing but ſpecies of flint. The ſubſtances produced by the vitrifiable claſs of bodies are not, as we have ſeen, ſo various as the concretions formed by thoſe of the calcinable. Moſt of the concretions formed by flint are hard and precious ſtones; but thoſe produced by calcareous ſtones are friable, and of no value.

Perpendicular fiſſures are found in flint-rocks as well as in ſtone. They are even frequently larger in flint, which proves this ſubſtance to be drier than ſtone. Both the hill conſiſting of calcinable, and that compoſed of vitrifiable matter, have clay or vitrifiable ſand for their baſes, which are the moſt commonly diffuſed matters of the globe, and which I regard as the lighteſt, being the ſcoriæ of the vitrified matter that conſtitutes the interior parts of the earth. Thus all mountains as well as plains are founded either on clay or ſand. We have ſeen, for example, in the pits of Amſterdam, and in that of Marly-la-ville, la-ville, that vitrifiable fand was always the deepeft ftratum.

It may be obferved, in moft bare rocks, that the walls of perpendicular fiffures, whether they be narrow or wide, correfpond as exactly with each other as fplit pieces of wood. In the large quarries of Arabia, which confift moftly of granite, the perpendicular fiffures are frequent; and, though fome of them are 20 or 30 yards wide, the fides correfpond exactly, and leave a deep cavity between them*. It is likewife common to find, in perpendicular fiffures, fhells divided into two pieces, each piece remaining attached to the oppofite fides of the fiffure; which proves, that thefe fhells were depofited in the folid ftratum before it was fplit †.

In fome quarries mentioned by Mr. Shaw, the perpendicular fiffures are exceedingly large; and for this reafon, perhaps, they are lefs numerous. In quarries of granite and flint in large maffes, blocks of ftone may be raifed, as the obelifks and columns at Rome, of 60, 80, 100, and 150 feet long, without the leaft interruption. It appears, that thefe vaft blocks have been raifed from the fame quarry, and, like fome fpecies of free-ftone, that they may be had of any given thicknefs. In other fubftances, the perpendicular fiffures are very narrow, as in clay, in marl, and in chalk; and they are wider in

* See Shaw's Travels.

† See Woodward, p. 298.

marble

marble and hard ftone. Some are imperceptible, becaufe they have been filled with a matter nearly fimilar to that of the ftone itfelf; but ftill they interrupt the continuity of the ftones, and are called *hairs* by the workmen. I have often remarked, that thefe hairs in marble and ftone differed from perpendicular fiffures only in the feparation of parts not being complete. Thefe fpecies of fiffures are filled with a tranfparent matter, which is a true fpar. In quarries of free-ftone, the fiffures are numerous, and confiderably large, becaufe rocks of this kind have often a lefs folid bafe than that which fupports marble or lime-ftone, the former generally refting upon a fine fand, and the latter upon clay. In many places, free-ftone is not to be found in large maffes; and in moft quarries, where this ftone is good, the blocks lie irregularly upon one another, in the form of cubes or parallelopipeds, as in the hills of Fountainbleau, which appear, at a diftance, like the ruins of old buildings. This irregular difpofition has been occafioned by the fandy foundation of thefe hills allowing the blocks to fink and tumble upon each other, efpecially where quarries have been formerly wrought, which has given rife to a great variety of fiffures and intervals between the different blocks: And it may be remarked, in all countries abounding with fand and free-ftone, that there are many fragments of rocks and large ftones in the middle of the plains and valleys;

and

and that, on the contrary, in countries abounding with marble and hard ſtone, theſe ſcattered fragments, which have rolled down from the hills, are exceedingly rare. This phænomenon is owing to the different ſolidities of the baſes upon which theſe ſtones are ſupported, and to the extent of the banks of marble or lime-ſtone, which is always more conſiderable than that of free-ſtone.

PROOFS

OF THE

THEORY OF THE EARTH.

ARTICLE XVIII.

Of the Effects of Rains—Of Marſhes, Subterraneous Wood and Waters.

IT has already been remarked, that rains, and the currents of water which they produce, continually detach, from the ſummits and ſides of mountains, earth, gravel, &c. and carry them down to the plains; and that the rivers tranſport part of them to the ſea. The plains, therefore, by freſh accumulations of matter, are perpetually riſing higher; and the mountains, for the ſame reaſon, are conſtantly diminiſhing both in ſize and elevation. Of the ſinking of mountains, Joſeph Blancanus relates ſeveral facts which were publicly known in his time. The ſteeple of the village of Craich, in the county of Derby, was not viſible in 1572, from