

the sea. All these causes produce currents, which often change the direction of the general movement. But, as this motion from east to west is the greatest, most general, and constant, it ought to produce the most signal effects; and upon the whole, the sea must gradually gain ground on the west, and lose it on the east; and although, upon coasts where the west wind blows during the greatest part of the year, as in France and Britain, the sea may gain land on the east, yet these exceptions destroy not the effect of the general cause.

P R O O F S

OF THE

THEORY OF THE EARTH.

ARTICLE XIII.

Of Inequalities in the Bottom of the Sea, and of Currents.

THE coasts of the sea may be divided into three kinds: 1. High coasts composed of hard rocks, commonly perpendicular, and of a considerable elevation, rising sometimes to the height of 700 or 800 feet. 2. Low coasts, of which some are almost level with the surface of the water, and others have a small elevation, and are often bordered with rocks nearly of a level with the water, which give rise to breakers, and render the approach of ships exceedingly dangerous. 3. Downs, or coasts formed by sand, either accumulated by the sea, or brought down and deposited by rivers: these
downs

downs form hills of more or less elevation, according to circumstances.

The coasts of Italy are lined with marble and rocks of different species. These rocks appear at a distance like perpendicular pillars of marble. The coasts of France, from Brest to Bourdeaux, consist almost entirely of rocks on a level with the sea, which occasion breakers. The coasts of England, of Spain, and of many other places, are bordered with rocks and hard stones, except particular spots which are employed as roads and harbours.

The depth of the water along the coast is generally proportioned to their elevation; a high coast indicates a deep water; and, on low coasts, the water is commonly shallow. The inequalities at the bottom of the sea near the coasts likewise correspond with the inequalities in the surface of the ground along the shore. This subject is illustrated in the following manner by a celebrated voyager.

‘ I have made it my general observation, that, where the land is fenced with steep rocks and cliffs against the sea, there the sea is very deep, and seldom affords anchor-ground; and, on the other side, where the land falls away with a declivity into the sea, (although the land be extraordinary high within,) yet there are commonly good soundings, and consequently anchoring; and, as the visible declivity of the land appears near, or at the edge of the water,

‘ whether

‘ whether pretty steep, or more sloping, so we commonly find our anchor-ground to be more or less deep or steep; therefore we come nearer the shore, or anchor farther off, as we see convenient; for there is no coast in the world, that I know, or have heard of, where the land is of a continual height, without some small valleys or declivities, which lie intermixed with the high land. They are the subsiding of valleys or low lands, that make dents in the shore and creeks, small bays and harbours, or little coves, &c. which afford good anchoring, the surface of the earth being there lodged deep under water. Thus we find many good harbours on such coasts, where the land bounds the sea with steep cliffs, by reason of the declivities, or subsiding of the land between these cliffs: But, where the declension from the hills or cliffs is not within land, between hill and hill, but, as on the coast of Chili and Peru, the declivity is toward the main sea, or into it, the coast being perpendicular, or very steep from the neighbouring hills, as in those countries from the Andes, that run along the shore, there is a deep sea, and few or no harbours or creeks. All that coast is too steep for anchoring, and hath the fewest roads fit for ships of any coast I know. The coasts of Galicia, Portugal, Norway, and Newfoundland, &c. are coasts like the Peruvian, and the high islands of the Archipelago; but yet not so

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‘ scanty of good harbours; for, where there are
 ‘ short ridges of land, there are good bays at
 ‘ the extremities of those ridges, where they
 ‘ plunge into the sea; as on the coast of Ca-
 ‘ raccos, &c. The island of Juan Fernandez,
 ‘ and the island of St. Helena, &c. are such high
 ‘ land with deep shore: And, in general, the
 ‘ plunging of any land under water, seems to
 ‘ be in proportion to the rising of its continuous
 ‘ part above water, more or less steep; and it
 ‘ must be a bottom almost level, or very gently
 ‘ declining, that affords good anchoring, ships
 ‘ being soon driven from their moorings on a
 ‘ steep bank; therefore, we never strive to an-
 ‘ chor where we see the land high, and bounding
 ‘ the sea with steep cliffs; and, for this reason,
 ‘ when we came in sight of States-Island, near
 ‘ Terra del Fuego, before we entered into the
 ‘ South-Seas, we did not so much as think of an-
 ‘ choring after we saw what land it was, because
 ‘ of the steep cliffs which appeared against the
 ‘ sea; yet there might be little harbours or coves
 ‘ for shallows, or the like, to anchor in, which
 ‘ we did not see, or search for.

‘ As high steep cliffs bounding on the sea
 ‘ have this ill consequence, that they seldom af-
 ‘ ford anchoring; so they have this benefit, that
 ‘ we can see them far off, and sail close to them,
 ‘ without danger; for which reason we call
 ‘ them bold shores; whereas low land, on the
 ‘ contrary, is seen but a little way, and in many
 ‘ places

‘ places we dare not come near it, for fear of
 ‘ running a-ground before we see it. Besides,
 ‘ there are, in many places, shoals thrown out
 ‘ by the course of great rivers, that from the
 ‘ low land fall into the sea.

‘ This which I have said, that there is usually
 ‘ good anchoring near low lands, may be illus-
 ‘ trated by several instances. Thus, on the
 ‘ south side of the bay of Campeachy, there is
 ‘ mostly low land, and there also is good an-
 ‘ choring all along shore; and, in some places
 ‘ to the eastward of the town of Campeachy,
 ‘ we shall have so many fathom as we are leagues
 ‘ off from land; that is, from 9 or 10 leagues
 ‘ distance, till you come within 4 leagues; and
 ‘ from thence to land it grows but shallower.
 ‘ The bay of Honduras also is low land, and con-
 ‘ tinues mostly so, as we passed along from thence
 ‘ to the coasts of Portobel, and Cartagena, till
 ‘ we came as high as Santa Martha; afterwards
 ‘ the land is low again, till you come towards
 ‘ the coast of Caraccos, which is a high coast
 ‘ and bold shore. The land about Surinam, on
 ‘ the same coast, is low and good anchoring, and
 ‘ that over on the coast of Guiney is such also.
 ‘ And such, too, is the bay of Panama, where
 ‘ the pilot-book orders the pilot always to sound,
 ‘ and not to come within such a deep, be it by
 ‘ night or day. In the same seas, from the high
 ‘ land of Gautimala in Mexico, to California,
 ‘ there is mostly low land and good anchoring.

' In the main of Asia, the coast of China, the bay of Siam and Bengal, and all the coast of Coromandel, and the coast about Malacca, and against it the island of Sumatra, on that side, are mostly low anchoring shores. But, on the west side of Sumatra, the shore is high and bold; so most of the islands lying to the eastward of Sumatra; as the islands Borneo, Celebes, Gilolo, and abundance of islands of less note, lying scattered up and down those seas, are low land, and have good anchoring about them; with many shoals scattered to and fro among them; but the islands lying against the East-Indian Ocean, especially the west sides of them, are high land and steep, particularly the west parts, not only of Sumatra, but also of Java, Timor, &c. Particulars are endless; but, in general, 'tis seldom but high shores and deep waters, and, on the other side, low land and shallow seas are found together*.'

It is, therefore, fully established by the observations of navigators, that there are in the bottom of the sea, considerable mountains, and other inequalities. We are also assured by the testimony of divers, that there are smaller inequalities occasioned by rocks, and that the cold is greatest in the hollows or valleys. In general, as formerly remarked, the depths of open seas augment in proportion to their distance from the coasts. It appears, from M. Buache's chart of that part of the ocean which lies be-

* Dampier's Voyages, vol. i. p. 422, 423, 424, 425.

tween the coasts of Africa and America, and from the draughts he has given us of the sea from Cape Tagrin to Rio-grand, that the bottom of the ocean is as irregular as the surface of the land; that abrolhos, where there are *vigies*, and where some of the rocks are on a level with the water, are only the tops of large and high mountains, of which Dolphin island is one of the most elevated points; that the Cape de Verd islands are likewise the tops of mountains; and that all round these abrolhos and islands, the depth of the sea is unfathomable.

With regard to the qualities of the different soils at the bottom of the sea, little can be said with precision, as all our knowledge is derived from sounding and from divers. We only know, that some places are covered with slime and mud of a considerable thickness, in which anchors can have no hold: It is probable that, in these places, the mud is deposited by rivers. Other parts are covered with sand of different kinds, similar to those upon land. In others are heaps of shells, madrepores, corals, and other productions of insects, just beginning to unite and to assume the form of stones: In others, we find fragments of stones, gravel, and frequently stones and marbles completely formed. In the Maldiva islands, for example, they build their houses with a hard stone raised from some fathoms under water. At Marseilles very good marble is raised from the bottom of the

sea, which, instead of wasting or destroying stones and marble, creates and preserves them: It is the sun, the earth, the air, and the rains, which alone corrupt and destroy these substances.

The bottom of the sea must be composed of the same materials as the surface of the earth, since the very same substances are found on both. At the bottom of some parts of the ocean are vast collections of shells, madrepores, and corals; and we find, upon land, numberless quarries, banks of chalk, and of other substances, mixed with the same shells, madrepores, and corals; so that, in every view, the dry parts of this globe resemble those covered with the waters, both in composition of materials, and in superficial inequalities.

To these inequalities at the bottom, we must ascribe the origin of currents; for, if the bottom were uniform and level, there could be no current but the general motion from east to west, and such as might occasionally be produced by the winds. But what incontestibly proves, that most currents are produced by the tides, and take their direction from inequalities at the bottom, is, that they uniformly follow the tides, and change their course at every ebb and flow*. This fact is confirmed by the testimony

* See Pietro della Valle on the currents in the Gulf of Cambrsia, vol. vi. p. 363.

of

of all navigators, who unanimously affirm, that, in those places where the tides are most impetuous, the currents are likewise most rapid.

Thus it is apparent, that the tides give rise to currents, and that they always follow the direction of the opposite hills or mountains between which they run. Currents produced by winds likewise observe the direction of the eminences concealed under the waters; for they seldom run in the direct path of the winds; neither do those produced by the tides invariably observe the course pointed out by their original cause.

To give a distinct idea of the origin of currents, let it be remarked, that they take place in all seas; that some are rapid, and others slow; that some are of great extent both in length and breadth, and others shorter and narrower; that the same cause by which they are produced, whether it be the winds or the tides, frequently bestows on each a difference both in celerity and direction; that a north wind, for example, which ought to produce a general motion towards the south, gives rise, on the contrary, to a number of separate currents, very different, both in their direction and extent, some running south, others south-east, and others south-west; some are rapid, others slow; some long and broad, and others short and narrow: In a word, their motions are so various and combined, that they lose all resemblance to their

general cause. When a contrary wind blows, every motion is uniformly reverfed; and the course of the different currents is precisely the same as would necessarily take place between two opposite and neighbouring hills upon the surface of the land, were it covered with water. Of this, the Maldiva and Indian islands, where the winds blow and the currents run regularly for six months in opposite directions, afford most striking examples. The same thing has been remarked of currents between shoals and sand-banks. In general, all currents, from whatever cause they proceed, have the same dimensions, and the same direction through their whole course; but they differ greatly from each other in every respect. This uniformity and variety can proceed from no other cause but the inequalities of the hills, mountains, and valleys, at the bottom of the ocean; for, it is an established fact, that the current between two islands follows the direction of the coasts; and the same phenomenon is exhibited between shoals and sand-banks. The hills and mountains in the sea, therefore, may be considered as the banks which contain and direct the currents: Hence a current is a river, the breadth of which is determined by that of the valley through which it runs; its rapidity is proportioned to the force by which it is produced, combined with the breadth of the interval through which it passes; and its direction is marked out by the position

position of the hills and other inequalities between which it shapes its course.

An opportunity is now afforded us of explaining that singular correspondence between the angles of hills and mountains, which is observable in every country of the world. We have already remarked this uniform correspondence of angles in the banks of rivers. The cause of this effect depends on the laws of hydrostatics, and might be easily explained. But it is sufficient for our present purpose, that the fact is general, and universally known; and every man may satisfy himself with his own eyes, that, when the bank of a river projects into the land, to the left, for instance, the opposite bank, on the contrary, makes a projection from the land on the right.

The currents of the ocean, therefore, which ought to be regarded as large rivers, and as subject to the same laws as those on land, must, like them, have formed, through the whole extent of their course, many sinuosities or windings with corresponding angles or projections: And, as the banks of currents are hills and mountains, either above or below the surface of the water, they must have produced on these eminences the same effects as our rivers do upon their banks. Thus, we have no longer any reason to be astonished, that our hills and mountains, which were formerly covered with the sea, and formed by the sediments of its waters,

ters, should have assumed, by the motion of its currents, this regular figure, arising from the correspondence of their opposite angles. They were originally banks of currents, or of sea-rivers, and must necessarily have assumed a figure and direction similar to those of land-rivers.

This alone, independent of the other proofs which we have adduced, is sufficient to show, that all our present continents and islands were formerly covered with the waters of the ocean, and throws much light on the theory which I have been endeavouring to establish. It was not enough to have proved that the internal strata of the earth were formed by sediments of the waters; that the mountains were elevated by successive accumulations of these sediments; or, that many strata were imprinted with shells and other productions of the sea. It was still necessary to investigate and assign the real cause of the correspondence in the angles of mountains, which hitherto had never been attempted, but which, when united with the other proofs, forms a connected chain of evidence in support of my theory, as complete as the nature of physical reasoning will admit.

The most conspicuous currents of the ocean are those in the Atlantic near the coast of Guiney. They extend from Cape Verd to the bay of Fernando. They run from west to east, which

which is contrary to the general motion of the sea; and they are so rapid, that vessels sail in two days from Moura to Rio de Benin, about 150 leagues, but require six or seven weeks to return. It would be impossible to clear these latitudes, were it not by means of the tempestuous winds which suddenly arise in them: But there are sometimes whole seasons in which the mariner is obliged to remain stationary, on account of perpetual calms, the sea having here no motion but what it derives from the currents; and these always run in upon the coasts, from which they extend not above 20 leagues. Near the island of Sumatra, there are rapid currents, which run from south to north, and which have probably given rise to the bay between Malacca and India. We find similar currents between Java and the lands of Magellan, and between the Cape of Good Hope and Madagascar, especially on the African coast from Natal to the Cape. In the Pacific Ocean, upon the coasts of Peru, and the rest of America, the waters move from south to north, which is probably owing to the constant blowing of the south wind. The same motion from south to north has been remarked on the coasts of Brasil, from Cape St. Augustine to the Antilles, and from the mouth of the Manilla Straits to the Philippines and Japan*.

* See Varen, Geogr. p. 140.

There

There are violent currents in the neighbourhood of the Maldiva islands; and between these islands, as already observed, the currents run alternately in opposite directions six months in the year, and are probably occasioned by the trade-winds.

We here enumerate such currents only as are remarkable both for their extent and their rapidity; because the number of lesser currents is almost infinite. The tides, the winds, and every cause that agitates the waters, produce currents, which are more or less perceptible in different places. We have already remarked, that the bottom of the sea is, like the land, intersected with mountains and valleys, shoals and sand-banks. In all the mountainous places, the currents must necessarily be violent; and, where the bottom is smooth and level, they are almost imperceptible; for the rapidity of a current must augment in proportion to the obstacles with which the waters have to encounter. The current between two chains of mountains will be more or less violent in proportion to their distance. The same thing must happen between two banks of sand, or two adjacent islands. It is, accordingly, remarkable, that in the Indian ocean, which is intersected with an innumerable quantity of islands and sand-banks, there are every where currents, which, by their rapidity, render navigation extremely dangerous.

Currents

Currents are not only occasioned by inequalities at the bottom, but a similar effect is produced by the coasts, from which the waters are repelled to greater or less distances. This regorging of the waters may be rendered perpetual and violent by particular circumstances: An oblique position, for example, of a coast, its contiguity to a bay or a great river, a promontory, or any particular obstacle to the general movement of the waters, will always give rise to a current: Now, as nothing is more irregular than the bottom and the coasts of the sea, the number of currents which every where appear ought not to create surprise.

All currents have a determinate breadth, proportioned to the interval between the two eminences which limit them. They run in the same manner as land-rivers; they form a channel, and cut their banks in a regular manner, with corresponding angles: In fine, the currents of the ocean have scooped out our valleys, shaped our mountains, and bestowed upon the land, while it remained under the surface of the waters, the form in which it now appears.

If any doubt should remain concerning the correspondence in the angles of mountains, I appeal to the testimony of every man's observation. Every traveller may remark this correspondence in opposite hills. When a hill makes a projection to the right, the opposite one uniformly recedes to the left. Besides, in opposite hills

hills separated by valleys, there is rarely any difference in their height. The more I observe the contours and elevations of hills, I am the more convinced of the correspondence of their angles, and of their resemblance to the channels and banks of rivers. It was the repeated observation of this surprising regularity and resemblance that first suggested the idea of the theory of the earth which I am now supporting. When to this are added the parallelism of the strata, and the shells so universally incorporated with different materials, no subject of this nature can admit of a greater degree of probability.

P R O O F S

OF THE

THEORY OF THE EARTH.

ARTICLE XIV.

Of Regular Winds.

IN our climates, nothing can appear to be more capricious and irregular than the force and direction of the winds. But there are some countries where this irregularity is not so great, and others where the wind blows constantly in the same direction, and with nearly the same degree of force.

Though the motions of the air depend on many causes; yet there are some more constant and powerful than others. But it is difficult to estimate their precise effects, because these are often modified by secondary causes.

The heat of the sun is the most powerful cause of winds: It produces a considerable and successive