Lib. C. Hayden

GEOLOGICAL ESSAYS;

OR,

An Inquiry

INTO SOME OF THE

GEOLOGICAL PHENOMENA

TO BE FOUND IN

VARIOUS PARTS OF AMERICA, AND ELSEWHERE.

BY HORACE H. HAYDEN, ESQ. M.D.

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Je sais que de nos jours les conjectures, les hypothèses sont proscrites de l'étude de la nature, et qu'on les regarde comme plus propres à retarder la marche de la science qu'à lui faire faire des progrès; et rien n'est plus vrai en général; mais quand ces conjectures sont fondées sur des analogies et sur des rapprochemens de faits, et de grands faits géologiques, je ne pense nullement qu'elles soient inutiles et qu'on doive les proscrire. Elles étendent les vues de l'observateur, et lui font remarquer des rapports qui lui auroient échappé.——*Patrin.*

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1820.

DEDICATION.

TO THE

HONOURABLE THOMAS COOPER, ESQ.

PHILADELPHIA.

SIR,

As the promoter of general science, and as a friend from whom repeated marks of favour and confidence have been received, this imperfect work on the Geological phenomena of this, and some other countries, is, with sentiments of gratitude, respectfully inscribed,

by your much obliged,

and very obed't servant,

H. H. HAYDEN.

Baltimore, October 13*th*, 1820.

PREFACE.

The various hints that have been offered, by different writers, on the Geological phenomena, or certain physical changes, that appear to have taken place in other countries, have long since engaged the attention of the author, and led him to examine some of the geological features of our own country, with a view to their origin, and the probable causes, by which they have been produced.

Among those, the alluvial districts upon the margins of most of the rivers, in the United States, and the great alluvial region, bordering on the Atlantic ocean, appeared the most interesting, and most worthy of a critical examination.

On these subjects, and others, having an intimate relation thereto, a considerable portion of the present work was written; though not with the most distant idea, that it would ever appear before the publick in its present form.

This imperfect sketch, however, was, in 1817, submitted to the perusal of several of his literary friends, among whom was Professor Silliman. It was also *read to Dr. S. L. Mitchell*, of New-York.

From the favourable terms in which it was spoken of, and the friendly encouragement held out, for its publication, he was induced to relinquish the intention of publishing it in detached anonymous sketches; to enlarge and extend the subject by a more circumstantial investigation of facts, and to offer it to the publick in its present shape.

In forming this conclusion, he was not insensible of the obligations, which he has assumed, nor of the essential prerequisites to an undertaking so arduous, and so important in its kind. Among the latter is the particular knowledge, that ought to be obtained of all local facts, that have any bearing or relation to the subject under consideration.

To acquire this, no pains have been spared. As early as the year 1814, he endeavoured to interest and engage the attention, of a number of resident and travelling gentlemen, of science and information, in collecting and communicating such facts, as were calculated to assist in the investigation of this new and interesting subject.

In this, however, he was unsuccessful; since, with the exception of the friendly communications of Professors Cleaveland, and Cooper, not the scrip of a pen has been received in answer to the queries proposed, and which are contained in the Agenda, attached to this work.

Being thus situated, no other alternative was left, but to trust to his own individual observations and exertions, and to the occasional hints and incidental remarks of historians and travellers who have visited, and written upon the different sections of this continent; or to relinquish a subject, vast in its extent, important in its nature, and replete with that peculiar kind of interest, which cannot fail to entertain, if not instruct.

Under such circumstances, and under disadvantages not within the limits of control, has the present work been written.

In presenting it to the publick, he has not the temerity to presume, nor vanity to believe, that it is calculated to please every one; or that it is free from errours. He is sensible of its imperfections, and particularly so, of the want of system, or that kind of order in the arrangement of the materials, which the subject strictly requires. Bnt he trusts that these will be overlooked, when it is considered, that this is *not the voluntary offering* of a candidate for literary fame; nor is it the offspring of a visionary whim, ushered into the world from sinister motives, or to answer pecuniary ends.

The principal and only motive by which he has been actuated, is the wish to interest and invite the attention of Geologists, naturalists, and scientifick men of every denomination, to the great and important physical changes, that appear to have taken place upon and near the surface of the earth, in various parts of the world, and more particularly in our own country; and also to the numerous and interesting facts, that seem to have, not only a direct relation to, but an intimate connexion with those changes; and this with the view of enabling us to form, something like, correct ideas of the causes and operations, by which they were produced; and possibly too, of the *times at which* they took place.

Among the most prominent of these changes, (and which may be considered, as being one of the most interesting features, in the Geology of this country,) is the alluvial region skirting the Atlantic ocean.

It is this which constitutes the principal subject of the present work, and in the examination of which, he has endeavoured to adduce facts sufficiently numerous and strong, to prove that the whole region, with the attendant phenomena, is the result of the operation of currents, that flowed from the north east to the south west; or from the north to the south over the whole continent of America.

Should these facts or proofs, however, be not sufficient, it is to be hoped, that when the subject has received that attention, which it merits, and the numerous remaining proofs, that are scattered over every portion of the continent, are collected and embodied, they will be sufficient, in the hands of some abler pen, to establish the facts upon the immutable principles of truth, and beyond the fear of contradiction.

In the course of this essay on alluvial formations, he has occasionally adverted to circumstances important in themselves, either separate, or as connected with the general subject; and which seemed to require an immediate examination and discussion.

This, however, could not be done, consistently with the plan of the work, as it would unavoidably occasion too many and too frequent digressions, which might be considered as unnecessary interruptions, rendering the whole tedious and uninteresting.

To avoid this, and to give a more ample view of each topick, he has, with slight references, thrown them into distinct chapters, in which each subject is separately examined.

If, in these, he has advanced opinions at variance with those generally inculcated, he is conscious of having done it, not from a spirit of opposition, or a fondness for innovation, but from a disposition to promote the cause of truth, which, from the nature of the principles that he has assumed, and the facts which he has adduced, will admit of no other possible construction.

Should they produce in the mind of the reader a corresponding conviction—should they tend to elicit one ray of light in the cause of science, all the motives will be gratified, and all the purposes answered, that were ever anticipated by the

AUTHOR.

GEOLOGICAL ESSAYS.

CHAPTER I.

The structure of the globe which we inhabit, and the infinitely varied features, either moral or physical, which are presented to human view in almost every district upon its surface, afford a subject for contemplation, that far transcends the feeble capacity of man perfectly to comprehend; much less is he able to delineate, with truth and correctness, the innumerable shades which are characteristick or indicative of some great and important change or operation, which has been wrought upon this stupendous fabrick.

Nevertheless, many have entered, as Geologists, with a becoming zeal, upon the arduous task, and with no inconsiderable degree of success, as well as credit to themselves. They have, regardless of the Mosaic account of the creation of this earth, endeavoured, from various phenomena, to account for its origin, formation, and the successive changes which it has undergone through an immense period of passed ages, upon principles peculiar to their views of the subject.

How far their opinions are correct, it is not the object of this work to determine. Nevertheless, it may not be amiss to observe, (viewing the Huttonian theory as inadmissible,) that however plausible the Neptunian doctrines may appear, and however numerous the facts which not only support the theory, but seem to stamp with the seal of truth the entire system; yet there are facts remaining which constitute insuperable obstacles to the complete establishment of this plan, as correct and unexceptionable. Such are the immense beds or quarries of the muriate of soda; the formation of the native metals, &c. &c. Independently of which there are other circumstances or geological facts, that frequently occur, and which are eagerly embraced in support of the Neptunian theory; but they are in many, if not in most cases, entirely irrelative having but little or no bearing or relation with the actual formation of this globe. They constitute certain geognostic features or characters, that not only favour, but strongly support the Neptunian theory; nevertheless, they are, as I shall endeavour to prove hereafter, almost, if not entirely accidental.

In a geological investigation, whether with a view to the original formation of the globe, or to the great and important changes it has undergone *subsequently* to its original formation, perhaps no country upon its surface affords a more suitable field for scientifick research, or more ample opportunities, and numerous facts from which to form correct ideas on these two points, than the continent of North America.

In its various parts are exhibited all the different formations, that are mentioned by geologists in support of the Neptunian theory: such as primitive transition, secondary, or floetz, &c. At the same time few or no indications occur that can favour in the least possible degree, the Huttonian theory; or, in other words, that any known part within the present limits of the

United States, can owe its origin to the "Intestinal motion" of Patrin, or volcanick agency ;* as not an indication of the kind, I believe, has ever been found east of the Mississippi river.

In tracing up, in their due order, all the different formations, and contemplating the varied features that are presented to view,† we cannot hesitate long in saying, that great and important changes have been wrought, in, and upon its surface, long since the completion of this globe ; consequently they are unconnected, and can have no relation with its original formation.‡

These changes are various ; but by what physical means they have been accomplished, no adequate solution has, as yet, been given. The means may have varied, or have originated from different sources, or may have depended on different causes ; but no one affords so strong grounds for presumption, or, in fact, such positive evidence in its favour, as the idea of a general current having prevailed§ over the whole of this continent, and, perhaps, over every other, by which those changes were produced.

In support of this opinion, this continent affords the most ample testimony, not only of the prevalence of such a current, but that it flowed from the north east to the south west. Among these proofs, I shall first take into view the district, which is, no doubt, strictly called alluvial, and which lies upon the borders of the

* See Chapter 6th. † See Chapter 7th.

‡ See Phillips's outline of Geology, page 70.

§ See Chapter 8th.

Atlantic ocean, extending from the state of Maine, to the bottom of the bay of Mexico.

I am aware that much has been said on the subject of currents, by various authors, and of the supposed results in a variety of instances; but I know of no one that has, in contemplating these results, endeavoured to trace them to their source, or to explain the cause of the currents which produced them. It is a subject which, if properly studied, may lead to a satisfactory solution of these phenomena.

This immense alluvial district forms, by far, the most interesting geological trait, that is presented to view, perhaps, on the continent of North America, on the subject of which there exists a diversity of opinions.

According to Mr. *McClure's* geological chart, it commences at Long Island, and stretching along upon the coast, increases in breadth as we advance towards its southern extremity, and is, in some parts, nearly two hundred miles in breadth.

On this important subject no one has, as yet, that I know of, attempted a correct topographical or geological description. Nevertheless partial accounts have been given by several, and opinions advanced with a view to account for its origin, and, (as is supposed,) gradual increase.

These opinions it becomes necessary for me to notice, before I proceed to offer an explanation of my own, on so interesting a point.

Mr. *La Trobe,* in a communication to the American Philosophical Society, seems to intimate that the alluvial district is produced in part, at least, by the sea; for he observes that "The shore, and the bed of the Atlantic near the shore, consist of fine sand.—The daily action of the flood tide, carries a certain quantity of this sand *above* high water mark, which, being dried by the sun and air, is carried further inland by the winds."

Mr. *La Trobe* in this instance, is only speaking of the "sand hills" at Cape Henry in Virginia; but that he entertains an opinion that nearly the whole was produced in a similar way, we have reason to believe from the following remarks in a note in the same memoir, viz. "I speak only of the coast of Virginia, at Cape Henry; for although I have the *best reason* to believe that the same natural process has produced *all* the *sand banks, islands,* and *sand hills from* the *Delaware* to *Florida,* I have only examined that part of the coast which is the subject of the present memoir."*

While I entertain a high respect for the opinions and talents of Mr. *La Trobe,* I must beg leave to observe, that although "the shore and the bed of the Atlantic near the shore" may consist of fine sand, it is well known that at a little distance, and from that to a great distance from the shore, at least within soundings, the bottom, or bed of the ocean is com-

* Philosophical Transactions, vol. 4, page 439.

posed more or less of green ooze, or mud,* which is inhabited by innumerable little shell-fish. This is the case, I believe with few exceptions, from Boston channel to a great distance to the southward; consequently the sand could not have been derived from that source to have formed *"all the sand banks, sand hills,* &c. from the Delaware to Florida."

Independently of this, there are numerous other places on the Atlantic coast, where the shores are composed of a most beautiful fine white sand, and which is constantly exposed to, and washed by the raging billows of the ocean; yet there has been but little or no alteration in the shores or neighbourhood adjacent, since the discovery of America; or within the memory of the oldest inhabitants living in their vicinity. Such are the shores of Long Island from its east to its south western extremity, and from thence to the Capes of Delaware with few exceptions. Such are also the shores of the main land from Watch Hill, at or near Stonington, Connecticut, to Hurl Gate, with few exceptions. Such is also the Island of Anguilla, and the beach on which the city stands at the bottom of great bay in the Island of St. Martins. These are both immense beds of fine *silicious sand,* constantly exposed to the operations of the trade winds and hurricanes, yet no visible change is produced in their extent, or general features, except that violent winds sometimes, *from local causes,* act with more

* See Chapter 9.

force on some parts than on others ; hence the sand is raised in clouds, carried, and deposited in a part not far distant; but which, from a similar cause, will, in a few weeks perhaps, be taken up and brought back again; thus shifting from place to place.

There are numerous places in the world, where similar circumstances occur; in many of which during the prevalence of high winds, the inhabitants are threatened with destruction. Such is the case at Norfolk, in latitude 55° N. where "the small cottages are sometimes totally buried under sand during high winds."*

In the sixth volume of the transactions of the Irish Academy, an account is given of the encroachment of sand over some parts of Ireland. Trees, houses, and even villages have been covered or surrounded during the last century. The roofs still rising above the waste attest the period and progress of desolation.

Mr. *Bakewell*, in his introduction to Geology, observes, "The loose sands of Lybia are spreading over the plains that border the Nile, and burying the monuments of art and the remembrances of former cultivation. From a similar cause the country immediately round Palmyra, that once supplied a crowded population with food, now scarcely affords a few withered plants to the camel of the wandering Arab."†

Linnæus says, "The Dutch are obliged to sow the sea mat-weed, or marran, (which will only grow on

* Stillingfleet's Tracts, page 75.

† See Bakewell, page 254.

pure sand,) to prevent the neighbouring parts from being overwhelmed by sand."*

So that although material changes have taken place, and are constantly taking place, and the buildings at, or about Cape Henry, are threatened with being buried with sand, and also the forests, yet it does not follow that this change or increase is produced by the sea. On the contrary, a circumstance of which Mr. *La Trobe* takes notice in the same memoir, inclines one to believe that, although a material change is going on in the neighbourhood of the light house at Cape Henry, neither this increase or accumulation of sand, nor any part of the alluvial formation, either depended on, or was occasioned by the sea; for Mr. *La Trobe* says, the swamps, or desert, to the northward and westward of the light house are overgrown with aquatick trees, &c. such as the gum, the cypress, the red maple, (acer rubrum) the sycamore, (or plantanus occidentalis) and also, "That the swamp, with its trees, extended to the sea coast perhaps *within* a *century*, is very evident from this circumstance: between the summit of the sand hills, and the sea shore, and more especially on the Chesapeake *side*, the undecayed, though *mostly dead* bodies of trees still appear in great numbers. Being on the windward side of the sand hills they have not been more than *half* buried."

Now, if the islands, sand banks, and sand hills, on the Atlantic coast, have been formed by sand washed

* See Linn. flor. Lapp. page 62.

up by the sea; or if such a change, as is exhibited at Cape Henry, could have been effected within a century, it will appear obvious to every thinking mind, that there must have been a total suspension of this cause, or of its operations, for nearly a century before; and from the following circumstances.

The trees which he mentions, are mostly slow in their growth, particularly the cypress and the gum, (L. Styraciflua); if the increase or extension of the alluvial formation or district, depends on the cause which Mr. *La Trobe* has assigned, and this increase has been as great as is alleged; these trees, and this forest could never have been brought into existence; for as fast as the trees had sprouted from the ground, they would have been buried by the sand thrown up by the unceasing agitation of the sea, and operations of the winds.

Nay more, if the trees had obtained half their present growth or height, before any inroads of the sand had been made on them, the result would have been nearly the same; for as the sand gradually climbed "up their trunks," their verdant foliage would have withered and died; and such is the case by Mr. *La Trobe's* own account; for he says, "By gradual accumulation the hill climbs up their trunks, they wither slowly, and before they are *entirely* buried, they die. Most of them lose all their branches, and nothing but the trunk remains to be covered with sand; but some of the cypress retains life to the last."

These circumstances afford ample proof that the time has been, when those trees had sufficient time to shoot up undisturbed; to grow to maturity without having experienced any material check in their progress, which, in all probability, must have occupied a space of more than a hundred, and, perhaps, two hundred years.

We must therefore look to some other source for the cause of this change at the capes of Virginia. Doubtless the erection of the light house and the keeper's dwelling, have been the principal local causes of so great and sudden an accumulation of sand, as is mentioned by Mr. *La Trobe,* who says, "That the sand hills have risen since the establishment of the light (which at that time was sixteen years) about twenty feet in height."

Now had this increase been general on the coast of Virginia, and continued from the christian æra, it would now exhibit a mountain on the borders of the ocean no less than two thousand two hundred and twenty feet high.

Mr. *Beaujour,* I find, in his Sketches of the United States (page 45) has advanced a similar opinion to that of Mr. *La Trobe,* on this subject.

Mr. *Stoddard* seems to have entertained a similar opinion relative to the alluvial formation or soil, on the coast of New Spain; for, in speaking of the Delta of the Mississippi, he observes; "The eastern part of New Spain, along the gulf, exhibits abundant proofs of similar advances, owing perhaps to the *constant ac-*

cumulation of *sand* by the *trade winds, which* is *driven* to *the shore* by the *perpetual* motion of the waves in that direction."

But why he should have resorted to two causes for the formation of these alluvial districts, I am unable to determine; but such is the case; for he observes, "Nothing is more certain than that the Delta has risen out of the sea, or *rather,* that it has been formed by alluvious substances, precipitated by the waters from the upper regions."*

From the latter of these two opinions, we might readily conclude what were his sentiments on that subject; but we are soon left in doubt again, by the following passage: "All the country about the gulf is evidently alluvial." This is doubtless the case; but how was it produced? This we are left to conclude from the following: "At what time it was *redeemed from the sea,* no one can conjecture; but as some of the oldest inhabitants can remember when the sands were less dry, much oftener flooded, and to a much greater extent and height than at present, perhaps its redemption is much nearer to our time than many are willing to admit." (Page 183.)

The word "redeemed" in the above sentence, seems to convey but an indefinite idea on the subject; for it has but a very superficial relation with alluvial formations. It seems to convey the idea that the alluvial district, so called, was once lost, perhaps by inroads

* Sketches of Louisiana, page 158—9.

of the sea, and again restored; or, that this extent of country has been recovered by man, from the sea, by artificial dikes, or mounds. This is by no means the case; for wherever alluvial formations exist, it is in consequence of direct inroads on the ancient limits of the ocean, rivers, &c.

Fortunately, however, Mr. *Stoddard* has in the following page, removed that degree of obscurity, with which the subject seemed to be veiled, and enabled us to understand what, in reality, is his opinion on this point, by the following. "No doubt the elevated islands scattered along the coast and already, in most instances, connected with the main land by marshes, were, not long ago, situated at *some distance* in the sea. These projections are caused by the *deposition* of the *sediment from* the *rivers, particularly* from the Mississippi. The Gulf of Mexico, though of great extent, is filled with shoals and sand banks, especially near the land, which render the navigation dangerous; and the *materials* of which they *are composed* have been *rolled* from the *sources* of the *great rivers*."*

It is a prevalent opinion with many, that the entire alluvial district has been formed, in the course of time, by the alluvial deposites from the rivers that discharge themselves into the sea. Others are of opinion that it is a part of the great whole, but of more recent formation than the primitive or secondary rocks.

That considerable quantities of matter are daily formed and deposited at the mouths of rivers, is with-

* Sketches of Louisiana, page 184.

out doubt correct; and that it is to this increase of alluvion, that we must attribute the inroads, which have been made upon the ancient limits of the ocean, in several instances on our Atlantic shores. But although we are informed of material changes having in the course of time taken place, yet no one has attempted to account for the immense extent of alluvial formation, where there are no rivers of any consequence, that could have contributed much in this great and extensive operation. Neither has any one, that I know of, attempted to assign any plausible reason for the *great difference* in the extent of the alluvial formation at the mouths of several of the great rivers in America, which discharge themselves into the Atlantic Ocean.

These two circumstances are of such importance in the present view, that it would be inexcusable to pass them over without notice.

In the first place, I shall take into consideration the five principal rivers to the northward of the Delaware, viz: the river of St. Johns, the Penobscot, he Kennebeck, the Connecticut, and the Hudson. The longest of these five rivers, viz: the Connecticut, is from two hundred and eighty, to three hundred miles; and the shortest, viz: the Kennebeck, is one hundred and forty.

Now agreeable to Mr. *McClure's* geological chart, there is no alluvial district appertaining to, at least, four of these rivers; (though I shall endeavour, by and by, to prove that there is some alluvial soil at their mouths,) and although the mouth of the Hudson is embraced in the alluvial district, it has not in fact but barely three miles of alluvial soil on the New-York side,* by which it passes; and the Connecticut river has about the same. How much the others, viz: the St. John's, which flows into the bay of Funda, the Kenne-

* I have mentioned three miles of alluvial formation on the New-York side, as it has generally been supposed, and in fact represented that the site on which New-York stands, is strictly of an alluvial formation; for in a geological description of York Island, by Dr. *Akerly*, (see Bruce's Mineralogical Journal, page 193,) it is said that "*the primary part is all the island, except that over which the city is built.*"

From the opportunities which I have had of examining York Island, I am unable to reconcile this opinion to my present views of the subject. That the ground, on which the city is built, and the hills that have been dug away, were alluvial is unquestionable: the rolled pebbles of various kinds, and boulders of granite and other kinds of rocks that have been found deposited there in the earth, are demonstrative of the fact. But it does not follow from these premises that the south part of New-York county, or the southern extremity of York Island, is to be considered as being a part of, or within an alluvial district. The same facts and appearances may be seen, in numerous instances, on the granite ridge, so called, not only within the limits of the primitive district, but *upon the ridges*, and those too in particular on the most southern borders of the primitive range. Such I am inclined to believe is, (with due deference to those who have advanced a contrary opinion,) the real foundation on which New-York stands; and that too from the following circumstances.

It is well known that the strata of gneiss are exposed to view, on the surface at the battery, at the present time, and running, apparently, in a direction nearly parallel with the Hudson river, which leads to the conclusion that this ridge or mass of rocks, is a spur of the granite ridge, and that it underlays the whole city.

beck and Penobscot have, I am unable to say with any degree of certainty; but it may be presumed that they have, at least, some. But the river Thames, on which New London stands, cannot, I believe, claim one rod of alluvial soil at its influx, at least on the eastern side.

It may be alleged, that those rivers embrace in their course so small a portion of country, that it cannot be expected that so great an extent of alluvial formation should be formed at their mouths.

In reply to this, the Connecticut river receives, principally, the auxiliary streams, from a superficies of about eighty miles in breadth, by two hundred and eighty in length; or 22,400 square miles; while the

That it is not a mere clump of rocks out of place is certain; for about twenty years ago, this ridge or spur was exposed to view, and daily washed by the waves of the Hudson river, at the north west corner of the battery. Not only so, but that its breadth extends across to the ancient or primitive shore of the east river is certain; for I am informed that when Messrs. *Penfield* and *Watson* began to erect their houses, near the battery, in 1791 or 2, they came upon a fine spring of water, which, though long buried, was recollected by the then old inhabitants, to have been many years anterior to that time, a copious spring and excellent water; notwithstanding its being, at that time, on, or very near the shore of the East river. In clearing out this spring and sinking a well, with a view to secure a supply of good and wholesome water, they were under the necessity of blasting several feet through solid granite or gneiss. Besides which, the same rocks appear in place again, I believe, at Corlear's hook, on the east side of the city. All of which circumstances justify the conclusion, that the southern extremity of York Island, though covered with alluvial grounds, is strictly primitive, and consequently within the primitive district.

Delaware river cannot claim two thirds of this quantity; and yet *it passes through an alluvial district, one hundred and forty miles.*

This disproportion is so great, that no person can suppose, for a moment that the alluvion brought down by the rivers, had *any* agency in forming the district in question.

But lest I should be considered as having been too limited in my view, I will extend it farther.

From the Chesapeake bay to East Florida, or Cape Sable, there are eight considerable rivers, exclusive of a number of lesser streams, (viz.) the Roanoke, the Pamtico, the Neus, the Cape Fear, the Pedee, the Santee, the Savannah, the Oconee, and Oakmulge; each of which is from 180 to 200 miles in length; the most of them take their rise in the primitive range of country; and after running the above distance in an almost south east course, they disembogue their waters into the Atlantic.

Now the alluvial district at the confluence of each of those streams is from 100 to 180 and even 200 miles in breadth; while the Connecticut and other rivers to the northward, pass through a much greater extent of country, and yet have but two or three miles of alluvial district.

To the southward of East Florida, there are two principal rivers, the Appalachicola, and the Alabama. These likewise, take their rise in the primitive district, and after running in a south westerly course, from 240 to 290 miles, discharge their waters into the sea. At each of these points the alluvial district is more than

200 miles in breadth ; while, as before, the Hudson and Connecticut rivers have but about three miles of alluvial formation at their embrochures.

But a more complete illustration of the subject, and a more positive proof, that the rivers of America have had but little or no agency in producing the alluvial district, is afforded by an examination of the two principal rivers in North America, (viz.) the Mississippi and the river St. Lawrence.

The first of these is supposed to run a distance of nearly three thousand miles through the country from north to south, and at the confluence of which the alluvial district is about 200 miles in width, that is, below, or south of the primitive range of country on the Atlantic coast. While the river St. Lawrence may be said to pass through a distance of country, almost equal to that of the Mississippi, including Lakes Ontario, Erie, Huron, Superior, and Michigan, (and *Herriot* says they are one river,) and yet there is not three miles of alluvial formation at its influx into the gulf of St. Lawrence. Or, if any exceptions can be made to taking into the calculation the great lakes, we will include only lake Ontario, as forming unquestionably a part of the St. Lawrence. Its extent would then be about one third that of the Mississippi, or 1000 miles ; consequently, we ought to have an alluvial formation at its mouth, equal in breadth to eighty miles ; whereas, there is not, it is believed, any visible formation of an alluvious kind.

It is the opinion of some, that the increase and extent of alluvial formations or deposites, depends more or less on the extent which a river or stream passes through a secondary, or transition district; inasmuch as the substances which compose these two districts are more liable to decomposition,* consequently liable to be carried away, by the meltings of snows and heavy rains, into the smaller streams, and from thence into rivers, and deposited at their mouths. But this will not hold good,

The Connecticut river, and I believe some others in the eastern states, runs through both; particularly the secondary formation, for a considerable distance, and yet there is but a very small extent of alluvial formation at its mouth.

The same may be said of the Susquehanna and Potomac rivers, each of which runs through both primitive and transition formation; yet it is a matter of doubt, if we judge from appearances, whether there is one foot more of alluvial formation at their influx into the Chesapeake bay, than there was a thousand years ago.

An other opinion is, that alluvial formations are, in some cases, occasioned by the retreat of the ocean, which, it is believed by many, is constantly retreating, and of course becoming less.

Henry, (in his Travels in Canada,) says in his remarks on the subsidence of the waters in that region,

* See Chapter 10th.

"every where the waters appear to have subsided from its ancient levels; and imagination may anticipate an era at which, *even the banks of Newfoundland will be left bare.*" It seems too, that Lucan entertained a similar belief with respect to the Syrtes in the Mediterranean, for he says,

> "Perhaps, in distant ages, t'will be found,
> When future suns have run their burning round,
> These Syrtes shall all be dry and solid ground:
> Small are the depths their scanty waves retain,
> And earth grows daily on the yielding main."—
>
> *Row's Lucan.*

Mr. *Clinton* in his excellent introductory lecture to the literary and philosophical society, (New-York,) adds two other kinds of alluvial formation, (viz.) one occasioned by "the subsidence or extinction of lakes," another, from "the overflowing, retreat, and change of rivers."

It is a circumstance much to be regretted, that in almost all our researches into the operations of nature, our views of a subject are too frequently arrested, and our opinions too often swayed by some seemingly important detail or feature, which presents itself to view, and which may be either accidental, or adventitious. Such, it appears to me, must have been the case with all those who have endeavored to prove that the sea is constantly retreating, and will ultimately become extinct; the plain and only inference that can be drawn from the writings of several on this subject: among whom are *Celcius*, *Playfair*, and particularly Mr. *Jameson*, who says, "That the water of the ocean has diminished and is still diminishing, can scarcely be doubted."*

This opinion, in all probability, must have been regulated by some obvious local change, which has taken place; or some inroads that have been made by terra firma, upon the ancient limits of the ocean, within the knowledge of man; and no country or place on the face of this globe, affords stronger grounds for presumption, or in fact a more positive proof in favour of such an opinion, than the alluvial district which lies along upon, and constitutes the present shores of the Atlantic ocean for nearly the entire extent of the United States.

But as strong as they are, or however formidable and rapid may have been the strides of the alluvial formation upon old Neptune's wide domains, it by no means constitutes a proof of the *actual* retreat of the sea; and I much doubt whether a case in point, really exists on the face of the globe, that is calculated to prove that there is one square mile less of superficies on the face of the ocean, than there has been at any time subsequent to the subsidence of the general deluge. On the contrary, I am inclined to believe, that no decree ever promulgated to man, through the medium of Holy Writ, has been more generally executed or fulfilled; nor any command, which that

* Notes to Cuvier's theory, page 214, American edit.

Sacred Volume contains, has been more implicitly obeyed than that which says of the limits of the ocean, "hitherto shalt thou come and no farther,"* or in other words, thou *shalt* come here and no farther, and here shall thy proud waves be stayed.

But, lest my opinion should be considered as not only groundless, but opposed to numerous circumstances which tend directly to prove a contrary opinion; I shall take a superficial view of the subject, and offer a few remarks in support of my assertions.

It will readily be admitted that considerable advances have been made, by alluvial formations, in various parts of the world, on the ancient limits of the ocean; at the same time, it will not be denied, that considerable inroads have been made on the land in different parts of the world, by the raging or overflowing of the sea. Many places have suddenly, or gradually disappeared from above the surface of the ocean, and many have as suddenly, or as gradually, risen above the surface. Numerous cases of this kind could be enumerated if it were necessary; however, a few facts, it is presumed, will suffice in the present case.

The alluvial district on the Atlantic coast of America, is, perhaps, as large as that which skirts the margin of any country in the known world; the reasons of which will be hereafter assigned.

* Job Chap. 38, verse 11th.—Chap. 26, verse 10th.—Jeremiah 5, 22d.

It may be thought that no instance has occurred, where a corresponding quantity of land has disappeared. It must be recollected that it is a very prevalent opinion (though by no means settled) that the whole Carribean sea was once occupied by dry land, and, together with all its islands, attached to the continent.

Whether this be true or not, certain it is that some parts have sunk or disappeared since the memory of man: such for instance as Port Royal in Jamaica.

A similar opinion is likewise entertained of the Canary Islands. *Humboldt*, I believe, considers that they are, or once were decidedly a part of the continent of Africa.

But considering these two cases as wanting confirmation; there are others which cannot be denied, and particularly in the Mediterranean. Mr. *Pocock*, who travelled into Egypt in 1737, observes, that the Mediterranean has in all probability, gained quite as much ground as it has lost.

"Nothing more is necessary," he says, "to produce conviction of this, than to examine the coast; for you will see, under water, not only a variety of artificial productions manufactured in the rock; but likewise the ruins of many edifices. About two miles from Alexandria are to be seen under water the ruins of an ancient temple."*

* Travels into Egypt, vol. I. pages 4 & 30.

The Abbe Fortis entertained a belief that the sea was not only gaining upon the land, but that its level is becoming more and more elevated, for he observes, "Proofs are also daily discovered, that its level actually rises,"* and in proof of its advances he further says, "In like manner some islands, and large pieces of the continent, about Grado, have, within these few ages, been covered by the sea, which every day advances and threatens fresh mischief; thus also the sea gained ground near Malamores, and covered a large tract of inhabited land, the ruins of which may still be seen under water in a calm: thus also the ancient city of Corea, opposite Rimini, is covered by the waves, and more than a mile from land; and thus also the suburbs of Pola in Istria are submerged, and along the shore, at low water the Mosaic pavements are discovered, as well as at Sipar not far from Parano, several palms under water."†

We are also informed by an anonymous English traveller, in his Journal of a Voyage, in which he describes several very ancient cities of the Archipelago; and in which he thus speaks of Delos. "We found nothing else, all along the coast, but the ruins of superb edifices which had never been completed, and the ruins of others which have been destroyed. The sea appears to have gained on the Isle of Delos, and the water being clear, and the weather calm, we had an opportunity of observing the remains of beautiful

* Abbe Fortis' Travels in Dalmatia, page 17. † Do. p. 464.

buildings, in places where now the *fishes swim* at their ease, and on which the small boats, of these countries, row to get at the coast."

It is pretty generally known and believed that the whole gulf of Tripoli has been formed by the sinking or disappearance of all that part or portion of the coast of Africa comprehended between Tripoli, or cape Bon near Tunis and cape Ras-Sern near Derna; and that too, long since the records of time have been substantially authenticated. "This opinion is supported," says *Ali Bey*, "by the great banks of Kerkena which are considered as the remains of a country submerged."*

Mr. *Shaw*, in describing the ancient city of Shershell and its port, says that the present inhabitants "have a tradition of the whole city being destroyed by an earthquake; and that the port, formerly very large and commodious, was reduced to the miserable condition it is in at present, from the arsenal and other adjacent buildings which were thrown into it by the shock." "The Cothon" he observes, "that had a communication with the western port, is the best proof of this tradition; for, when *the sea* is calm and low (as it frequently happens after strong S. E. winds) we then discover, all over the area, so many massy pillars and pieces of great walls, that it cannot well be conceived how they should come there without some such violent concussion."†

* Ali Bey's Travels. † See Shaw's Travels, page 39.

Numerous cases of a similar kind could easily be cited if necessary. But admitting that the sea has gained upon the land in some instances, and that the land on the contrary has gained upon the sea in others; it does not, by any means, prove that there is an actual but gradual diminution of the waters of the ocean.* If such were the case, we should, every year have numerous islands appearing above the surface of the water in almost every part of the ocean; that is to say, in the vicinity of islands and continents. Not only so, but we should have, every succeeding year, innumerable reefs, or hidden rocks and quick sands to encounter, at the risque of the lives of millions of our fellow creatures, and ultimately, the almost total occlusion of a friendly intercourse between the nations of the earth, as well as almost a complete annihilation of commerce upon the bosom of its waters.

But this is not the case; Heaven, in its unerring foresight, has decreed it otherwise; and the surface of the sea, doubtless, retains the same elevation, and extent of superficies that it did, at least five thousand years ago. Of this, we have the most unquestionable evidence that can be required; and that in almost every part of the world. The shores and coast of America afford sufficient data to calculate upon, without having a recurrence to foreign countries.

* To this opinion, De Luc seems to be decidedly opposed, and says "Proofs are every where found that such a change is chimerical."

There are a great number of rocks, whose points, or heads at complete low water, just shew themselves above its surface, and have been well known in that situation for more than one hundred years past, and without the smallest visible alteration in their appearance, at that particular state of the tides.

The Lattimer rock, lying about midway in the Rhode Island passage, through Long Island Sound, affords a striking instance of this kind. This rock has been well known for more than one hundred years. Its head or apex, at a certain state of the tide, appears just above the water near the middle of the passage between Fisher's Island, and Watch Hill, on the Stonington side, (Connecticut.)

Now, it is doubtful whether the Nilometer affords a better standard to judge of the increase and decrease of the river Nile, than the above rock does, of the actual increase, or decrease of the ocean on the coast of America.

I could enumerate several others, equally as well, if not better known, and no less suitable objects by which to regulate our opinions on the subject. Among these are the Hogsback, and several others, at, and near Hurl Gate at the western extremity of Long Island Sound.

Now although no visible difference is perceptible in these rocks, as to their positions, and appearances for more than a hundred years, it may be said that they have not been sufficiently long known and observed, to enable us to determine a point of so great importance.

Admitting this to be the case, if we refer to countries, well known in history from the most remote periods of time, in search of objects on which to fix our attention, we are sure of a successful result; for the shores of Europe, Asia, and Africa afford the most abundant proofs that the sea still rolls its proud waves to the extent of its ancient limits, which it could not do, if it has been and is constantly decreasing.

"Upon the western banks of the Tafna, *almost contiguous* to the sea, are the ruins of the ancient Siga, once the royal city of the Numidian kings."*

Its present name is Tackum-breet, the Tebecritum probably, of Leo.

Of the ancient city of Sher-shell, Mr. *Shaw* says, "Nothing certainly, could have been better contrived for strength and beauty than the ancient situation of this place. A strong wall forty feet high supported with buttresses, and winding itself near two miles through the several creeks of the *sea shore, hath secured it from all encroachments of the sea.*"†

Cape Blanco (in Africa) the Promontorium Candidum of Pliny, and probably the Promontorium Pulchrum of Livy, where Scipio made his descent on his first African expedition, is, according to Mr. *Shaw*, the same in situation and appearance, as it respects the sea, that it was in the days of Scipio.‡

* Shaw's Travels page 19. † Do. page 39. ‡ Do. page 142.

Of the port of Hippo on the coast of Barbary, he says, "There are *still remaining* the *traces* of a *large pier* that was carried out a *long way into the sea* to break off the N. E. winds, the want whereof, together with the great aversion the Turks have to repairs, will, in a short time, demolish a haven that in any other country would be inestimable."*

Of Fort St. Louis, the Baron *De Tott* says "I shall likewise observe, for the natural philosopher, that Fort St. Louis, *built at the point of the projection of land* which formerly was the island where he disembarked, *is still washed by the waters of the sea.*"†

The ancient Utica was a maritime city situated between Carthage and the promontory of Apollo. This city, which is now seven miles from the sea, together with that of Carthage, which is about the same distance from it, are considered by some as unequivocal proofs of the gradual receding of the sea.

The following will show how little foundation there is for such a belief, or how little support is to be derived from this source.

"Neither, (says Mr. *Shaw*) hath Carthage, the next place to be described, much better supported itself against the north east winds and the Me-jerdah; which, together, have stopped up its ancient harbour and made it almost as far distant from the sea as

* Shaw's Travels, page 145.

† Baron De Tott, vol. II. part 2, page 91.—The time of the landing of St. Louis, in Egypt, was about the year 1240 or 43.

Utica." This it must be recollected, lies between the cape called Castra-Cornelia and the peninsula on which Carthage stood.

"Upon the other side of the peninsula towards the south east, *Carthage has been a looser to the sea;* for in that direction near *three furlongs in length,* and *half a furlong,* or more, *in breadth lyeth under water.* In rowing along the sea shore," (where Carthage stood,) "*the common sewers discover themselves in several places,* which, being well built and cemented at first, time hath not in the least injured or impaired."*

In Maundrel's Journey from Alleppo to Jerusalem, in the year 1669, he observes, "In the Adriatic Gulf, the light house of Arminium, or Rimini, is a league from the sea; but *Ancona,* built by the Syracusians, is STILL *close to the shore.* The arch of Trajan, which rendered its port more commodious for merchants, is situated *immediately upon it.* Barritta, the favourite spot of Augustus, who gave it the name of Julius Felix, preserves no remains of its ancient beauty, except its *situation* on the BRINK of the sea, *above which* it is *elevated no higher* than is necessary to secure it against the *inundations* of that element."

Ali Bey, in speaking of the Mediterranean sea, observes, "It is to be remarked that the ancient Paphos, situated upon the sea shore, is a monument of

* Shaw's Travels, pages 150 and 151.

the *stationary condition* of the Mediterranean sea, which, *during so many ages, has not sunk a single inch* from its general level."*

As a further confirmation of this fact, the rocks of Scylla and Carybdis, are still a dread to the toilsome mariner, while, at a distance, he listens, through the sleepless night-watch, in painful anxiety, to their awful roarings.

Most of the sea ports, that were frequented in ancient days, remain still the same, or at least without any visible alteration, and are still the resort of their numerous ships; such are Malta, Rhodes, Marseilles, and many places well known for ages past.†

* See Ali Bey's Travels, vol. page 33.

† See Cuvier's Theory, page 53, American edition.

CHAPTER II.

I HAVE been thus particular, in order to prove that the sea is not likely soon to be dried up; and that alluvial formations are not produced by the sea.

I shall, in the next place, pass over that kind of alluvial formation, which is said to occasion the extinction of lakes, but which I shall notice hereafter, and endeavour to prove, that the alluvion of rivers, with some few exceptions, is by no means so common, and so extensive as is generally imagined;* or if there be a visible increase of alluvial districts in some *few instances*, it is too small and limited to afford any support to those, who maintain that alluvial districts in general, are formed by rivers.

The alluvion that is formed by rivers may be said to depend, both in its quantity and extent, on three material circumstances.

1st. On the extent of country through which the rivers pass.—2d. On the nature of the soil, of which the country is composed.—And 3d. on the rapidity with which the current flows in those rivers.

* See Chapter 11th.

This alluvial formation thus produced, will be of two kinds; the first diffused, and the second circumscribed, or limited. The first depends on the uninterrupted flow of the current of any river into a lake, bay, or sea. The second depends on the obstruction or check, which the current of a river may experience, (and which may be saturated with alluvious matter,) by the tide flowing in direct opposition to such current.

As both these kinds occur, I shall take notice of each, in order to avoid any suspicion of having been partial in my view of the subject.

The river Thames, (or by some called Norwich river,) in Connecticut, is formed by two principal branches, the largest of which takes its rise near the Massachusetts line. In their courses, they receive a great many auxiliary streams, all running through a country generally cultivated; consequently much broken up, and liable to be carried away by rains and the melting of snows; yet no visible increase of alluvial formation is produced by this river, particularly, as has been observed, on the east side, at its confluence with Long Island Sound.

In this latitude and longitude, the flood tide sets in so strong, and rises so high, that the moment in which it overpowers the current of the river so as to check its descent, that moment the sand and gross silicious matter, which is kept afloat by the *current only*, is deposited at the bottom, or in part wafted back by the tide as far as it sets up. Hence, the principal cause of the bar in that river, which obstructs the navigation above

New-London, and on which the Macedonian, United States and Hornet were obliged to unload to get over, when the British lay before that place in 1814.

But this is not all that constitutes the alluvion, which is brought down by rivers. It consists principally of two kinds of substances; the one silicious or sand, and predominant; the other alluminous, which is light and is long held suspended in water, and, where there is a current, carried a great way before it is deposited; and this very substance I shall make use of, in part, to prove my position.

As soon as the current of the river, checked by a counter current, the tide, has deposited its sand and silicious matter, it there forms the principal bar in the river; immediately below which, the water deepens, and the bottom alternates, and is almost entirely alluminous, or composed of a blue and intensely tough clay, of which all New London harbour is composed, and which renders it the surest and safest anchoring ground on the Atlantic coast. Not only so, but the principal part of Long Island Sound, on the north shore, is nearly the same; and which is, doubtless, a consequence of the lightness of the alluminous matter, which is held long suspended in water, and so widely diffused before it is deposited. Hence it is, that no visible alteration is, or can be produced, in those latitudes, and under those circumstances, even for ages.

The same particulars attend the Connecticut river, fifteen miles to the westward of the Thames; with this difference, however, that the latter discharges its waters into a deep bay, at the bottom of which New London stands.

The waters of the Connecticut river, after passing through a great extent of country, are discharged almost immediately into Long Island Sound; the current of which, for nearly three quarters of the ebb and flood tide, being very strong, crosses the mouth of the river almost at right angles.

At, or very near the confluence of this river, where its current is checked by that of the tide in the Sound, the principal bar, which obstructs its navigation, is formed across its mouth, and is well known by the name of Say-Brook bar.

This bar, as well as the bed of the river, for a great distance above, is composed of a fine silicious sand; and at ebb tide, there is not, perhaps, more than six feet of water in the channel. Whereas *immediately below* it, we have from two and a half to three fathoms, with a bottom composed of a *tough* blue clay.

Here is no appearance of alluvial formation occasioned by the river. The banks on each side are, nevertheless, alluvial, as I have before observed, for about two and a half or three miles above its influx; but these are far above the surface of the water at flood tide, perhaps twenty or thirty feet, and, in fact, were never known, I believe, to have been overflowed; not only so, but the banks on the western shore and the land adjacent, were, about thirty or forty years since, covered with lofty trees quite to the seashore, or that of the sound; many of which must have required one hundred years or more to perfect their growth. The northern shores of the sound, were, at that time, covered with huge trees to the very margin of the beach, which could not have been, if the alluvion increases in the ratio that is pretended by some.

At the mouth of the Hudson river, or rather at, and near, the ship channel at Sandy Hook, sand banks and bars abound; but they are in part, I presume, formed by sands raised by the winds, from Long Island and the Jersey shore, and carried into the water; and also, by the current of the East river and those on the Jersey side.

The principal part of the alluvial matter brought into the Hudson river, comes from the country above the highlands, and is principally deposited where the current is *first* checked by the tides, which is some way above the highlands; as near as I can recollect, the principal bar in that river is above Kinderhook; and above that are numerous sand bars; no river alluvion has, I believe, accumulated at its mouth. The rocks at the battery doubtless appear the same at ebb tide, above the water, (that part excepted which has been covered by made ground,) that they did when Hudson visited it in 1609.

The same remarks will, almost, apply to the Delaware river, with the exception of the banks which lie in the channel between New-Castle, and the capes; and even in this instance, the number, size, and extent of the several banks, or spits, correspond with the number, size, and extent of the rivers, which flow into the Delaware river, from the Jersey and Delaware shores.

The relative situation of those banks to the rivers, seems to show that they were gradually deposited there, by the currents being opposed by the tides; and that as soon as the currents of the rivers resumed their wonted course, uninterrupted, these banks were modified in this form, by the almost reciprocal action of the current of some of those rivers which flow into the Delaware river almost opposite to each other, and nearly at right angles. Hence it is, that instead of running obliquely or across the river, or being diffused, they are *long* and narrow, and, in some cases, ranged parallel to each other, as many as three or four in number.

The next in course, and most important in every point of view, is the Chesapeake bay. If there was no other case to which we could refer to regulate our opinions, as to the truth of the proposition under consideration, this alone would be amply sufficient. An immense bay, one of the largest in the known world, extending from the sea nearly, or quite, two hundred and seventy miles into the country, and every superficial inch of which is bounded by an alluvial soil, or banks of alluvial formation.

Into this great reservoir, are poured the waters of about forty rivers and creeks; five of which are of the largest class, and take their rise in the primitive range of country.

From a moderate calculation, this bay receives the waters that are collected from a superficies of about sixty thousand square miles.

To pretend to enter into an examination of the probable changes produced in this bay, by alluvion brought down and deposited in its bed by those numerous rivers and smaller streams, would be extremely tedious, uninteresting, and unnecessary; since a reference to, at least, two of its principal streams, (viz.) the Susquehanna and Potomac rivers, will be quite sufficient to determine the probable result from the whole; and without entering into a minute examination of these two great rivers, it may suffice to say, that there is no material difference between them and the Connecticut, Hudson, and Delaware rivers.

The currents of each and all of them are checked by the reflux of the tides. Whenever that takes place, the silicious matter, suspended by the currents, is at once deposited. Hence, the sand banks and sand bars at the mouths of rivers; but the alluminous matter which is brought down, and which predominates in the soil, generally, of the state of Maryland, is held much longer suspended, and is, doubtless, very generally diffused over the borders of the Chesapeake bay.

There are but few or no indications of alluvious deposites or formations; no islands of recent formation. If there is some appearence of the land having encroached on the bay; there are others where the waters of the bay have gained on the land.

As a proof of this, where there is an appearance of made ground, there is not the shadow of a shrub on its surface. Where there are indications of the water having tresspassed on the ancient limits of the shores, (which is mostly in consequence of severe and long continued storms or gales of wind,) the banks, which are high above the water and often covered with aged oaks, whose boughs have hung leafless over its surface for at least a hundred winters, are broken and washed down by the force of the surf, and those trees are laid prostrate on the beach.

The Mississippi river is perhaps, an exception in this case; having, no doubt, occasioned a considerable extent of alluvial formation at, and near, its influx into the gulf of Mexico; but it appers by no means difficult to explain the cause of this difference.

This river, and its tributary streams, not only flow through an almost immeasurable extent of superficies, and the water thereby collected, causing such a pressure as to bear every thing before it, but its current is propelled with such rapidity, that the tide, which in this latitude flows but little,* has not the power to

* Mr. Stoddard says "The tides have but little effect on the water at New-Orleans; they sometimes cause it to swell, but *never to slacken its current.*"—Sketches of Louisiana, page 164.

This conclusion must appear obvious to every one, who may feel disposed to consider the influence of the tides, in this great bay, the average height of which scarcely exceeds that of eighteen inches. Mr. Stoddard says "The difference between the *highest and lowest stages of water in the Balize* is about three feet."—Ibid.

check its current, but in a moderate degree. Hence it is, that almost every thing that is suspended in its waters, is hurried down its stream into the gulf of Mexico.

But although this river has extended its limits a considerable way into the gulf of Mexico, yet I am not inclined, by any means, to admit that it has been the principal cause of the alluvial district from above, and below New-Orleans, to its mouth.

If the Mississippi river has been the cause of the alluvial formation through which it runs, as is believed by some, to what source shall we look for the cause of nearly the same extent of alluvial district, between it and East Florida? Or, between East Florida and Cape Hatteras? Or in fact, that which lies each side of the Chesapeake bay; every inch of which is surrounded by an alluvial district? Not certainly, to successive layers of alluvion, brought down by those rivers, and deposited over its entire surface; for it will be admitted on all hands, that the alluvial district on the Atlantic coast has not, in all probability, been overflowed, either by the sea, or rivers, since the subsidence of the general deluge.*

* Baron de Tott in speaking of the Delta of the Nile, observes, "It is proper to observe, that the Delta, more elevated than the rest of Egypt, is bounded towards the sea by a forest of Palm trees, called the forest of Beleros, the land of which is much higher than the *highest* rising of the waters; and this topographical remark is sufficient to destroy the system of the formation of the Delta by a sediment. A country, which is higher than the greatest inundadations, can never owe to them its origin."—Vol. II. part 2, p. 32.

The most then, that the Mississippi river ought to claim, is that which extends beyond a line drawn from lake Borgne, across to the bottom of Atchafalaya bay, which line will correspond very nearly with the line of coast from East Florida, to a great distance west of the Mississippi river.

Whether this be the case or not, we *must* look to some other source for the cause of the formation of this immense district which lies on our Atlantic coast.

Viewing the subject in all its bearings, there is no circumstance that affords so strong an evidence of the cause of its formation, as that of its having been deposited by a *general current,* which, at some unknown period, flowed impetuously across the whole continent of America; and that from north east to south west.

With this in view, I shall, in the next place, proceed to examine the subject, and endeavour to substantiate the fact: should I fail in the attempt, I flatter myself that it will not be through a deficiency in the force of evidence, but of the amount at issue.

Admitting that such a current may have existed, it will be necessary to inquire, what, in all probability, was the character and extent of its operations? That would no doubt depend on the extent, gravity, velocity, and duration of this current.

In regard to its extent, I believe I shall make it appear that it was general over the whole surface of, at least, this continent. Of its operations, although they are strikingly obvious, I shall endeavour to point them out more clearly than they appear at present, to every one.

Of its gravity and velocity, we must judge by its effects. Of its cause and duration, it is impossible to determine.

I shall assume the position that the course of this current, was not only influenced by, but, in fact, depended on that of the general current of the Atlantic ocean. That from some unknown cause, its waters rose, not merely above the common height of flood-tide, but to that degree, that it overran its ancient limits, and spread desolation on its adjacent shores.

The same fruitful source, from whence proceeded the probable cause of the Atlantic ocean rising at first, above its ordinary height, continued to yield its inexhaustible supplies, until this current, knowing no bounds, swept lawlessly over the desolated land.

In proportion to the increase of the waters of the Atlantic, (for I speak only of it at present,) and the consequent rise, so must have been the acceleration and force of its current; and in proportion to the velocity or rapidity of this current, so must have been its ravages and its general destruction wherever it may have prevailed, whether over the extended plains, or beneath the mountains lofty heights.

The consequence was, that the earth or soil, susceptible of the operations of this current, was hurled from its bed, wafted beyond the shores of the continent, and deposited in the ocean all along the coast. And *in proportion to the extent of soil or land over, which* *this current prevailed, so will be the precise extent, or breadth of the alluvial district;* except in some few unimportant cases, where, from local causes, some difference may appear.

I will now see how far this opinion is supported by facts. From the entrance into the straits of Bell-Isle, by the way of the gulf of St. Lawrence, across to Sandwich bay, is but a small distance; even from the mouth of the river St. Lawrence, or St. John's river, which discharges itself into the St. Lawrence, across the country to Orange bay or harbour, on the coast of Labrador, and over which this current must have passed, is but about two hundred and eighty or three hundred miles, and that rocky in the extreme. The result is what might be expected; there is but little or no alluvial soil, except on the margins of some rivers, which I shall have occasion to notice hereafter.

As we advance further to the southward, we find the country, across which this current is prevailing, gradually increasing in breadth; that is from the coast of Labrador through the New England states; and we likewise see a corresponding increase of alluvial formation; but which, however, is so small as not to have been noted in Mr. *McClure's* geological chart, until we come to Long Island, extending from the meridian of New London to the mouth of the Hudson river, in a north east and south west direction.

It may be said that a great disproportion exists between the distance across the continent, from the coast of Labrador to the mouth of the Connecticut river, and the alluvial district opposite to it; and the distance from Sandwich bay, across to the mouth of the straits of Bell-Isle and the alluvial district opposite to it; and more particularly so, between the distance of the latter, and that from the coast of Labrador and Trenton, in New-Jersey, and the alluvial district through which the Delaware river runs at that meridian. This is admitted, but let us see if this difficulty cannot be obviated in such a way, as will tend to strengthen and support my opinion, rather than militate against it.

It must be observed, in this case, that the current of the Atlantic ocean, in its due course, would pass through the straits of Bell-Isle, the gulf of St. Lawrence, and the bay of Funda, in a line nearly parallel to that part of the coast of America; consequently, much alluvial formation could not be expected, except on the margin of the rivers. But a still more important circumstance is yet to be considered. As soon as the waters of the Atlantic ocean had risen to such a height as to sweep its current, (which it must be remembered was in a south west direction,) across the eastern part of this continent, the full force of its operations was acting in direct opposition to the current of the river St. Lawrence. Hence, meeting with an insurmountable check in its course, and the waters of Lakes Erie and Ontario, urging on their accumulated forces in their usual channel, it occasioned a reflux upon Ontario and lake Champlain. The consequence was, that their natural boundaries were no longer capable of retaining the increasing tide; it overwhelmed the neighbouring country, and poured forth its waters in torrents into the Connecticut and Hudson rivers, bearing away, by its irresistible force, every moveable substance.*

From hence, and the increasing influx of the Atlantic, propelled by a corresponding current into the gulf of Mexico, we may attribute the increase in breadth of the alluvial district, from Long Island to the capes of Delaware, and perhaps further.

Before I proceed to a more general view of the continent of America, with the intention of pointing out the operations of a general current which once flowed over its surface; or in search of facts to prove the probable existence of such a current; I shall enter into a partial examination of a few circumstances or features, which present themselves in several parts of the district of country which I have mentioned, both as to their locality and extent; and afterwards to apply them as, at least, strong presumptive evidence of the existence of such a current at some remote period of time.

* With persons who have read the additions to Cuvier's Theory of the earth, by Dr. S. L. Mitchell, of New-York, it may be supposed that this hint, together with those which relate to the formation of alluvial districts at the mouths of rivers, was derived from that work: of which see pages 335—345—383—393, and particularly 395.

In justice to myself, it becomes necessary to observe, that having been free to communicate my opinions to him on this subject, long before the publication of that work, (see the preface,) there is reason to hope, from the known liberality of that gentleman, that he will, if required, shield me from the imputation of having *borrowed* either of those sentiments from that work.

Among these, is that of rolled or water worn pebbles of different kinds; and also that of the wave like, or undulating appearence of almost every section of alluvial formation, whether perpendicular to the surface, or inclined, shewing the operations of a current from the north east.

The subject of rolled pebbles is, when viewed in its full extent, one of the most interesting geological facts, that is, or can be presented to the human view; for they not only give us an idea of the formation of mineral substances in general, being composed of almost every species of rock; but they speak, in a language that cannot be misunderstood, and tell us of some of the physical changes which this continent, and perhaps every other, has undergone; and of the nature and extent of those changes. They tell us, in the most emphatick terms, that they were, by a resistless current, torn from their primitive beds, and hurled in irresistible confusion to where they now remain.

These unequivocal proofs of universal desolation, are interspersed upon the borders of almost every river in the known world, which has its source in, or passes through any distance of primitive, transition, or secondary formation of rocks.

It is alleged by some, that water worn or rolled pebbles are, in general, brought down by the currents of rivers, and streams of running water.

If this be true, it would tend very much to prove, that they were not washed up by the ocean, and left by its gradual retreat; an opinion as absurd, as it is inconsistent and unphilosophical.

It will be admitted that the beds of rivers are sometimes paved, in a manner, for a considerable distance with rolled pebbles: that they are sometimes amassed in very considerable quantities on the very margins of the rivers, between high and low water mark; but this is by no means calculated to solve the following question.

By what physical means, were those immense quantities of rolled pebbles amassed together, or thrown up into hills that are from one hundred to two hundred feet above the surface of the river, in the neighbourhood of which they lie, and which are sometimes spread over many square leagues of country, over which, the current of *no one river upon earth has ever flowed?* It is both morally and physically impossible that such results could, by any means, be produced by any river flowing through the district of country where they lie.

Nothing short of a universal current could have produced such effects; and it must have been of such extent and rapidity, as to have hurled them into motion with almost as much facility, as the leaves of trees are raised into the air by a whirlwind.

That such a current *did once prevail*, they remain as an unequivocal testimony; and also of its operations. That it flowed from the north east, to the south west, is evident from the following circumstances.

The rivers, if they may be so called, in the neighbourhood of Baltimore, run mostly in a direction from north to south, with some unimportant deviations. In almost every instance where the rolled pebbles abound, they are in much the greatest quantities on the west, or south west side of the river or creek.

Another circumstance of a singular nature, and worthy of particular attention is, that wherever an auxiliary stream falls into the river or creek, on the east side, and meanders through a valley for a considerable distance above, and in a north east direction, (for the small streams fall into the principal ones at an angle of about forty-five degrees,) we observe, on the opposite or west side, and in a south west direction from the mouth of the valley and brook, a considerable elevation of ground or hills, and composed, almost entirely, of rolled pebbles and sand; while on the east side there are but few, in comparison, and sometimes none; if there are any, they are much the most abundant on the margin, or bank of the valley on the south side.

There are even valleys on the east side of Jones's Falls, running for some distance up into the country in a north east direction, and in which no water flows of any consequence, except after a great rain; and in the hills on the south side of the valley, there is an abundance of pebbles; at the same time, but very few are to be found in the hills on the north side of the valley.—All of which circumstances tend to point out, in a very obvious manner, the operations of a powerful south west current.*

This opinion receives additional support from another circumstance.—The hills on the margin of Jones's

* In support of this opinion, an interesting fact has recently occurred, and which, in this case, is of too much importance to be omitted.

In the opening and extension of Belvidere-street, in this city, (Baltimore,) it became necessary to cut through a hill, on the west side of Jones's Falls, to the depth of twelve or fifteen feet. This hill is on the very margin of, and constitutes, at that point, the southern border of the granite ridge.

Its greatest height above Jones's Falls, which is at the foot of it on the east, is about sixty feet; and is composed of gneiss, in which black horn-blend forms a constituent part.

In cutting through the hill the workmen came upon the summit of the ridge of rocks, at the depth of nearly ten feet below the surface. This it was necessary, in order to follow the grade of the street, to cut away to the depth of about five feet.

The section or bank on the west side of the street (its course being north and south) presents the following appearances.

From the point of the ridge, as exhibited in the bank, to the north, and in the direction of the dip of the rocks, the slope of the ridge or rocks, for some distance is gradual.—At the point of the ridge on the south side, is a sudden pitch, from the shelving or overhanging of the rocks. From this point to the extremity of the section to the south, which is about sixty paces, the bank is filled with rolled pebbles; and immediately at the pitch of the rocks they appear as having been thrown down by cart loads.

From a strict examination of the whole section, it appears as if the pebbles were driven over the surface or northern slope of the hill by a powerful current until they had arrived at this sudden pitch, when they were let fall or precipitated to the bottom. In

Falls, and Gwinn's-Falls, and upon the west side, contain, it is true, rolled pebbles of almost all sizes, from that of a pea to that of five or six pounds weight; and they abound, a mile or a mile and a half to the west of

support of this opinion, there are but very few pebbles in the northern part of the section, and those small.—Moreover there are other appearances in this section of the hill which (setting all conjectures aside) amount to proofs positive that the pebbles were brought and deposited there by a powerful current from the north.

Among the pebbles in the bank, on the south side of the ridge, I have counted upwards of thirty masses of granite, micacious schist, and green stein. Now well defined granite does not occur within one mile to the north of where these masses now lie; and the green stein range does not occur to the north within three miles. To the south of the ridge, neither granite nor green stein were ever known to exist in place; for from the bank in which these masses now lie, to the capes of Virginia, every foot of land is alluvial.—Therefore the fair conclusion is that they must have been brought and deposited there by a powerful current from the north; for in no direction to the south do the same kind of rocks exist within the distance of five and perhaps six hundred leagues.

As the appearances in the above described bank, or section of the hill, are liable to changes by the operations of rains, or by digging and levelling for the purposes of building, and which may hereafter render the statement doubtful, they have been examined by two respectable gentlemen who will substantiate the facts, as described.

Similar facts, I believe, are observable from one extremity of the granite ridge to the other, or from New-York to Georgia. I have observed them in numerous instances in the alluvial region, and south of the granite ridge, and particularly in the city of Washington. At a little distance north of the United States Branch Bank in that city, is a circumscribed spot of about one acre of those streams; sometimes more: but as we *recede from* those streams, in a south west or west direction, the pebbles *invariably* grow smaller, so that at the distance of three and four miles west of the streams and particularly Gwinn's-Falls, they are not bigger, in *general*, than filberts or walnuts, and from that down to a bird shot, showing that the stream or current had the power of conveying the small pebbles a great distance; while the larger ones were deposited, soon after they were raised from the bottom of those rivers where, during preceding ages, they had been mostly formed, on or near the margin of those streams.

It may be a question with some; from whence came these pebbles? This seems to be, by no means, a difficult matter to solve.—These streams have their

ground, covered with masses of rocks and rolled stones of various sizes, mostly of a quartzose kind, or in other words of granular quartz. Among these, I discovered in February (1820) rolled masses of Amygdaloid, and of hornblend porphyry, containing epidote, both peculiar to the Blue Ridge or South Mountains in Maryland and Pennsylvania, and which cannot be found in any place, perhaps, within sixty miles of Washington city. Moreover, among these rocks were some of a granular quartz, that would weigh, probably, from two to five hundred weight, containing perfect impressions of shells resembling the Terrebratulite. This kind of rock, with like impressions, is not, I am credibly informed, to be found in any place, in a northern direction, short of Herkimer county state of New-York; or far beyond the North Mountains in Pennsylvania. From the place at which they now lie, (which is alluvial, and three quarters of a mile from the Potomac river,) to the Atlantic ocean *which* is about two hundred miles, every inch of country is of an alluvial formation.

source either in the primitive or transition range, and, in every instance run through the former or granitick ridge; so that there could have been no want of materials to form water worn pebbles.

The same may be observed on the west side of the Susquehannah river below the granite ridge. What the appearances are above, I am unable to say.

The same I believe is the case with the Delaware river.—How it is on the west side of the Hudson river, at Bergen, and the other places in its vicinity, I cannot recollect; but the alluvial formation on which New-York stands, is filled with rolled pebbles; while but few are to be found on the Long Island side opposite or in any part of the northern shore of that island.—I believe that the principal part of the streets in New-York, are paved with the stones that were dug out of the hills, in and near the city, in levelling them down.

These stones were, doubtless, first brought down by the current of the east river; or at least were formed on and above the granite ridge; and were subsequently, by the north east current, which I have mentioned, raised from the bottom of the river, and deposited with the alluvian on its western shore, above, and where New-York stands.—This is from four, to five or six miles, south of where the stones were probably formed; and which distance, corresponds with that of a number of other places; which inclines me to believe that the rolled pebbles *in the alluvial* districts of this country, lie, in general, from three to five miles, and sometimes more from their original gangue or locality; and that always in a south west direction from it.

I shall in the next place take notice of the Connecticut river. The falls over which this river runs, for the distance of from fifty to sixty miles above its influx into the sea or sound, are, I believe, principally composed of a fine grained ferruginous sand stone; and for the distance of four miles below what is called the foot of the falls of the Connecticut river, the margin of the western bank and bed of the river is covered with water worn pebbles of the same kind, as the rocks which compose the falls above; while for the same distance on the opposite or eastern shore, there is scarcely a stone to be found, until at the distance of five miles below the falls, a small river discharges itself into the Connecticut river on the east side. This small stream, called Scantic, has its source in a primitive range, called the East Mountains, in contradistinction to a like range on the western side of the Connecticut river, and flows for several miles over a rocky and stony bed, before it enters the alluvial district, which is from four to five miles wide at this place. Its general course is south westerly, until within one mile of its confluence, where its course is almost due west, inclining northerly, and enters the Connecticut river nearly at right angles.

The margin of the Connecticut river below the Scantic river, for some distance from the water, and also its bed, are covered with water worn pebbles or stones; at the same time, not a stone is to be found in the bank of the Scantic river, nor at its mouth on the north side, except such as have been brought or thrown there from the south shore; neither is there any on the opposite shore of the Connecticut river.

It may be observed here, that where a current is of sufficient force to move the pebbles on the bed of a river or creek, so as to carry them down the stream to its mouth, and discharge them into a larger stream or river, it would be very natural at least, to expect to find them below the mouth of the auxiliary stream, and not above it.

This is undoubtedly correct; but, in the present instance, I have remarked that the Scantic river enters the Connecticut river nearly at right angles; consequently, when the current of this river was sufficient to carry the pebbles down the stream, they would be thrown into the Connecticut river, at some distance, and that corresponding with the angle which the Scantic river makes with the Connecticut river, inclining, however, a little down the stream of the latter.

In this case, an abundance of pebbles would be found at the mouth of the Scantic: but it is not so. It is perhaps three hundred yards distant below its mouth, before the pebbles on the beach commence; and they continue to cover the shore for half or three quarters of a mile below; having the appearence of being raised from the bed of the Scantic, and carried obliquely or diagonally across in a south west direction, and deposited in a bank, that is perfectly alluvial, on the margin of the Connecticut river, because checked there by the powerful current of that river which sets almost due south.

That these pebbles were brought from near the primitive range of mountains to the east, is probable from this circumstance. I have often, when a boy, gathered the carburet of iron or black lead, in rolled masses, among the stones, on this beach.

It may be said in reply to these remarks, that they are natural results, and could not otherwise be expected; that where a river runs any distance through a stony country, and even passes some distance through an alluvial soil, the water worn pebbles will in time, be carried down the stream, and be deposited at or near the river's mouth.

Let us now see whether this opinion is correct. The Windsor river so called, (an auxiliary stream that falls into the Connecticut river,) is composed of two branches, one of which takes its rise in a primitive range in the county of Litchfield, (Conn.) the other in the same range in Massachusetts. The first of these runs in an easterly direction until it arrives at the foot of the mountain near Farmington, (Conn.) where it takes a northerly course, until it joins the second branch called Salmon brook, which comes from the northward; when suddenly turning at right angles, it passes in one stream, through the mountain: from thence it takes a south easterly direction, and discharges itself into the Connecticut river on the *west side* (as may be seen by the map of Connecticut) *about two miles below the mouth of the Scantic river.* From the passage of the Windsor river through the mountains, to the distance of between four and five miles, it runs over almost one continued bed of rocks; and during a time of freshet or high water, the current flows with the rapidity of a sluice. From thence to the Connecticut river, it flows through a district of alluvial formation.

From the foot of the falls (so called) to the distance of two miles below, the bed of the river is, in many places, covered with water worn pebbles, which have been, in the course of time, hurled down its stream *thus far only.*

From thence to its discharge into the Connecticut river, about two miles, scarcely a pebble is to be found, big or little, neither on its bed, in its banks, *nor at, or below its mouth:* and what is still more worthy of remark is, that from some distance above the foot of the falls, to where the pebbles cease to cover the bed of the river, the hills on the *south west side* of the river (its course being south east) are, in many places, filled with water worn pebbles; while on the *northeast side* from its passage through the mountains to its confluence with the Connecticut river, scarcely any pebbles are to be seen; a circumstance that cannot fail to excite the attention of an observer.

Such, in part, are the results of my own observations on the subject of rolled, or water worn pebbles.

Let us now, for a moment, inquire into the probable cause of so powerful, and so general a current; and since nothing short of, at least, a partial deluge, could have overflown the country to the extent which is necessary to produce the effects which I have mentioned, we must look to a partial or general deluge, as *absolutely necessary* in the first place.

Of such we have no authentick account, excepting that which happened in the days of Noah. Nevertheless, there is much reason to believe that it is not the only time in which this earth has been totally or partially inundated. Mr. *Cuvier* seems to entertain a belief that this globe has been thrice deluged, at different periods of time. However that may be, we have strong indications in this country, of there having been at least two deluges, over the whole continent, and which, perhaps, I shall take notice of hereafter.

Since it is not the object of this work to ascertain the number and periods, at which these events took place; I shall proceed to inquire into the manner in which an occurrence of such moment, was probably accomplished, and what influence it had in causing a general current, sweeping across the whole continent of America, from the north east to the south west, in preference to any other course, or point of the compass.

To this end, I shall examine the plain text as related in the 7th chapter of the book of Genesis, verse seventh: "For yet seven days, and I will cause it *to rain upon* the earth forty days and forty nights, and *every living substance that I have made, will I destroy from off* the *face* of *the earth*."

It is generally admitted, by almost all who believe in the universal deluge or Noatic-flood, that it was caused by incessant torrents of rain for the above mentioned space of forty days and forty nights. Such is the language of Josephus; "The Almighty, at the appointed time caused torrents of water to fall upon the earth, in such rapid and ceaseless succession for the space of forty days, &c."

Let us suppose this to have been the fact, and that it was likewise universal. If this is admitted, which is by no means improbable, it affords but little or no grounds for a belief that a general current could have been a consequence.

The gradual or rapid increase of the waters must have depended on the quantity which fell into the bosom of the ocean, and that also which fell on the face of the different countries distributed over the globe. This being, we will suppose, equal, or nearly so, could have no tendency to cause a current in the former.

With respect to the latter, the case must have been widely different, for a certain space of time; for in proportion to the height, inequalities, and rapid or gradual descent of any district or country, towards the sea, and to the quantities of water which fell upon the face of such country, so must have been the increase and rapidity of the currents which flowed over its surface, into its rivers, and thence into the sea; and such no doubt they were, on this occasion, that *all nature stood appalled* at the momentous scene; while bursting torrents rushed impetuously from the mountain's brow, and hurled destruction in their mad career.

But even these could not have had any influence in producing a general current in the ocean; for in proportion to its rise, the rivers, over the face of all countries, falling into the sea in every possible direction, and mingling in the parent mass, would be checked in their course, and ultimately subdued, as the waters of the sea inundated the land, in the same manner as a flood tide of the ocean, checks the current of a river or rivers.

But admitting that the rain fell in torrents for forty days and forty nights "in ceaseless succession," it is not only, very much a matter of doubt whether it could have had any influence in causing a general current, but whether, in fact, the general deluge could have been caused from this circumstance alone; for it is said that *after* the *forty days* the *flood was upon the earth*, "that the *waters increased* and bare up the Ark."*

This being the case, it is necessary to look to some other source for the cause of this dreadful event.

* Genesis, chap. 7, 17th & 18th verses.

CHAPTER III.

It is believed by some "that by the breaking up of the fountains of the great deep, we are to understand an irruption of waters from the southern ocean." Mr. Kirwan seems to be of this opinion, for he observes, "This is pretty evident from such animals as the elephant and rhinoceros being found in great masses in Siberia, mixed with different *marine substances;* whereas, no animals, or other substances belonging to the northern regions have ever been found in *southern* climates. Had these animals died natural deaths, in their proper climate, then the bodies would not have been found in such masses. But that they were carried no farther northward than Siberia, is evident from there being no remains of any animals, besides those of whales, found in the mountains of Greenland. That this great *rush* of *waters* was from the *south, or south east,* is further evident (he thinks) from the south east sides of almost all great mountains being much steeper than their north, or north west sides, as they necessarily would be, if the force of a great body of water fell upon them in that direction."

However great the probability may be, of this *rush of waters* from the south, it does not account for a general current setting from the north east to the south west, of which we have the most indubitable proofs, in this country.

Dr. Clark says, of the fountains of the great deep being broken up, and the windows of Heaven being opened: "It appears that an immense quantity of waters occupied *the centre* of the antediluvian earth; and as these burst forth by the order of God, the circumambient strata *must sink,* in order to *fill up* the vacuum occasioned by the elevated waters. This is probably, what is meant by the breaking up the fountains of the great deep. These waters, with the seas on the earth's surface, might be deemed sufficient to drown the whole globe."

I am not a little surprized to hear an opinion so improbable in itself, coming from Dr. Clarke, as in saying that "the *circumambient strata must sink,* in order to fill up the vacuum occasioned by the elevated waters." In this case, as there was no *apparent necessity* that the "circumambient strata should sink in," would it not have been as easy for that Almighty Being who created the earth, to support these circumambient strata in their natural place, as to have elevated the waters from this supposed cavern, for the express purpose of inundating the world? To deny it is impious.

Another circumstance that militates against such an opinion is, that if the circumambient strata sunk "in order *to fill* up the vacuum occasioned by the elevated waters" how, let me ask, were the elevated waters ever to return again?

Unless this vacuum was, in the wisdom of an almighty providence, reserved for the subsidence of the waters which once occupied it, the world might have remained inundated to this day.

To determine, with any degree of precision, what is actually meant by the "fountains of the great deep" is extremely difficult, perhaps impossible.

If the waters which caused the general deluge, or Noatic flood, were contained in "the centre of the antediluvian earth," and it could be ascertained from what point or points the waters issued, we might be enabled to determine what influence they could have had in causing a general current across the continent of America, as well as the whole Atlantic Ocean, which follows of course.

But the circumstance is, of itself, so improbable, and so completely enveloped in the most profound obscurity, that no inference can be drawn that is in favour of a general current arising out of this cause.

There is, however, one source, though not established in the opinions of the philosophers of the present day, which carries with it a great degree of plausibility if not probability. To it I shall refer, until a better offers.

It has been asserted by a writer of no common celebrity, that the probable cause of the general deluge was the *entire melting* of the ices at the two poles of the earth—and that this was occasioned by "the sun deviating from the ecliptick," an idea as ingenious as the circumstance would be novel; but which, however strange and absurd it may appear, carries with it as much probability as that of the sun's being made to stand still, (in scripture language) in the days of Joshua.

Be this as it may, it is not my intention to advocate the theory of St. Pierre in the present instance; neither shall I pretend that the circumstance alluded to, is, by any means established, since *no positive* testimony can possibily be adduced to substantiate the fact—nevertheless, I shall *assume* the position, and that with *no other view* than to enable us to trace up and comprehend, some of the probable consequences naturally resulting from an event so momentous in its kind, and so stupendous in its operations; and to see how far they tally with various geological appearances that are presented to view in different parts of the United States.

That two immense regions of ice have accumulated, and remain at the poles, is certain. That the one at the north pole extends south about twenty degrees; and that of the south pole about twenty-three or twenty-five degrees north. That they extend to the north and south into regions unknown is highly probable. That if we admit the possibility of the earth's changing its position, (of which mention is made in several instances) so that the sun should pass over the poles, the consequences must have been such as to mock all human efforts of conception. But from what we see and know, we may venture to contemplate a scene so vast, nor hazard the imputation, though we indulge in extravagant conjecture, of exceeding the bounds of reality.

Let us now suppose that the earth with its axis was changed from north and south, to east and west; and that the sun passed immediately over the two poles of the earth, upon an unknown meridian. The result, we must readily believe, would have been the certain and inconceivably rapid dissolution of those immense hemispheres of ice. For as soon as the sun had mitigated the intensity of the cold, and, by its genial influence, softened the temperature of those cheerless regions, the yielding ice, in gushing torrents, must have rushed, in wild confusion, from their glassy summits, and sought a wonted level in the neighbouring deep. In a few short days the atmosphere at the poles must have become heated, and the melting of the ices general; while each pole was changed into an almost boundless fountain, pouring, incessantly, its mighty waters into the adjacent seas.

I shall now, at least for a while, confine my remarks more particularly to a view of the north pole.

From this pole, there are but two outlets; the one into the Pacific ocean, through the comparatively narrow channel at Bheering's straits; the other, through an immense channel into the Atlantic ocean, between the coast of Greenland, and north cape on the northern coast of Lapland. These two outlets are situated almost diametrically opposite to each other on the two sides of the globe : and whether the sun passed through the meridian of the Atlantic ocean and south sea, as is pretended, or upon a meridian passing through the continent of North and South America, and Asia, is immaterial in the present view, *since* by far the greatest proportion of the waters must have been thrown into the Atlantic ocean. No sooner was this operation, established, and this accession of strength and power thrown into the Atlantic ocean in particular, than its tide began to rise above its common limits, accompanied by a consequent current, both constantly increasing, the one in height, the other in rapidity proportioned to the increase of power at the focus. These, following the natural course of the Atlantic, soon swelled its waters above the shores of the adjacent continents, over which they began to flow in riotous disorder.

At the commencement of this frightful drama, it is highly probable that the current, issuing from the pole, was divided by the craggy heights of Spitzbergen, and a part thrown into the White Sea ; while the other, directing its force against the inhospitable shores of Lapland, and the rocky cliffs of Sweden and Norway, was thrown back upon the eastern and southern coast of Greenland ; from thence in a south western direction, until it struck the south eastern coast of Labrador, along which it swept, through the straits of Bell-Isle, across Newfoundland, Nova Scotia, and along the Atlantic coast into the gulf of Mexico. The rapid dissolution of the ices at the pole, constantly progressing, and as constantly increasing the rapidity of the current and quantity of water in the ocean, it continued to rise in awful majesty, and threaten universal destruction by its resistless force, sweeping across the neighbouring continents.

A cursory view, or even a glance at the subject, will enable us to form an idea of the operations that must naturally have occurred, from this new order of things. The current, bursting through each avenue, swept in its course every yielding substance. In a short space of time, the southern and eastern coast of Labrador, over which this current was urged with increasing force, was desolated. The soil, which, before, had fertilized this rocky coast, was hurled adrift, and mingling with the waters, was carried across the country into the gulf of St. Lawrence, and across a part of New-England, into the sea or general current of the ocean.

The waters continuing to rise, soon inundated the frozen regions of Iceland and Greenland, and urging on their precipitous course, swept across Davis's straits, and rolled their tumultuous surges into Hudson's bay, embracing the whole coast of Labrador, while the unequal current of the St. Lawrence was *forced back and upwards to its parent source.*

At this stage of the general deluge, while the waters were overwhelming the earth, the awful denunciations of an offended God were fast fulfilling, by the sure and utter extirmination of every beast of the field, and every creeping thing that creepeth upon the face of the earth. At length, the floods of the pole forming a junction with Baffin's-bay, and the Acrtic sea, defying all bounds, overrun their ancient limits, and hurled their united forces, in dread confusion, across the bleak regions of the north to consummate the awful scene. Thus lakes and seas uniting, formed one common Ocean, which was propelled with inconceivable rapidity across the continent between the great chains of mountains, into the Gulf of Mexico, and, probably, over the unpeopled wilds of South America, into the southern ocean.

Let us now see what were the probable consequences, when examined in this view, as it respects the geological appearances which prevail in almost every part of this country.

As has been observed, the operation of the current, flowing across the south eastern coast of Labrador, which was immediately exposed to its fury, was to deprive it almost, if not entirely, of its soil which it carried away; but being too small in quantity, no visible alluvial formation was occasioned upon the coasts, at the eastern extremity of the United States. Nevertheless a considerable change has been wrought upon the coasts near the sea in those parts, particularly on the margins of rivers having a northwardly and southwardly direction. Professor Cleaveland, in a letter to me on this subject, observes "I have attended the digging of several *wells* in this vicinity (Brunswick, Maine,) which gave decided indications of important, but probably gradual changes on our shores. These indications appear in the existence of *blue clay* at the depth of twenty feet below the present soil, *perfectly* resembling that which is taken from the *borders* of *creeks* and *bays* of *salt water,* in its *odour* and other properties.

This clay contains numerous bivalves, and some univalve-shells now found on our sea shore ; and rolled stones of granite or gneiss, with those little shells *adhering,* which seamen call barnacles. One of these wells is twenty miles from the *sea shore,* and *three* or *four* miles from the *nearest* tide-water, above which, it is elevated perhaps seventy feet."

Although the whole coast of Labrador was subject to the operations of this current until it was nearly deprived of its soil ; yet, owing to the direction of the current, and distance or extent of country over which it had to pass, that is, from the coast of Labrador to the mouth of the Hudson river, little or no alluvial formation is perceivable until we come to the mouth of Connecticut river, or rather the east end of Long-Island, which is a little south east of the Connecticut river, and is strictly alluvial, a distance of nearly seventeen degrees of longitude and about ten of latitude.

I may here be permitted to repeat, that as soon as the waters of the ocean had risen to a sufficient height, and the general current had acquired a power, sufficient to check the current of the river St. Lawrence, in direct opposition to which it was urging its force, a new order of things was established, and a wonderful increase of power added ; for the waters of Baffin's and Hudson's bay, overflowing their ordinary limits, poured their whole forces upon the great Lakes, Superior, Huron, Michigan, Erie, and Ontario; which, being no longer able to discharge themselves by the St. Lawrence, overrun their ancient limits, and, being at first confined by the great chains of mountains, spread destruction over the land, and rushed, with inconceivable rapidity, into the general current of the Atlantic ocean and gulf of Mexico. The consequence was, that the face of the country being overflown, and for a long time saturated with water, and as constantly subjected to the operations of an impetuous current, the soil and earth were torn up, carried, and deposited along upon the coast of America, from Long-Island to the bottom of the bay of Mexico; and in proportion to the extent of country, as I have before observed, over which this current passed; to the quantity of soil, and rapidity of current, when unaltered or changed by local circumstances, so is the extent or breadth of alluvial deposites from Long Island to the bay of Mexico.

For example, the distance or extent of country over which this current flowed, from Sandwich river on the coast of Labrador, to the latitude of Cape Cod, is about twelve degrees of latitude. In this distance, as has been already remarked, there is little or no alluvial soil on the coast.

But in consequence of the coast of Labrador stretching away north westwardly, from cape Charles to cape Chidley, or Button Island, the distance is greatly increased; so that the difference of latitude between Cape Chidley and New-York, is about 29°, a difference so great that we need not wonder, when we consider that almost all the rivers south of the St. Lawrence, and it excepted, flow in a southwardly direction, and favourable to the current; that we should find a portion of alluvial formation equal, at least, to the breadth of the east end of Long Island; or even the west end which is still much broader. Nor need we wonder at the increase of alluvial formation from New-York to the bay of Delaware, if we admit, that by this general current, that of the St. Lawrence was inverted, and flowing upwards in the direction of Champlain and so on, between the chains of mountains into the Ocean.

Nay more; if the alluvial district, contained between New-York and the bay of Delaware, could have been formed by a general current flowing over the face of the country, from the coast of Labrador to the latitude of Philadelphia, which place is, in fact, on the southern border of the primitive range, we need not be at a loss to account for the breadth of alluvial formation on the coast of Florida, and in the neighbourhood of the Mississippi river; when the current must have necessarily passed over an extent of more than 50 degrees of latitude: and also, a proportionate breadth of alluvial formation throughout the whole intermediate space.

This however will be more fully comprehended by an *attentive* examination of the map of the United States, including the British possessions in North

America.* I shall, in the next place, take notice of a variety of important facts, as related by several travellers, who have, at different times, explored the uncultivated wilds, as well as the more civilized parts of this great continent, in order to prove, not only the existence of a general current from the north-east to the south-west, but to see how far they are calculated to support the opinion, that the north pole was the great focus whence issued this current, the cause of so many and such stupendous results.

I have said that one of the consequences of this current was, the rending of the soil from its primitive bed, particularly, where most exposed, and bearing it away, leaving the rocks literally bare.

Heriot, in his travels through the Canadas, speaking of Newfoundland, observes, "Besides the bays already noticed, this island contains a variety of others, particularly on the *eastern coast*, among which, two

* When this work was first announced to the publick, it was intended to have introduced several drawings, representing sections of alluvial districts, where the alluvion and other formations, alternate with each other: and also, a correct map of North America, embracing the Arctic sea and north pole, in order to afford the reader a correct view of the source and direction of these supposed currents, and of the probable consequences: but not having received that encouragement and support, which is indispensably requisite in such an undertaking, it became necessary, in order to avoid the risk of pecuniary difficulties, to pursue, though reluctantly, a course more consistent with prudence and economy. Hence they have been omitted.

are remarkable for their extent; those of Trinity and Conception. Near the latter is the harbour of St. John, which is secure and well fortified, bordered by *dark* and gloomy rocks which exhibit a *barren inhospitable* appearance: the country, on a nearer view of its soil, belies not the character of its rude uninteresting features, which, amid their *nakedness,* display *neither* grandeur nor sublimity."—*Page* 38.

In describing the country on the north side of the river St. Lawrence, in the vicinity of the river Moisa, he observes, "no country can exhibit a more *wild aspect,* than that which here extends on either side of the river. Stunted trees, *rocks* and sand, compose these *inhospitable* and *desolate* territories, which *cannot boast of an acre of soil* capable of yielding any useful production."

The same traveller, in speaking of the vicinity of Camourasca, observes, "the sulphurous springs found here, and the immense masses of *broken rocks* which *appear* to have been thrown together by some violent, and uncommon effort of nature, afford grounds for supposing that this part of the country has undergone material changes."—*Page* 70.

In Mr. *Hearn's* Journey to the Arctic sea, and in his description of Marble island, on which Messrs. *Knight* and *Barlow* were lost, together with the whole ship's crew, when on a voyage of discovery, we find the following; "The figure head of the ship, and also the guns, &c. were sent home (England) to the company, and are certain proofs that Messrs *Knight* and

Barlow had been lost on that inhospitable island, where neither *stick* nor *stump* was to be seen, and which lies near sixteen miles from the main land. Indeed the main is little better, being a *jumble of barren hills and rocks, destitute of every kind of herbage except moss, &c.;* and, at that part, the woods are several hundred miles from the sea side."*

Further, "With regard to that part of my instructions, which directs me to observe the nature of the soil, &c. it must be observed, that during the whole time of my absence from the fort, I was invariably confined to *stony hills and barren plains* all the summer."†

In the latitude of about 68° north, longitude 119° west of London, they fell in with the Stony Mountains, "And surely," says Mr. *Hearn*, "no part of the world better deserves that name. On our first approaching these mountains, they appeared to be a confused heap of stones, *utterly inaccessible* to the foot of man."

And of the face of the whole country, inhabited by what are called the northern indians, he says, "The tract of land inhabited by the northern indians is very extensive, reaching from the fifty ninth to the sixty eighth degree of north latitude, and from east to west is upwards of five hundred miles wide. It is bounded by Churchill river on the south, Athapusean Indians' country on the west; the Dog-ribbed and Copper In-

* Hearn's Journey, Introduction page xxix. † Page xviii.

dians' country on the north; and by Hudson's bay on the east. The land throughout that *whole tract of country* is scarcely any thing, but one *solid mass of rocks and stones,* and, in most parts very hilly, particularly to the westward."* &c.

Mr. *Mc Kenzie* (in his travels, or voyages) speaking of Turtle portage, and lake of that name observes, "At the first vase from whence to the great river, the country has the appearance of *having been* overrun by fire, and *consists in general of huge rocky hills.*"†

In describing the French river, which discharges itself into Lake Huron, he says, "There is *hardly a foot of soil to be seen from one end of the French river to the other;* its banks *consisting of hills of entire rock.* The coast of the lake is the same but lower."‡

In describing Lake Superiour he says, "Along its north shore, is the safest navigation, as it is a continued *mountainous embankment of rock from three hundred to one thousand five hundred feet high.*"

The face of the country (on Lake Superiour) offers a wild scene of *huge hills and rocks, separated by stony vallies,* lakes, and ponds."§

At page 61 he observes, "This lake (Winipic) in common with those of this country, are bounded with black and grey rocks."

After giving a general view of the regions to the north and east of the lakes, he observes, "Of this

* Hearn's Journey, page 227. † McKenzie's Travels, page 36.

‡ McKenzie's Travels, page 37. § Page 49.

great tract *more than half* is represented *as barren and broken; displaying a surface of rock* and fresh water lakes, with a *very scattered and scanty proportion of soil.* Such is *the whole coast of Labrador* and *the land* called east main, to the *west* of the heights which divide the waters running into the river and gulf of St. Lawrence, from those flowing into Hudson's bay. It is, consequently inhabited, only by savages, whose numbers are proportioned to the scantiness of the soil; nor is it probable, from the same cause, that they will increase."*

And further "the proportion of it (the soil) that is fit for cultivation, is very small, and is *still less in the interiour parts;* it is also very difficult of access; and whilst any land remains uncultivated to the south of it, there will be no temptation to settle it."

Capt. Cook, when endeavouring to find a north west passage, observes "that the appearance of the country, (North America) in latitude 57° 3′ north, discovered little else than *naked rocks.*"†

He likewise observes that the barren isles in latitude 59 degrees north, are composed of naked rocks.‡

Many parts, both of Europe and Asia, in those latitudes discover the same inhospitable aspect, and which are mentioned by several travellers, particularly, *Wraxall,* who in his Description of Stockholm,

* Hearn's Journey, p. 426. † Cooke's Voyages, vol. II. p. 186.
‡ Vol. II. page 193.

observes, "Agriculture cannot exert her powers, nor labour produce harvests, *where nature has denied the means.* The eye discovers nothing *on every side* except firs and *rugged rocks;* and it would seem as if famine had here fixed her eternal residence.

"There is somewhat uncommonly savage and inhospitable in the whole circumjacent country here. Even in this lovely season, when all animate and inanimate nature wakes from the long slumber of a polar winter, every thing is joyless and unfertile, and the rays of the sun are reflected from the *expanse of stone* that invests the city round on every side, and from whose bosom *no verdure springs* to regale the eye."*

To what, let me ask, shall we attribute the deficiency of soil throughout these gloomy and inhospitable regions? Or why this almost uniform barrenness, and even repulsive sterrility and naked rocks, throughout almost all the high northern latitudes of North America, and even of Europe and Asia?† Were they never covered with soil like other parts of the world? doubtless they were. Or, if they have once experienced the unappeased wrath, the eternal denunciations of an offended God, why have not the different portions of the globe, in a more southern latitude, experienced it in like manner? It will be said, perhaps, that they have in a considerable degree. In reply to this, it may be observed that if there are a few solitary in-

* Wraxall's Travels. † Wraxall's Description of Sweden.

stances of this kind, they bear no proportion, in point of extent and magnitude, to those under consideration.

It would appear, that nothing but the constant and irresistible force of a general current, and that too issuing from the pole, could have produced such palpable results. This opinion is strengthened by the following circumstances.

Mr. *Clinton,* in a work that I have already mentioned, has taken notice of several very interesting geological facts, which are so intimately connected with my present view of the subject, that I shall gladly make use of them, as being, perhaps, the most authentick and correct that have been given us by any historian or traveller.

He observes,* "The appearance of the lands belonging to the Holland company, particularly from Batavia to lake Erie, furnishes strong indications of the recession of that lake. Near Vandeventer's tavern, in Niagara county, about twenty-two miles from the lake, there is a perpendicular descent which is said to extend from the Genesee river to Black Rock; between it and the stony ridge, which runs from the Genesee river to Lewistown, there is an immense valley twenty miles across, called Tonewanto valley. The precipice at Vandeventer's is from one hundred to two hundred feet. "The distance, or extent of this ridge,

* In note 7th, page 51, of his Introductory Lecture to the Literary and Philosophical Society.

from east to west, is about 78 miles." And further, "Its general altitude above the neighbouring land is thirty feet, and its width varies considerably; in some places it is not more than forty yards; its elevation above the level of lake Ontario is perhaps 136 feet, to which it descends by a gradual slope, and its distance from that water, is between six and ten miles. There is every reason to believe that this remarkable ridge was the ancient boundary of this great lake."

Of this latter remark there can be no doubt. But before I proceed to make any comments on the above quotations, I shall offer a few remarks on the subject of lake Ontario.

CHAPTER IV.

It is much to be regretted that Mr. *Clinton* did not, (or could not consistent with his plan,) give us a more general description of this interesting lake; for the want of which, I am obliged to depend on verbal, though respectable information from several sources. That is, that the alluvious formations on Lake Ontario, are by far the greatest, or most extensive on the north side of the lake. That it extends from near the western part of the lake, northwardly, almost to Lake Nipisin; from thence north-eastwardly embracing the river Utawas, and a part of the country of the ancient Algonquins; thence south-eastwardly taking in Mont-real.

Whether this be true or not, Mr. *Heriot* says, "The land on the north east coast of Lake Ontario *is low* and, in some situations, marshy," therefore, doubtless composed of alluvion.

With respect to the alluvious formation on the south side of Lake Ontario, Mr. *Clinton* observes, "These facts evince, beyond doubt, that Lake Ontario *has receded from this elevated ground;* and the cause of this retreat, must be ascribed to its having enlarged its former outlet." A similar opinion is likewise entertained of the north east shore of Lake Erie: but are there corresponding appearances of a recession in other parts of these lakes? Is there a like quantity of alluvious formation at the west end of Lake Ontario? On the northern shore, and west end of Lake Erie? Or in fact, are similar districts to be found on the shores of Lakes Huron, Michigan, and Superiour? I believe not; and if so, or indeed, if there are not corresponding appearances on the shores generally, of Lakes Erie and Ontario, with the exception of rocky or mountainous districts, we cannot with propriety consider those two cases as actual proofs of a recession, exsiccation, or wasting away of the lakes; on the contrary, it is rather an encroachment of the land, upon the water; and since there are not similar districts on the other great lakes, whose superficies are not only equal but much greater, regulated by the same laws, and subject to the same operations, it seems necessary to look to some other source for the cause of appearances so interesting, and peculiar to these two lakes.

Admitting then the existence of a general current setting across the continent from north and east, to south and west, the problem is easily solved; for while the current was flowing in direct opposition to that of the St. Lawrence, it was likewise flowing in a southwesterly direction across the East Main and coast of Labrador, from Cape Chidley almost in a line with Lakes Erie and Ontario, elevating the soil in its course and depositing it on their shores, the same as is deposited on our sea coast.

But it will be asked, why is not the same effect produced on the shores of Lakes Huron, Michigan, and particularly Superiour, whose northern shore Mr. *McKenzie* tells us, "is a continued mountainous embankment of rock, from three hundred, to one thousand five hundred feet high."

In reply, I have remarked that in proportion to the extent of country or superficies over which this current had to pass, so will be the extent and breadth of alluvious deposites both on lakes as well as seas. And this, I think, is fully verified in the present case; for the distance from Hudson's bay, or the southern part called James' bay, across to Lake Superiour in a south-westerly direction, is but about five degrees; while that from Cape Chidley to Lake Ontario is about twenty degrees; and more than half of this immense district Mr. *McKenzie* tells us "*is destitute* of soil, presenting *nothing but enormous rocks.*"

Admitting that this country was once covered with soil, though in a sparing degree, need we be surprised that a small quantity of alluvial deposite should be formed on the shores of Ontario and a part of Erie? Nay, admitting the truth of this position, and that the space between the Alleghany Ridge and Rocky Mountains, to have been once an inland sea like that of the Red Sea; need we wonder that it should be filled up; while an impetuous current was tearing up the soil, and sweeping it over a surface extending from the Arctic sea, to the mouth of the Missouri river, a distance equal to about 40 degrees of latitude? Need we wonder that this space, now rich in cultivation, should abound with the remains of numerous and varied species of shell fish, while those immense focusses, Hudson's Bay, Lakes Superiour, Michigan, Huron, Erie, Ontario, and many others were yielding up their treasures to the impetuosity of a resistless current, to mingle in promiscuous ruin, and be swept across the country and deposited in this, now extinct sea? Indeed, in this view, it appears by no means problematical.

But to return to Lake Ontario. Not only does the extent of country over which this supposed current must have run; and the proportionate alluvial deposite on the shores of Ontario, favour the opinion that these deposites were actually occasioned by this cause only; but there are others of equal, if not more importance in support of this hypothesis.

Mr. *Clinton* observes, when describing the ridge in the vicinity of the south shore of Lake Ontario, that "The gravel with which it is covered was deposited there by the waters, and the stones every where indicate, by their shape, the abrasion and agitation produced by that element. All along the borders of the western rivers and lakes, there are small mounds, or heaps of gravel of a conical form erected by the fish (it is said) for the protection of their spawn; these *fish banks* are found at the *foot of the ridge on the side towards the lake; on the opposite side none have been discovered.*"

Here, I am at a loss to determine, whether Mr. *C.* meant on the opposite shore of Lake Ontario, or the opposite side of the ridge. But it is of little importance which of the two was intended, since I will venture to question, whether there is a single instance of these fish-mounds to be found on the northern shore of Lake Ontario, either above, or beneath the water.

These water-worn stones or pebbles, I have before remarked, were, probably, formed in the course of ages, by the currents of rivers, and carried down their streams and spread over the beds of those rivers in immense quantities, as is the case at this day, in a thousand instances.

Such was probably the case with Ontario; and as soon as the general current had acquired sufficient velocity and power, they were elevated from the bottom and deposited with the alluvion on the shores, because the ridge, or bank of any river, which is the same thing, being higher than the waters, they were obstructed in their course, and consequently deposited with the sand and gravel, the latter of which, in the present instance, were subsequently collected together into heaps by the fishes of some kind or other.

Such is precisely the case on the western shore of the Connecticut river, for the distance of about three or four miles below the Falls, where there are hundreds of these mounds, of a low pyramidal form, from the size or quantity of half a bushel, to that of eight or ten bushels, and what is no less extraordinary than favourable to my hypothesis, is, that not one single instance of the kind has, I believe, ever been found on the eastern shore of that river.

The same may be observed on the west side of the Susquehannah, from six to ten miles above tide water.*

A similar fact is likewise mentioned by Mr. *Bartram*, as existing on the shores of Broad river, which discharges its waters into that of the Savanna. "The waters at this place," he says, "were still and shoal, and flowed over a bed of gravel just beneath a rocky rapid; in this eddy shoal were a number of little gravelly pyramidal hills, whose summits rose almost to the surface of the water, very artfully constructed by a species of Cray fish, (cancer macrourus) which inhabited them."†

These are not the only circumstances which Mr. *C.* mentions, that are favourable to my views of this subject, exclusive of which, I could adduce numerous other cases equally favourable to the opinion; but one or two of which, I shall mention in the present instance.

I have been informed by a gentleman of respectability, who was a witness to the fact, that while the Britsih were employed in erecting a fort at Kingston, on lake Ontario, in 1814, they discovered, at the depth of fifteen feet below the surface, a variety of seeds lying

* For this fact, I am indebted to Dr. R. W. Hall, who further observes, "The fishes which form these mounds, are a species of small mullet or gudgeon. They elevate the stones by suction, and deposite them on the mound, as I have often seen."

† Bartram's Travels, page 43.

in the earthy veins between the strata of lime stone rock; and in which they had doubtless lain for many ages, in a perfect state of preservation, so much so as to have subsequently produced entire and perfect plants of their several kinds. Among these are the Areca Cispitosa, Poa Alpina, Poa Quinquefida, Uniola Gracilis; Festuca not described; Arundo Canadensis; Elymus Canadensis, and a Cerex, resembling, Fraseri. These plants are completely alpine, and are *peculiar to the mountains to the northward of the lakes.**

To what shall we attribute these singular phenomena, but to the agency of a general current setting from the northward in a south westerly direction? We

* The circumstance of seeds having been found deposited between the strata of lime stone, may, with some, appear doubtful. But it must be recollected, that the lime stone spoken of in the present instance, is secondary; and that it is by no means uncommon to find organick remains in similar situations, particularly those of vegetables.

Patrin speaks of a variety that is found in the secondary slate, and about the coal mines in the environs of St. Etienne. He has also given a very accurate representation of a specimen containing five different impressions of vegetables. Among which are the seeds, or, in his own words, "the fruit which has always been considered as resembling the grains of coffee, and which in general is true. I have found specimens still surrounded with their membranes, and it appears that it is the fruit of an umbelliferous plant, perhaps of a Thapsie."

In the same specimen is likewise represented a remarkable Polypodium, "resembling the Polypodium Unitum of the Isle of France," and still bearing its fruit or seeds in fine preservation.

can easily conceive how seeds are transported to a great distance from the place of their growth, by winds, and currents of rivers, in which case they are soon after destroyed, or vegetate anew. But in this instance, it is no easy matter to determine with certainty, how these different seeds were transported from a distance, precipitated, or deposited, and preserved in a mass that *must have*, subsequently, become carbonate of lime, unless we admit that they were suddenly transported in troubled waters, saturated with earth, as suddenly deposited at that point, perhaps by some whirlpool or eddy, and the superincumbent mass as suddenly changed into lime-stone.

It is not only necessary that these seeds should be suddenly transported, deposited and fixed in their gangue, if I may so call it, but it is *indispensably* necessary that it should have taken place in the *autumn* or *winter* immediately after their growth or maturity; and that too, when both the air and water were at such a state of temperature, as to be totally unfavourable to vegetation; otherwise, these seeds must have germinated, and consequently have been destroyed. Ad-

The same specimen also contains a fruit, which is considered as that of an exotick plant, and on the subject of which Patrin observes, "The learned Jussieu has in possession numerous examples, (of the kind,) very well characterised; but he has declared that he knows not to what genus it belongs."—See Patrin's Natural History of Minerals, Tome 5, page 326 and 7; and also Phillip's Description of Organick Remains in the Island of Sheppey. Outline of Mineralogy and Geology, page 96.

mitting this fact, and that they were transported by a current flowing from the north, it may have been the result of the general deluge, which, according to the author whom I have already quoted (*St. Pierre*) happened in the month of February and March. If this circumstance be true, it will enable us to determine, why the seeds were preserved from germinating or perishing, and also, why those immense masses of granite, mentioned by Mr. *Drake* in his Picture of Cincinnati, should be found upon an alluvial soil, at least one hundred leagues from the nearest granite, in place, on the north; and perhaps one thousand leagues from the nearest on the south; for it is well known, that large masses of rocks of different kinds are often enveloped in ice, and, by the freshes of rivers or tides of the sea, are raised and transported to a great distance, before they are disengaged. This circumstance has been taken notice of by several writers.

Tilloch has observed that masses of stone are sometimes transported by cakes of ice, in which they happen to be enveloped; a circumstance equally as probable as that of huge animals being transported, to a great distance, upon masses of floating ice, which frequently occurs. The great White Bear, from the arctic regions, and also the White Fox, are annually brought from the northern coast of Greenland by these means, and cast upon the coast of Iceland, to the great annoyance of the inhabitants.* While this circumstance

* See Troils's Description of Iceland.

goes far to prove, that those enormous islands of ice were formed in the neighbourhood of some continent, or island, it heightens the probability that they might at the some time contain vast fragments of rocks.

Mr. *Bakewell*, in his introduction to geology, *(page 55)* makes the following remarks, "Vast masses of rock near the sea shore, are sometimes enveloped in fields of ice, and raised up and transported to distant countries. Ice is specifically lighter than water; every cubic yard will support a stone of one hundred pounds weight: hence we need not be surprised at the insulated rocks of granite, that are sometimes found in situations *far remote* from primary mountains. *These blocks have been floated over the ocean*, and their angular points and edges defended from attrition during their passage, by the surrounding ice. In this manner large fragments of granite, and other primary rocks, may have been brought upon our coast (England) from Norway and Greenland."

The truth of Mr. *Bakewell's* opinion is strongly corroborated by the following fact to which I was an eye witness. In the winter of 1780, well known for being one of the severest ever experienced in this country, the ice in the Connecticut river was increased to a great thickness and solidity: In many instances, the water in the river was literally frozen to the bottom. In the month of January, as usual, there came a great and sudden thaw, accompanied with incessant torrents of rain, which appeared to spread over an immense extent of country. The consequences were such as might be expected ; the snow which was over five feet deep, was quickly melted ; every stream as suddenly became a river ; and every river threatened to become an ocean. The Connecticut river was very soon raised almost to a level with its banks, and the ice which was two and a half feet thick, was borne away by the current in the most terrifick majesty ; for wherever it was impeded in its progress, by an island, or the narrowing of the shores of the river, it was broken up, and immense masses raised into the air, until their elevated positions, preponderating over their floating foundations, were left to fall on the surrounding ice with a report, equal in some instances to that of small pieces of ordnance.

This scene of awful grandeur was extended for miles to the north and south, and while thousands were contemplating the frightful spectacle, the ice, being very solid, and hurried on by a powerful current, became obstructed at the mouth of the straits twenty-five miles below near Middletown, and the whole force of the river for a short time was impeded : the water set back and upwards, and enormous masses of ice were hurried over the banks of the river, into the creeks and larger streams to a considerable distance from the river, into the meadows and low grounds : when on a sudden, from the pressure above, the obstruction at the straits gave way, and this threatening appearance almost in a minute vanished : the water fell to its natual state, and left huge masses of transparent ice in the meadows and intervales, to be removed only by the powerful influence of a summer's sun. When this was accomplished in the following season, large pieces of rocks and heaps of rolled pebbles were left exposed to view on an alluvial surface, on which, before, a stone could not be found for its weight in gold. These rocks and stones from their characters, were known to be the same as those which composed the bed of the river many leagues above.

Those masses of granite mentioned by Mr. *Drake*, have been a subject of wonder and surprise with many, and, in this instance, well may they excite a degree of curiosity: not because we see masses of primitive rocks entirely out of place, as in alluvial formations; or at a great distance from where they were probably formed. This is by no means an uncommon occurrence. We see them in various parts of the United States;* numerous instances of the kind

* But a few years since, in digging away, and levelling the road in the town of Windsor, in Connecticut, and at the distance of nine miles from Hartford, a part of a rock was uncovered, which, from its apparent size, it was found necessary to remove. This was accomplished, and it still remains in the highway. It is of granite of an unusual kind: the quartz and felspar are in fine grains, with a proportion of black hornblend; the whole intermixed with small irregular and isolated masses of black mica. Its weight may be one ton, or a ton and a half. Its form is more singular, perhaps than its composition, being of two irregular masses joined by a kind of neck, the curve of which has the appearance of having been hollowed out on two sides by the operations of running waters, giving it the shape and resemblance of what are considered

are likewise to be seen, in various parts of Europe, particularly in mountainous districts.

Palassau, in his geological description of the Pyrennees, observes, that immense boulders of granite,

Indian idols or gods. The base or body of the rock, is perhaps four times as large as the apex or head.

In the same town, and in the parish of Wintonbury, at the distance of seven miles in a S. W. direction from this rock, is another of the same kind of granite, and of nearly the same form and dimensions. It stands at the end of a horse shed, near a publick Inn, kept by a Mr. Roberts; and serves as a substitute for steps, to assist in mounting on horseback.

I have been thus particular in pointing out and describing these two rocks, for the following reasons.

The first mentioned rock was found at the distance of half a mile west of the Connecticut river, in the second plain or bank, which is *perfectly alluvial.*

The second stands, at present, about seven miles west of the Connecticut river on what may be considered the third plain or bank of the same river, being considerably higher than the first and second, and commencing upon the latter with a quick ascent, and is likewise perfectly alluvial.

That these two masses were never formed where they now are, is as certain as that they now exist; for not a rock of the kind is to be found, in place, for many leagues distant.

The nearest granite to the east, is on the range called the east mountains, and is distant twelve miles, with the Connecticut river intervening. The nearest in a north direction, is in the state of Massachusetts, distant from thirty-five to forty miles. The nearest on the south, nearly the same. On the west, no granite occurs of any kind within the distance of twelve or fifteen miles, with the range of West Mountains intervening, which is entirely of a secondary formation.

limestone, and other rocks, are frequently torn from the sides of those mountains, and carried to a great distance into the low grounds, by the resistless torrents of water that often rush from the steep and awful precipicies of those stupendous snow-capped heights.

This will not appear strange when we learn from the same author, that whole villages are sometimes swept

Hence, the fair and unequivocal conclusion is, that they *must have been* brought from some unknown point or place to the northward, by currents of water, and deposited where they are; and that too, most probably, enclosed in ice: for such is their form that if embraced in a mass of ice of sufficient size, and elevated from the earth by water, they might be floated over the ocean without the chance of escape, except by the melting of the ice.

Cases of a similar kind occur elsewhere, as will appear by the following extract of a letter from Professor Cooper:—"The shore of the north east bank of Susquehannah, from Wilksbarre in Pennsylvania, down to Sunbury, is, or a few years ago was, abundant in sienitic rolled pebbles, from the size of a man's head to the size of a marble; red felspar, hornblend, and quartz; felspar and quartz; felspar and hornblend; quartz and hornblend. I know of no sienitic formation in the vicinity: the nearest I have heard of from Col. *Gibbs* and Mr. *McClure*, is in the *vicinity of Lake George, and to the eastward of it.* These are annually shifting their places, being enveloped with ice, which when it is deposited on the shores lower down, the ice melts and leaves the stones. I have traced them from Wilksbarre as low down as Sunbury and even Harrisburgh."

By what possible means, I would ask, were these stones, (of which there can be *no mistake,* for I have seen and examined them) brought from Lake George *over land* to Wilksbarre, except by a current setting from the north east, which is precisely the direction from the one to the other of these two places?

away, at the foot of those mountains by those dreadful torrents. These rocks not only prevail in numerous places at the foot of the mountains on the side of France, but also on that of Spain.

Blocks of granite are found in the beds of some of the rivers, in the north west part of Yorkshire, and in the clay pits in Lancashire and Cheshire, at a great distance from any granitic mountain.*

In the Baltic are a number of islands formed by alluvion, and in which are masses of primordial rocks of granite, brought, no doubt, by ice which was driven by the currents and lodged upon these islands.

"The Danish islands in the Archipelago are Funen, Zeeland, and some small islands in the Kategate, named Lenoe, Anholt, and Samsoe. These are principally composed of zeest, or alluvion, and in these are found gravel and blocks of granite."†

"Fanoe, Rom, Sylt, and Amrom, were originally islands of the same nature as the neighbouring continent, but have been since extended by marshes or alluvion. These islands also contain gravel and blocks of primordial stones."‡

"The shallow bottom between the island of Sylt, and that of Fora, is alluvial, and there are found on it gravel and blocks of granite."§

* See Bakewell's Introduction to Geology, page 80.

† See Jameson's Notes on Cuvier, page 202. ‡ Page 204.

§ Page 205.

Cuvier observes, that "In some countries, we find numerous, and prodigiously *large blocks* of primitive substances scattered over the surface of the secondary strata, and separated by deep vallies, from the peaks or ridges, *whence these blocks must have been derived.*"*

Mr. *Jameson* observes that "numerous large blocks, or masses of mountain rocks, are frequently met with, in almost every country in Europe, and frequently very far removed from their original situations. Switzerland, and the surrounding countries, present numerous and very interesting appearances of this kind. On the mountains of Jura, immediately in the line of direction of the Vallais, and nearly to the height of 6000 feet, enormous blocks of granite are found resting upon the lime stone rock of that range of mountains. These blocks are of that species of granite, which forms the mountains of Ornex, belonging to the group of Mont Blanc; hence, it is inferred that they must have been transported by the force of water, from that region to their present situation."†

Where large masses of rocks are found out of place, in the neighbourhood of high mountains, as the Pyrennees; we can easily conceive how those masses of granite and other rocks, are removed out of their proper places, and deposited where they are, when we can actually see them hurried down the impetuous current, seemingly, with as much facility as that of rolled peb-

* Theory of the Earth, p. 43. Amer. Edit. † Page 190.

bles. Such is the case on the sides of almost all high mountains; and such was evinced in a very striking manner, in the neighbourhood of Baltimore, and in many places in Baltimore county and elsewhere, during the dreadful fall of rain which was experienced, in almost every part of the United States, in July 1817. In this instance, rocks of granite of many tons weight were hurried down the streams a quarter of a mile or more, and that almost on a perfect level.

With respect to the masses of granite in the state of Ohio, and in the neighbourhood of Cincinnati, and also in the states of Kentucky and Indiana, the case is very different. There are no mountains within a great distance, from which they could have been torn; neither are they on the bottom, or on the margins of rivers, from whose sources they could have been brought, either by the current or by ice; but promiscuously interspersed over a great extent of country, which is, beyond all doubt, decidedly alluvial.

Neither is there any known volcano from which they could have been thrown; or, if there were such, the judicious remarks of Dr. *Drake* on the subject, are sufficient to remove all doubts on that point, (viz :) "that their surfaces discover *no signs of vitrification,* and their distribution too much in groups to favour this suggestion."*

Hence, there remains no point or incident on which the mind can fix, that will explain this phenomenon,

* Drake's Picture of Cincinnati.

except that of their having been transported by a current from high northern regions, enveloped in enormous masses of ice; and from *no other point;* for it would be absurd in the extreme, to suppose that masses of ice could have been formed in the torrid zone, or even within the temperate zone, of sufficient magnitude to have transported those rocks *from the south* to their present situation. Hence, the conclusion is, that they were brought there by the same current, that once flowed from the north east to the south west, or from north to south, over the surface of the whole continent of America.

This opinion receives additional support from the following circumstance; the huge fields and mountains of ice, which every spring float down the Atlantic ocean, seldom reach the latitude of from 39° to 40°, which is about the latitude in which those rocks lie, before they become *so weak and rotten* as to be incapable of supporting, or retaining any considerable weight that might be attached to them. It therefore follows as a natural consequence, that by the time the masses of ice had reached those latitudes, they must necessarily have discharged the entire balance of their freight, if they contained any.

On the few remaining facts, which I shall notice in the present instance, I might repose in entire confidence; deeming them, alone, sufficient to prove, not only the existence of a general current, setting from the north east to the south west, across the continent of America; but that nearly the entire alluvial district, bordering the Atlantic shores from Long Island to the gulf of Mexico, was formed by the operations of this current.

1stly. On almost all the rivers in America, that have a southerly course, and run any distance through an alluvial formation, (that on the borders of the ocean excepted,) we find from actual observation, and from Stoddard's Sketches, Drake's Picture of Cincinnati, Lewis and Clarke's, McKenzie's, Herriot's and other travels, two, and sometimes three, alluvial banks on each side.* Those which are next to the rivers, on

* It is particularly worthy of remark, that the same circumstance is observable in the great alluvial region of America, which bounds the Atlantic on the south; and that of Asia, which bounds the Arctic sea on the north.

The Abbe Chappe D'Auteroche, who visited Siberia in 1761, has taken particular notice of this fact. He describes the plains of Siberia, which extend to a great distance within the dominions of Russia, to be four hundred leagues in breadth, in their widest part, from south to north, and upwards of seven hundred leagues in extent from west to east. Over this immense region he travelled seven hundred leagues. In this distance he observed three, and in some parts, four distinct plains, the height of which, above the sea he ascertained.

Three of these plains he describes as being parallel with the horizon. The third he observes, "makes an angle of about two degrees and a half with the horizon at Tobolsky." And further, "It rises more and more *towards the south, and sinks towards the north.*" Or, in other words, as it approaches the Arctic sea.—Abbe Chappe's Travels, page 156 and 32.

The alluvial region of America will *doubtless* afford corresponding results, should any one undertake to make the necessary observaeach side, are, in general, from twenty to twenty-five feet above low water. The second, which are at a greater or less distance from the rivers, are from thirty to fifty feet above the first, and sometimes more.

tions. But as no one has hitherto attempted it, that I know of, it is impossible for me to point out the number of plains with their extent and limits, that may be contained within this vast district. This much, however, I may venture to assert, from my own observations, and from verbal testimony.

The highest level of our alluvial district is that part, I believe, which joins upon the granite ridge, or range of primitive formation. At right angles from this range, or in a south east direction, it extends to the distance of between twenty-five and thirty miles, nearly on the same level. From thence, on very good authority, there is a sensible difference in the height of the general level of the soil above the ocean. This extends to a similar distance, whence there is an obvious but gradual descent to the ocean. And, moreover, what seems worthy of further notice is, that the second range of plains or levels, seems to be, by far, the most abundant in fossil organick remains. Whether so or not, it is a subject by *no means* unworthy of a more particular attention.

Since writing the above, I find the following interesting facts mentioned by Mr. Bartram in his travels through East and West Florida :—

" In our progress from the sea coast, we rise gradually, by several steps or ascents, in the following manner. First, from the sea coast, fifty miles back, is a *level plain*, generally, of a loose sandy soil, producing spacious high forests," &c.

Secondly, " We now rise a bank of considerable height, which runs *nearly parallel* to the sea coast, through Carolina and Georgia : the ascent is gradual by several flights of steps, for eight or ten miles, the perpendicular height whereof, above the level of the

These two alluvial banks so uniformly accompanying each other, upon almost all rivers of any magnitude, where there is an alluvial formation upon their borders, constitute the only, yet unequivocal indications, at least, of two general deluges over this part of the continent; and to which I alluded in a former part of this essay.

I say general; the one was probably such; the other may have been partial; that is, not rising to so great a height as to cover the highest mountains, or even the highest hills. These two deluges happened at two different epochs, probably, not very remote from each other.

But the circumstances that favour the opinion of a north east and south west current is, that, in general, the alluvial banks on the north and east sides of the rivers are considerably the widest, with few excep-

ocean, may be two or three hundred feet, and these are called the sand hills,) when we find ourselves on the entrance of a vast plain, generally level, which extends west sixty or seventy miles, rising gently, as the former, but more perceptibly."

Thirdly, "The next ascent, or flight, is of much greater, and more abrupt elevation, and continues rising by broken ridges and narrow levels, or vales, for ten or fifteen miles, when we rest again on another extensive *nearly level* plain of pine forests, mixed with various other forest trees, which continues west forty or fifty miles farther."—*Bartram's Travels, page* 28, 30 and 31.

These plains are represented as being composed, (at the surface at least,) of sand and small gravel; and while their existence affords a powerful support to my opinion, they likewise prove the striking correspondencies that prevail in the general and prominent features of those two immense districts.

tions, and these are mostly in the lower bank. This I attribute to the following cause.

It is an established principle, and one that will almost universally hold good, that when an auxiliary stream falls, either obliquely or at right angles, into a stream of equal or greater magnitude, the auxiliary branch will urge on its alluvion and deposite it, sometimes to a considerable distance into the principal stream; until overcome by the power of the latter, it is then swept away by the general current. This may be every day observed in rivers, creeks, brooks, and their auxiliary streams. Hence the conclusion, that the general current, while it was rising in height and increasing in rapidity, must naturally urge on, or force the currents of rivers further westerly and southerly, and meeting with a partial check by the current of the latter, which must be supposed to rise in height and increase in rapidity, in a corresponding ratio, continued to deposite their alluvion upon their eastern and northern shores only, until the highest hills were inundated and the currents of rivers were merged in that of the general current; after which the increasing quantity of its alluvion, meeting with no check, was swept across the continent and into the ocean.

When I speak of rivers having been urged from their *original* and primitive courses or beds, by a continued lateral force, I do not mean to infer that they were originally restricted to the same narrow limits that they in general now are; very far from it: It must appear obvious to any person that is accustomed to travel with his mind awake, and his eyes open, that most of the rivers east of the Alleghany Ridge, and north of the alluvial district upon the borders of the Atlantic, must have once run through small, but beautiful lakes, interspersed at different intervals of their distances, from their sources to their influx; in a manner similar to that of the St. Lawrence, which, in its course runs through Lakes Superiour, Huron, Erie and Ontario. But these numerous reservoirs, in whose tranquil surfaces, surrounding nature, in all her varied hues, has been a thousand and a thousand times reflected, have long since been effaced and filled up with alluvion, and that too most probably deposited by the current of which I am speaking.

On the gradual subsidence of the general inundation, the rivers, from necessity, being compelled to flow, resumed the several channels which they had previously occupied when overpowered by a superiour force, and where the alluvial deposites, being the least in quantity, afforded the least resistance to their currents.

Whether this may seem the most rational mode of explaining this phenomenon, I shall not, at present, insist; but certain it is, that the alluvial banks, as I have before observed, on most of the rivers having a northerly and southerly direction; are considerably the widest on the èasterly and northerly side. On the Connecticut river, the alluvial banks on the east side are nearly twice the breadth of those on the west side, except in some instances, where, in the lower banks, the river has in the lapse of time varied its course, most probably from some local cause.

On the Hudson river, above the high lands I believe the same may be observed. With respect to other rivers, I refer to the authors whom I have already named.

2dly. It is a well known fact, that in digging for wells and other purposes along upon the northern borders of the great alluvial district, (and in some instances, perhaps, at a greater distance from the primitive range,) we find at the depth of forty or fifty feet, the remains of a variety of vegetable substances, and in some cases, in a high state of preservation.

On Long Island, the remains of trees have been found at the depth of forty-five, and fifty feet.* I am likewise informed, that in New Jersey, Delaware, and in the city of Philadelphia, remains of trees are found at the same depth.

The same thing occurs in different parts of Maryland. In Baltimore, at the depth of forty-five or fifty feet, we find the remains of trees and their fruits, particularly the black walnut, (Iuglans Nigra) in abundance.

In Virginia this fact is notorious, and I believe in all the states from Virginia to that of the Mississippi.

In the western country beyond the Alleghany, remains of trees are said to be found at a great depth

* See Bruce's Mineralogical Journal for Mitchell's account of Long Island, pages 132 & 162—63.

below the surface of the earth, and, in some instances, bearing evident marks of the axe that was used in felling the tree.*

In Ohio, grape vines are found at the depth of forty feet below the surface.†

Mr. *Stoddard*, in his Sketches of Louisiana, when speaking of the alluvial lands, on Black river, observes, "An opinion prevails that these and the other alluvial lands in the *low country* are at this time much more elevated than formerly." This is fully supported by three known facts.—The advances of the land into the sea; the *existence of trees and other woody substances* at a considerable depth under ground apparently deposited there by the waters; and the annual formation of an alluvious stratum, by means of the expansion of the Mississippi and other rivers.''‡

In describing the Chickasaw Bluffs, and those at Natches, the river St. Catherine, at Fort Adams, and at Baton Rouge, he observes "Many of them exhibit the appearance of rock; but their substance when carefully examined, is found to be extremely porous, and composed of hard indurated sand, by no means strongly combined, and easily broken in pieces. Others of them are solid banks of sand of various colours, intermixed with laminæ of iron ore, ochre and argillaceous earths. At the *bases* of some of them, (whose height

* British Spy, p. 29. † See Drake's Picture of Cincinnati, p. 70.
‡ Stoddard's Sketches, page 199.

he says are seventy-five, others more than two hundred feet,) numerous trees of various dimensions are found converted into stone, by the petrifying quality of the springs about them."*

Also, "*large trees* are often found from *twenty to twenty-five* feet UNDER ground, in some of the *extensive bottoms,* and from *four to six miles from the channel.* Add to this, the *trunks of large trees* at the same depth, appear in a *horizontal* position near the *bases* of the banks; also in the sides of the banks newly caved in, *trees* in a *perpendicular position* are constantly seen, *whose shafts above their roots are sunk from twenty to twenty-five feet below the surface* of the ground."†

Mr. *Bartram,* in describing the cliffs or high banks below Natches, on the Mississippi, observes, "From eight or nine feet below the loamy vegetable mould at top, to within four or five feet of the water, these cliffs present to view strata of clay, marle and chalk, of all colours, as brown, red, yellow, white, blue and purple; there are separate strata of these various colours, as well as mixed or particoloured; the lowest stratum next the water is exactly of the same black mud or rich soil, as the adjacent low cypress swamps, and above the cliffs we see vast stumps of cypress and other trees, which at this day grow in these low, wet swamps, and which *range on a level with them.* These stumps are sound, stand upright, and seem to

* Stoddard's Sketches, page 382. † Page 383.

be rotted off about two or three feet above the spread of their roots; their trunks, limbs, &c. lie in all directions about them. But when those swampy forests were growing, and by what cause they were cut off, and overwhelmed by the various strata of earth, which *now* rise near *one hundred feet above*, at the bank of the cliffs, and two or three times that height but a few hundred yards back, are inquiries perhaps not easily answered."*

* Bartram's Travels, page 433.

CHAPTER V.

From all the cases which I have enumerated, together with many more that I could mention if it were necessary; it appears that those vegetable and other remains, are found either upon the soil on which they grew, or on the ancient bed of the ocean or rivers.

In the state of Maine, it appears that they find, at the distance of twenty miles from the sea, and at the depth of twenty feet below the surface, "numerous bivalve, and some univalve shells, now found on our seashore," enveloped in a stiff blue clay, "perfectly resembling that which is taken from the borders of creeks and bays of salt water, in its odour and other properties." Besides these "rolled stones of granite, or gneiss with those *little shells* adhering which seamen call barnacles."

In Baltimore, these substances are found upon a bottom resembling marsh mud. At Fort M'Henry, in sinking a well, in the Star Fort in 1814, the workmen came upon a mass of carbonated wood, being part of a tree, as is supposed, lying across the well, at the depth of fifty feet or more, in a boggy marsh. This is two miles south of the granite ridge, or northern border of the great alluvial district.

In Virginia these substances are found in a stiff blue clay; and even on the Mississippi, Mr. *Stoddard* says, when speaking of the *Delta,* "these are buried in a substratum of black earth, *below the level of the ocean,* and already begin to be decomposed, and converted into fossil fuel."*

From hence, the obvious conclusion is, that at some one or more memorable epochs, the entire mass of alluvial formation, under which these vegetable remains are found, with a few exceptions near the mouths of rivers, was deposited upon them, and that too, by a general inundation, that was agitated and propelled by a current, which raised the yielding soil from one place, and carried and deposited it in another.

Let us now see how far this conclusion is supported by the facts which I have stated.

The bivalve and other shells, found near Brunswick (S. Main) at the depth of twenty feet, together with "rolled stones of granite or gneiss having *barnacles* adhering to them" are found *only* at, or near that depth. Now there being no appearance of any thing of the kind in the intermediate space between the surface and that depth, I am led to inquire, how we shall reconcile the opinion, that the alluvial deposites or districts were formed in the course of ages by the annual overflowing and deposites of rivers? If they originated from this cause, we might very naturally expect to find univalve shells of certain kinds, (though

* Stoddard's Sketches, page 159.

not of barnacles,) and rolled stones of granite, or some other kind, in every layer or stratum, from the depth of twenty feet to the surface; because these substances being found on land, may every year, be carried away by the currents, in the spring freshes or in ice, and deposited in regular successive layers with their alluvion: but this is not the case; neither is it possible that it can be so; because the banks of rivers, in a thousand instances, although composed entirely of alluvion, were never known to have been overflown.

On the other hand, we find it equally as difficult to reconcile those circumstances to the opinion, that the alluvial and all other districts are the deposites from the sea, and that, on its gradual subsidence, they have risen to their present height above its surface; for if the various families of shell fish were in existence, at the time the deposites were going on, at the depth of twenty feet below the present surface, and particularly the barnacle which belongs exclusively to salt water, and is common, I believe, to every sea and latitude in the known world, we might reasonably expect to find them in every successive layer, from that to the surface. Neither is this the case.

The latter, in particular, are found *adhering* to stones in a blue clay, that, in all probability, once formed the ancient bed of the ocean; and which has been buried, with all its animal and vegetable exuviæ, by an immense deposite of alluvion, brought from theland by an irresistible current.

The same reasoning will hold good with respect to the deposites of vegetable exuviae in various parts of the United States; for in not one instance, can I find that vegetable remains have been discovered lying between a certain specified depth, (which is, on an average, upon the margin of the alluvial district, from thirty-five to forty feet,) and the surface of the ground.

This being the case, all ideas of our alluvial districts having been formed by deposites from an annual, or, (which sometimes happens,) semi-annual inundation of the lands by our rivers, is at an end, and for reasons already advanced.

A very different opinion prevails with many I know; and among a host of others, is Mr. *Stoddard*, who in his interesting sketches, when speaking of the Mississippi, observes "The banks of the river are composed of alluvious strata, and in places where they newly cave in, the different layers are easily distinguished. The banks between the Ohio and Missouri, have generally, in a low state of the water, an elevation of more than forty feet, and exhibit to the eye about *nine hundred* distinct layers. What conclusion results from this fact? Most certainly, that these alluvious banks have been accumulating during a period of *nine hundred* years; and probably much longer, as the freshes since the first discovery of the country, have not risen over them, more than once in twenty years. No doubt the number of layers is *precisely* the same as that of the freshes."*

* Stoddard's Sketches, page 383.

Admitting this statement to have been perfectly correct, let us examine it with a view to ascertain the probability of the conclusions which are drawn.

In the height of about forty feet, there are nine hundred layers, each of which is supposed to be the result of an inundation, or overflowing of the banks. Now forty feet divided by nine hundred gives four eighths and $\frac{240}{900}$ of an inch, in each layer or deposite. Then let us suppose that the upper half only of the bank, or twenty feet, has been overflowed but once in twenty years, (which he says has been the case in their *present* state, "since the discovery of the country.") it follows, since about half an inch is the amount of each deposite, that it would require the space of nine thousand six hundred years to have formed the upper half of the bank.

But lest this should be considered too great a proportion, that has been so seldom overflowed, I will take only one fourth of the height (viz.) ten feet; and even this would require, at that rate, about four thousand two or three hundred years to have formed it, instead of nine hundred, the time allotted for the formation of the whole height, according to Mr. *Stoddard's* calculation.

If we were to admit that these entire banks were formed by the overflowing of the Mississippi river, and that each layer was the result of an annual inundation, the whole of which requiring nine hundred, or even eighteen hundred years for their completion, the question very naturally presents itself, since Mr. *Stoddard* is unwilling to admit that the great valley of the Mississippi was ever a lake,* what was the Mississippi doing for the space of about four thousand years previous? for we must admit that it has flown as long, perhaps, as that of any other river. Were there no alluvial deposites in those days; no annual inundations by long continued storms of rain, and by the melting of the snows? Doubtless there were: but it is highly improbable that the present banks of the Mississippi river, or those of any other rivers, except at the mouths of some, were formed by their annual alluvious deposites. Neither is it probable, that the different strata which present themselves in those banks, were each the result of an annual deposite; for we find in the section of a hill upon the margin of the great alluvial district, on the Atlantic, where probably no river has ever flowed, the same stratification, in parallelisms of one or two inches, as regular as the courses of brick in a wall. Examine those strata in a perpendicular section of the hill, at right angles from the first section, and they appear undulating, tortuous, or having various degrees of declination; so that all attempts to determine the time employed in their deposition and formation, is rendered abortive by this circumstance alone.

If the great alluvial district upon the borders of our Atlantic shores, and the alluvial banks of all our rivers were gradually formed by the annual deposites of

* Stoddard's Sketches, page 384.

alluvion from the overflowing of those rivers, we might reasonably expect, since it is well known, that in every spring and autumnal flood, from time immemorial, a great quantity of logs and drift wood is floated down their currents, and carried into the sea, or deposited in their beds, that we should find, particularly in the banks of rivers, some of their remains deposited in every foot of the alluvial formation, from the bed of the rivers to the highest point that is inundated : but this I believe *is not the case.* I have been zealous in my endeavours to obtain information on this point ; and in no one instance can I find, from the state of Maine to the Mississippi, that vegetable remains have been discovered between two or three feet below the surface, and about the medium depth of forty feet ; except in some swamps, where stumps and logs are sometimes found at the depth of four or five feet, buried, in the course of time, probably, by the decomposition of vegetable matter : and also in alluvial islands in the channels of rivers, where every foot of their depth, particularly of that part which receives the force of the current, discovers logs, brush-wood, bark, nuts, and leaves, promiscuously thrown together and buried by successive deposits of alluvion.

3dly. In the great alluvial district of which I have been speaking, and which contains, beneath its surface, almost from one end to the other, an immense and highly interesting cabinet of natural history, there are found, besides deposites of vegetable substances, great quantities of fossil remains, of fishes of various species, of birds, and in particular of various kinds of quadrupeds.

A part of a jaw, with a tooth, of what is supposed to have belonged to the spermaceti whale, has been found in Monmouth county, (New Jersey,) in the neighbourhood of Sandy Hook, in an extensive deposite of marine shells : and doubtless many more have already, or will be found in various parts of the alluvial district in New Jersey, and also in Delaware.

In Maryland, upon the eastern, and some parts of the western shore, there have been found the skeletons of whales, sharks, porpoises, and other large fish ; as also terrapins, and almost incredible quantities of fossil shells of various kinds, many of which are unknown to exist at the present day.

These substances, with great numbers of the teeth of sharks and those of other fishes of various sizes, are sometimes dug up in the marle or shell pits, but more frequently washed out of the banks of rivers, at low water, and are exposed on the shores. Sharks teeth are found at St. Mary's (Maryland) three inches in length, some of which may be seen at Mr. Peale's museum.

At Choptank, a species of very large scollops, resembling the Pectens Magnus, subrufus, of Lister, are washed out of the banks, with barnacles of an extraordinary size attached to them, and which may likewise be seen in Mr. Peale's museum (Baltimore.) In Virginia also the carcasses of whales, of sharks of a great size, of porpoises, of terrapins, and shells of various kinds, in immense quantities, are found in digging of pits or wells, or washed out of the banks of rivers, at, or near *low water mark*, and in one instance fossil remains of a bird of a large size*.

In North and South Carolina, similar discoveries have been made—in one instance the skeleton of a shark, forty feet in length, was found nearly entire, some of the teeth of which are nearly four inches broad at their base, and may be seen in the cabinet of the Literary and Philosophical Society, in New York.

The circumstances of the fossil remains of fishes of various kinds, being so widely distributed over such an extent of country, is calculated to excite, in the enquiring mind, a degree of wonder and astonishment; while with many, it is viewed with a cold and inexcusable indifference; either because it so frequently occurs, and is so common; or, with others still more enlightened, because occurrences of a similar nature, as is supposed, are frequent, and have long since been known to exist in different parts of the world. But if the subject were examined with due attention, and the various circumstances considered in all their bearings and relations, few would hesitate to acknowledge, that scarce a parallel case exists in the known world.

How, or in what way, those fossil remains were brought and deposited in the manner and where they

* See Philosophical Transactions, vol. IV, p. 437, and British Spy page 19, sixth edition.

are, it is impossible to tell ; or, in endeavouring to explain the secret, what method will bear most the semblance of, or approach nearest the truth, it is equally as difficult to say.

Some have attempted a solution of the phenomenon, in a way that has obtained considerable credit ; while others have advanced opinions unsupported either by reason or analogy.

But however plausible they may appear, it is not my intention, in the present instance, to discuss the merits of the former ; much less am I disposed to take notice of the latter. Two circumstances, however, I must necessarily take into view, in explaining my own ideas of the subject.

In the first place it is highly improbable that these fishes were floating alive, and naturally in their own element, and that they were caught or entrapped by a deposition of alluvion from the sea, in a natural state, and by which they were buried alive, and the alluvial district formed ; and for the following reasons.

There are *many points* of the *alluvial district,* which are actually higher than many parts of the primitive district on its borders, and particularly of the granite ridge ; consequently, there ought to have been alluvial deposites of equal height upon the latter likewise ; but this is not the case.

Secondly, If this district was formed by deposites from the ocean, when at that height, why do we not find those fossil remains of fishes and other marine animals, throughout the whole depth of the alluvial formation, and also upon the margin of the primitive district, as well as at low water, or nearly on the present level of the ocean? If fishes existed *before* this alluvial deposite, which *must have* been the case, as they are now found *below it*, in what appears to have been the ancient bed of the ocean, they must necessarily have existed during, as well as subsequently to, this deposite of alluvion: therefore we might reasonably expect to find them throughout the entire depth of this district; but this *is not* the case.

Thirdly, If the district in question were formed by deposites from the ocean, by which the fishes and other marine animals were buried; why is it that we cannot discover any of their remains, within a considerable distance of the primitive district, or granite ridge, which must be allowed by all, to have been the ancient border of the ocean, and at present the northern boundary of the alluvial region?

From the best information that I can obtain, no remains of fishes, (those of shell fish excepted,) have as yet been found to the northward of the Chesapeake bay, within about twenty or twenty-five miles of the granite ridge. It is, I believe, at about the same distance, that they are found in Maryland. In Virginia, they are found within a shorter distance; and as we advance to the southward, the distance from the primitive range seems to be still less.

To what this circumstance can be owing, I am unable to tell; unless, as we advance towards the gulf of Mexico, the waters of this part of the district were, originally, deeper than further northward; therefore, they very naturally frequented the waters nearer the primitive shore.

But, even admitting the truth of this supposition, it does not explain the cause of the detention of such numbers as are found, of various kinds; nor the means that were employed to bury them in the situation, and at the depth in which they, at present, are discovered; neither is it, at best, a matter of easy solution, upon principles that are wholly unexceptionable.

There are, however, certain traits in the natural history or character of fishes, that afford strong grounds, not only for a plausible, but a rational, hypothesis; and one, that is, perhaps, as well calculated to unfold the truth on this point, as that of any other.

It is a well known fact, that fishes of almost every description, are as easily disturbed, and discover as much anxiety or uneasiness, and are as easily affrighted, by an unusual agitation of the element in which they move, as men and animals in our common atmosphere during a gale of wind, or a hurricane.

This is well known to sea faring men of observation, and many others. During a calm, at sea, thousands of fishes are often seen sporting leisurely in the lucid waves; but the moment that a strong breeze of wind springs up, by which the surface of the sea is agitated, they disappear, and perhaps none of them are to be seen; but if there are, and particularly during a storm or gale of wind, their movements are quick, and discover much agitation.

They are also, in moderate weather, frequently seen in shoals, driving with surprising velocity through the water, from a point that indicates to seamen, a sure prognostication of an approaching gale of wind, or dreadful swell of the sea from that quarter. And are not the same characteristick habits, discoverable in almost every species of the winged tribes? Do we not see almost every individual of the feathered race disappear, at the threatning onset of a hurricane, to seek, in a safe retreat, a shelter from its destructive ravages? with this exception, only that the hated Sheer-Water, in sportive gambols, fearlessly skims the maddening billows, while the ship-wrecked seaman, with envious gaze, beholds it in safety, mocking the foaming summits that every moment threaten him with death.

Denon, in describing the approach of the Kamsin, or hurricane in Egypt, observes "The yellow horizon shewed the trees on its surface of a dirty blue; the *flocks of birds* were flying off before the clouds; the affrighted animals ran loose in the country, followed by the shouting inhabitants, who *vainly attempted to collect them together again.*"*

In the description of an approaching hurricane of dust at Lucknow (Hindostan) it is observed, "The birds were flying very high, making a terrible screaming."†

The fishes that annually ascend our fresh water rivers, during the spring floods, discover the same characteristick habits.

* Vol. II, p. 328. † Lord Valentia's Travels vol. I p 161,

During the prevalence of a rapid current, when the fresh is at its height, accompanied by a violent north east wind, it is well known by fishermen that "the fish will not run" as it is termed; they seek shelter under projecting points, and headlands, and in eddies where they are less disturbed.

In some instances, when the waters are turbid with alluvion, they run into the small creeks and auxiliary branches of larger size, and not knowing their situation on account of the water being so charged with mud (for fishes cannot see better in muddy water than man in a thick fog or smoke,) they pursue their course through a wide extended flood, which overflows the meadows and low grounds, into orchards and cornfields, where, on the sudden falling of the water, they are often left in little ponds in low places. This is sometimes the case with shad, but more particularly with herrings, which have, in this situation, been caught, by thousands, with baskets and buckets.

It is also said, that whales by coming too near the stream or current of the Maelstrom, are caught in its yawning vortices; in which situation, it is impossible to describe the dreadful noise they make in their fruitless struggles to extricate themselves from the inevitable destruction that awaits them.*

Admitting these facts, need we wonder, that while the whole Atlantic ocean was agitated by a current

*See Pontoppidan's History of Norway, page 79, and Brook's description of the Maelstrom.

flowing with inconceivable rapidity to the south, that thousands of Sharks, of Porpoises and smaller fishes, affrighted at the dreadful onset, should endeavour to flee from its threatening influence, and seek safety in the less troubled waters of the deep bay of Mexico; or along under the ancient borders which skirted this extensive gulf on the north? *Need we wonder*, while, at this portentous epoch, avenging heaven was threatening universal ruin; "when every living creature that creepeth upon the face of the earth" was soon to be destroyed; and man, the outcast, awaiting his hopeless doom, that the great Leviathan of the deep, hurried by a resistless current from his wonted haunts in the cold regions of the north, should seek peace and safety in this less troubled sea? To me it appears by no means improbable; and if we admit the supposition, it is easy to explain the cause of their being detained, and buried in such numbers where they are; for as soon as the ocean had risen to such a height as to flow across the continent, the flood or current, being thickened with mud and earth which it had raised in its course, was carried into the bay or gulph of Mexico, by which they were involved in thick darkness, (to them,) and as the alluvion was deposited, they were literally deluged with mud, and buried alive where their remains are now found.

This affords a satisfactory reason why the skeletons of fishes, that are found in this district, are almost entire, that is to say, the bones, though disjointed by time, are nearly all found together.

An opinion is entertained by some, particularly those who believe that this district has been formed, in the course of time, by the alluvion thrown upon our coast by the gulf stream, that these were likewise thrown, either dead or alive, upon our coast, and subsequently buried by an accession of alluvion washed up by the ocean. But is it probable that the body of an animal can remain on the sea shore one or two weeks at most, exposed to an incessant agitation and abrasion by the billows of the ocean, without being completely disjointed, and the bones scattered upon the beach; particularly during the summer season? Nay, I will ask if there is a point between any two rivers, from Cape Henry to the Mississippi, where there has been a sufficient actual increase of alluvion to bury the carcass of a whale within twenty years? I doubt not! and if so, will any person contend that the carcass of a whale could have remained, under such circumstances, one twentieth part of that time, without being completely dissected, bone from bone, when *Bremontier*, in his new and interesting "*Recherches sur le movement des Ondes*" tells us, that the pebbles upon the sea shore, in many places, are, by the action of the surf, ground to the most "impalpable molecule (powder) insomuch that its specific gravity scarcely exceeds that of water, and is hence borne away with the tides into the sea, or, when the tides are at ebb, becoming dry upon the beach, is taken up by the winds and carried further inland in clouds of dust.

Under such circumstances, it is impossible to admit that the district in question, could have been formed by the alluvion washed up by the sea; nor in any other way than by a current setting across the continent of America, from the north east to the south west, or from north to south. This I hope will be made to appear satisfactory by the following facts and conclusions.

I have observed, that among other fossil remains, found in the alluvial regions, were those of quadrupeds.

In New Jersey, fossil bones and teeth or grinders of the Asiatick elephant, have been found of an immense size.*

On the eastern and western shore of Maryland, these remains have likewise been found.

In digging a well in the star-fort of Fort M'Henry, a tooth of the Mastodon (or Mammoth) was found at the depth of near sixty feet below the surface.

On the eastern shore of Maryland, in Queen Ann's county, an enormous grinder of the Asiatick elephant was likewise dug up, on the plantation of Mr. *Carmichael*, enveloped in a stiff blue clay. This I have in my possession.

Since the above grinder was discovered, I have received information from a very respectable source, that a pair of large horns of the deer kind were found,

* For particulars relating to these, and a variety of other interesting facts of a similar kind, see the New-York edition of Cuvier's Theory, by Dr. S. L. Mitchell.

with the carcase of a whale, in digging in the marle or shell pits on the eastern shore of Maryland.

In the marle pits, near Easton (Maryland) fossil vertebral bones, apparently of quadrupeds, have been dug up, some of which are more than six inches in length, by about five in diameter: in others, of which I have specimens, the diameter is greater than the length.

In the summer, I believe, of 1811, the bones of a mammoth were dug up on the banks of York river, (in Virginia,) from *below low water mark,* in the mud.*

In digging the Santee canal in South Carolina, the bones of a mammoth were dug up, and are at present, it is believed, in the library at Charleston, together with other bones and teeth, which it is said resemble those of the horse; but which more probably belonged to a species of deer or buffaloe, dug out of the same canal.

Now the circumstance of the fossil bones of quadrupeds being found in an *alluvial* formation, *below, at, and a little above, low water mark, in a district that has, beyond all possible doubt, been once occupied by the ocean,* goes far to establish three very important facts.

The first is, these animals, not having been inhabitants of the sea, *could not* have been *washed* up by the ocean and deposited where they are.

* For a knowledge of this fact I am indebted to Dr. S. L. Mitchell, who, while in Congress, communicated it to me by letter.

2dly. They being, or having been land animals, and not in the habit of associating with whales, sharks, or porpoises, but being found with the remains of these animals, affords a very strong presumptive evidence, that they must have been conveyed *from the primitive soil*, or what was the ancient continent, to where they are now found.

In support of this, M. *Cuvier*, when speaking of fossil organic remains of quadrupeds found upon islands in the sea, says, "When they (the islands) contain any of the larger quadrupeds, these *must have been carried to them from other countries*."*

3dly. Since these animals were the inhabitants of dry land, it is highly improbable that they would voluntarily leave that situation, and go the distance at which they are found from the original or primitive borders of the continent, and deposite themselves BELOW *low water* mark, and that too when, probably, the ocean still occupied it; and since it is pretty plainly proved by the learned *Cuvier*, that some of these animals, as the mammoth, were extinct before mankind inhabited the earth, they must have been carried there by force; and since no common means could have effected this operation, we are compelled to refer it to the operations of a general current that flowed from the north,† and by which, they, with the whole mass of

* Cuvier's Theory, page 75.

† There is reason to believe that M. Cuvier, at least suspected that some of the existing phenomena may have been produced by

alluvial matter, were swept from the continent and deposited along on the borders of the Atlantic coast.

Such are the facts, and such appear to be the only rational inferences deducible from them.

But whether the currents, so often mentioned in this essay, are to be considered as having originated from the fall of torrents of rain, in ceaseless succession, for the space of forty days and forty nights; or, as is, by some supposed, from the approximation of a comet towards the earth; or from the outlet of the waters contained in the centre of the antediluvion earth—whether they originated from the dissolution of the polar ices, under *any* possible circumstances; or whether, in fact, the north pole *was* the great focus, whence these currents issued, or not, it is impossible to determine.

It is a subject from which the human mind, in the eager pursuit of truth, *must and will ever be repulsed:* for the circumstances *essentially* important to its elucidation, are veiled in impenetrable mystery.

We have before us, the book of inspiration; and in it we are told of the universal deluge or flood, which by its operations, was to *destroy every living thing that had been made, from off the face of the earth.*

this or a similar cause; for in his remarks on fossil organick remains, he observes, "May it be concluded, that the transportation of these living organized bodies, if such a thing ever happened, has taken place *from north to south*, or from east to west; or was it effected by means that irregularly scattered and mingled them together?" (Theory of the Earth, page 66, Am. edition.)

In the great volume of nature, we see its effects, which appear to be scattered over every region, or habitable portion of the globe; and we are left free, to contemplate and trace them to their cause.

These effects, so multiplied and various, so obviously plain and intelligible, inform us in a language that cannot be misunderstood, that in America, they were produced by currents which flowed across the continent from north to south; and in Asia and a part of Europe, from south to north.

To these facts, the attention of the philosopher and the votaries of science are earnestly invited.

The interest which they are calculated to excite, will richly compensate for the trouble of an investigation; independently of the sublime emotions which the numerous and diversified objects of fossil organick remains, those "medals of creation" are calculated to inspire.

But this is not all. By an attentive examination of these facts, we shall, not only aid and assist in the great work,* so happily begun and advancing, but be enabled to trace up, in successive gradations, and to comprehend the various physical changes that have taken place, since this earth has been rendered the fit habitation of organized beings.

To attain this point, we may be considered as having arrived at the *ne plus ultra* of human sagacity and penetration, as it respects the science of geology.

* See Parkinson's Organick Remains.

For, although it is admitted that the Huttonian theory is, in some instances, not without support; and that the Wernerian theory, in its general principles appears not only plausible, but highly probable; yet, in the discussion of their merits, it may be asserted, without fear of contradiction, that he who attempts to explain, on the principles of either, the infinitely varied phenomena that are presented to view, in the structure of the globe; or he who attempts to reconcile the equally numerous and varied anomalies, glaring inconsistencies, palpable contradictions, and inexplicable facts, alike to those principles, will find himself, at last, involved in a labyrinth, so inconceivably intricate, that it will be impossible to extricate himself, except by plunging headlong, as many have already done, into infidelity; or, in humble submission, to *elevate his mind to the great author of creation, and to acknowledge his incapacity to comprehend the works of Him, "Whose ways are unsearchable and past finding out."*

CHAPTER VI.

Volcanick Agency.—Very frequent are the instances in which we *hear* of whole districts, in this country, that are *supposed* to have been subjected to the operations of subterranean fires, if not actually *produced by them:* and frequently we *hear* of masses of mineral substances being found, which are *said to bear* the unequivocal marks of having been produced by intense heat. Hence the conclusion, that they have been ejected from some, now extinct, *volcano.*

Among the many of this description, is that of the West River Mountain, (Conn.) which is represented, in the Annals of the American Academy, as well as in an American Geography, as being volcanick ; and from this place specimens have been preserved as the supposed lava of this extinct volcano; but which on examination, have proved to be nothing more than hematitic iron ore.*

This account was, probably, recorded at a period when much less was known, in this country, of mineral substances, than at the present time ; and particularly of volcanoes and their products. Hence, the

* See Bruce's Mineralogical Journal, page 19.

mistake is not so much to be wondered at, as that many persons, at the present day, should persist in contending that the mammellated and botryoidal hemaetite are the real products of fire.

Among the advocates for the existence and operations of subterranean fires, earthquakes, extinct volcanoes, and their yawning craters, in this country, no one seems to be more prominent and strenuous than Mr. Volney.*

Were we to rely upon the assertions of this author, we might take it for granted, that the principal part of the continent, east of the Mississippi, had been the great theatre of each and all of these physical evils; for he not only points out the different districts where their effects are represented as being manifest; but to their operations he attributes the "*confusion in which the Atlantic or maritime regions are at present found*;"† a region or district, which, in point of order and regularity, in the course and extent of the great and prominent ridges; of the uniformity and correspondence in the order and succession of the subordinate ranges, and of their respective materials, which may be traced in almost uninterrupted parallelisms from one end of the district to the other, may challenge a comparison in any known portion of the globe.

This, however, is not all. He even attempts to define the courses and limits of these hidden agents of

* See Volney's Views of North America, page 97 to 101.

† Page 99.

destruction; and says, "The line of this subterranean fire runs north west and south east, affecting strongly the direction of the sea and lake Ontario." The latter of which, to cap the climax, he considers, on account of its great depth, as bearing the most indubitable criteria of its having been the great focus of a volcano; for he observes, "From these circumstances, the inference is *clear, that the bed of the lake*, (Ontario,) is the crater of an extinguished volcano." And as a confirmation of this he further observes, "This conclusion is strengthened by the *many volcanick* substances found upon its shores, and of which skilful eyes, would, no doubt, discover many other specimens."*

What the nature and character of the substances are, of which the shores of Ontario abound, and which are said to bear the marks of volcanick origin, no one that I know of, has, as yet, undertaken to give a description; neither are we better informed of the "numerous remains" of volcanoes, that are said, by the same author, to exist on the Alleghany mountains.†

If the lapis suillis or foeted carbonate of lime constituted the numerous remains, of which Mr. *Volney* speaks, he doubtless may have seen, on this ridge, the greatest abundance; and which, it is believed, bears as close a resemblance to volcanick products, as that of any other that can be found there, since the *whole*

* Volney's View of America, p. 99. † Do. page 100.

ridge is represented, as being exclusively of a *secondary formation.*

Without attempting further comment upon the opinions of this *Great Writer,* it may be observed that when travellers or historians, however eminent their acquirements, or elevated their names and reputation, attempt a description of the geology of a country and its minerals, and we hear them substitute the term "*talc bank,*" or "*bed of isinglass,*"* for a granitick ridge five miles in width and several hundred miles in length—when, moreover, we hear them speak of "granite marble,"† and "calcareous granite,"‡ we have much reason to suspect, that their knowledge of the subject is extremely superficial or inadequate; or that they have acquired their information, on this subject, from some source out of the common order; or one that is not known and recognised by the geologists of the present day.

The geology of this country, as well as that of almost every other, presents numerous appearances that are calculated to mislead a superficial observer, and to induce a belief, that they were decidedly of volcanick origin: while a more careful investigation, by a more experienced eye, would produce a contrary belief.

The Chevalier *Lammanon* was so firmly convinced that the trap formation of the Alps of Champsaur,

* Volney's View, p. 100. † See Shaw's Travels.

‡ Ali Bey's Travels.

was of volcanick origin, that he wrote and published a work in support of his theory.

But a more mature reflection and critical examination of the substances, produced a conviction of his errours in a degree so forcible, that he not only suppressed but destroyed the whole edition, with the exception of twelve copies.*

Although it is very much doubted whether subterranean fires and volcanoes ever existed in this country, east of the Mississippi; yet it will readily be admitted that many instances have occurred, in which substances have presented themselves, bearing strong marks of their having been subjected to the operations of intense heat; and hence have been considered as of volcanick origin.

In a number of places in the secondary range which runs through the state of Connecticut, masses of this kind may be found.

In the town of North-ford, I believe, numerous fragments of this description may be seen in passing along the road. They are composed of an extremely porous trap or whinstone, which actually appears to have been in a state of fusion; but which, however, on a close examination, will not, from a variety of circumstances, justify such a conclusion. Among these the following are not of the least importance.

The blocks which I had an opportunity of examining, were, probably, detached portions of the great

* See St. Fond's Travels, vol. I. page 23.

mass that forms the upper part of the ridge extending from New Haven, into Massachusetts, commonly called the West Mountain. This part of the ridge is composed of trap or whinstone. In some parts it assumes a columnar form, standing almost perpendicularly. In others, it is composed of enormous broken and shapeless masses of the same materials, slightly connected, and easily broken up; and among which, may be found in abundance, splendid specimens of phrenite, zeolite, &c. particularly in the neighbourhood of Simsbury.

Among this latter kind of trap, a great quantity may be found, filled with small spherical masses of zeolite; on being long exposed to the atmosphere and changes of weather, the zeolite is probably decomposed and disappears, leaving a complete porous mass which much resembles the *bulleuse* lava, and as such, it is well calculated to impress a belief of its having been, at least, modified by the agency of subterranean heat or fire. But all ideas however of this kind are dispelled, when we examine the structure of this mountain, and find, that its base for many leagues in breadth, is composed almost entirely of old red sand stone; the most decided and unequivocal evidence, on the contrary, of its Neptunean origin.

The part in particular on which the ridge of trap rests, is, in many places, considerably more elevated than the adjacent country, particularly at New Gate in the town of Granby, and having a dip or declination, of from thirty to forty-five degrees to the east.

Under these circumstances, it seems impossible that either the columnar, or irregular and porous trap can owe its origin to, or even be modified by, the agency of subterranean heat, while its substruction, the red sand-stone, discovers not the least possible indication of a similar agency.

It is this important ridge or mountain, bounded on the east and on the west, by others composed of primitive and transition rocks, which renders the mineralogy and geology of Connecticut so highly and particularly interesting; and, at the same time, gives to New Haven a decided superiority over any other situation in the United States, for the cultivation of those two sciences.

From Yale College, that fountain of literature, and where those two sciences are cultivated with the most happy success; an individual, or the whole mineralogical class may, in the space of two hours enter upon the primitive range; observe and examine through the various gradations and transitions, the order, structure, and arrangement of the various strata that compose it.

From thence, in a short space of time, they enter upon the secondary district, and at the foot of the West Rock, (so called) the base of which is red sandstone, they contemplate with mingled emotions of awe and pleasure, the abrupt and lofty battlements of columnar trap, whose mouldering fragments have, for ages past, been tributary to the soil below; and on the surface of which, vast masses, burst off by the frost from the heights above, are still lying in undisturbed disorder.

From thence they can ascend the height, and from its lofty summit, behold, in one extensive view, all the varieties of the most prominent and important features that are embraced in the science of geology.

On the left, to the south east, is a range of hills, being, probably, the southern extremity of the East Mountains, so called, composed mostly of granite differently modified.

Immediately on the left, to the east, is the east rock, which, like the height from which it is viewed, is secondary and composed likewise of different substances.

On the right, to the west and south, is seen a range of bold hills, composed principally of amphibolic rocks variously modified; and also some others, which together, form an extensively interesting field of study to the geologist. Besides these, the districts which I have mentioned contain a very extensive variety of minerals common to these formations, which render the district equally as interesting to the mineralogist.

Immediately in front, and as it were at the feet of the observer, lies the beautifully extended plain on which New-Haven stands, which is perfectly alluvial.

Under such circumstances, and possessing such superiour advantages; it may safely challenge a competition with any other situation in the United States, as being best calculated for a mineralogical and geological school; and, while conducted by one whose conciliatory manners, zeal, and unceasing exertions in the cause of science, are so universally known, we may safely predict that the time is not far distant when it may vie with the Wernerian school, and become the Friberg of America.

CHAPTER VII.

All the different formations, &c.—Hitherto, Geologists, in giving a description of the different materials that enter into the composition of the globe, and also of its formation, have pretty much confined their views to two grand divisions, (viz.) the primitive and secondary; the first of these having a reference to such rocks as are destitute of organick remains; and the last, to such as are composed in a greater or less degree of organick remains. In these, the subject of alluvial deposites, which is in itself, to a certain degree, a formation, is left entirely out of view, or if taken notice of, it is in connexion with all secondary formations. But in a careful examination of the subject, I can see no impropriety in considering it as a distinct formation, and as justly entitled to the appellation of ternary, as the latter of the other two, to that of secondary.

The idea of alluvial formations or deposites being considered as a third or ternary formation, and distinct from the other two, may be objected to on the score of its being, in general, made up of materials *already* previously formed. The same may be said of secondary or shell lime-stone, and several other secondary rocks: and who can say that the several constituent parts of the primitive rocks were not formed, previously to their aggregation?

2dly. It may be objected to, on account of the difference in the several results, that are manifested in rocks of secondary formation, and those of alluvial districts.

3dly. It may be objected to, on the score, that while secondary formations are the results of a natural operation; alluvial formations are the results of accidental operations, consequently, differing materially in their essential characters.

With regard to the first objection, the remarks which I have already advanced in reply, I consider quite sufficient.

In reply to the second, it may be necessary, in the first place, to observe, that by "the difference in the several results," I have a reference to the various materials that enter into the composition of secondary and alluvial formations, and their different modifications. In this respect, it must be admitted that a very great difference exists, not only in their texture and composition, but in the process of their formation. Yet as great as it is, the difference between alluvial and secondary formations, is not greater than that between secondary and primitive.

To place the subject in a proper light, it may not be amiss to present a slight view of the two formations separately. Rocks of secondary formation are various, but I shall only take notice of such as contain organick remains; such as secondary or shell limestone, containing various species of shell-fish and other animals, completely changed in their nature, and, by being combined with carbonate of lime, formed into a compact or solid mass, and susceptible of being wrought into various shapes or forms, and of being converted to sundry useful purposes.

Also, secondary gypsum, containing impressions of a variety of fishes, and animals; likewise, secondary slate, containing perfect impressions of fishes and of various vegetable *substances*, which, though changed in *substance*, have suffered no change in form.

In these several rocks are often found different mineral substances, such as lead, zinc, &c.

The alluvial formation is generally composed of sand, gravel, and rolled pebbles of different kinds.

In this formation, notwithstanding its being, as I have observed, the result of an accidental operation, we likewise see the mineralizing powers exerted, though in a far weaker degree, and the process of new formations carried on, though upon a much smaller scale, and to a far less extent.

In this formation, we find beds of bituminous wood, and coal; petrified wood; immense beds of variously coloured clays; extensive mines or beds of fine argillaceous, and bog iron ores; beautiful crystals of selenite, &c. These and many other substances are found in place in various parts of the great alluvial district, on the Atlantic coast. The only alluvial rocks that are found in this district, are those of sand stone, which are evidently the results of an alluvial formation.

In alluvial deposites, in almost every country, are likewise found, immense quantities of animal remains, though in a state very different from those which are found in secondary formations.

I have remarked, that secondary formations are, generally, the results of a natural operation, or in other words, they are natural deposites from water, probably, in a state of perfect tranquillity. And that alluvial formations are the results of accidental operations; for in almost all instances, they are amassed and formed by the operations of currents, which have been produced by natural or accidental causes.

I have also remarked that a great difference exists, not only in their texture and composition, but in the process of their formation.

This is so striking, that while it constitutes a distinctive characteristick between the two formations, it affords an interesting subject of inquiry, as to the principles, by which secondary and alluvial rocks, and the animal and vegetable substances therein contained, were solidified; and also, the difference of time required in their productions.

It is, I believe, a prevailing opinion with many, that almost all secondary rocks, as well as those of the primitive kind, must have required a long and tedious process in their formation, by precipitations, crystalization, &c. and which must have occupied an immense period of time for their completion.

How it may be with primitive rocks, I shall not attempt to say in the present instance; but a careful examination of the structure of the secondary kind, which I have already mentioned, will by no means justify such an opinion. On the contrary, there are certain indications in many of them, which justly warrant the belief, that their formation must have been inconceivably quick and rapid, and particularly those which contained the remains of organized bodies of fishes and other animals, in a state of preservation so perfect, as to enable the naturalist to determine, on the slightest inspection, the class, order, and species, to which they severally belong.

This conclusion is drawn from the following circumstances:

1st. Fishes and other animals, found enveloped in solid limestone, plaster, or slate, and possessing their *natural* form and character, afford strong reasons to conclude, that had the precipitation and formation of the rock, or substance in which they are contained, been slow or gradual, the superincumbent weight must have had a great tendency to have destroyed their natural form, by compressing them, while soft and yielding, into a thin and almost shapeless mass.

But this is not the case. We see innumerable instances in the sections of various kinds of secondary marbles of Europe, where different species of the tribes of molluscae and shell fish, are represented almost as perfect, in every particular that relates to their form and structure, as when living; except, that their substance is changed into perfect carbonate of lime, or like the substances which surrounds them. This is so common, and so often met with that it is unnecessary to mention any particular case.

2dly. Lapidified fishes have been found in numerous instances, and in various parts of the world, inveloped in gypsum and slate rocks; possessing all their characters, as it respects their form, size, stripes, marks, spots, and even colours, in some specimens, so perfect as to enable the experienced naturalist to determine the species to which they belong almost at sight.

"Petrified fishes have been discovered in solid rocks in the very attitude of seizing and swallowing their prey."*

In a specimen obtained from Vestena Nuova and exhibited in the Museum of Natural History at Paris, "is seen a pike which has died with another fish of the same species still in his throat."†

"Many of the fossil fishes found in the slates of La Bolca, have, from their state of preservation, been recognized as belonging, in particular, to those of the south sea."‡

"A workman, in attempting to square a stone, obtained by demolishing the Abbey of Vaucelles, split it into two parts; one of which exhibited the impression

* See Bakewell's Introduction to Geology, p. 442.

† See Parkenson's Organick Remains, Vol. 3, p. 252.

‡ See Shirwan's Geological Essays, p. 71.

of a fish, and the other the fish in relief. The fish was examined by the professors of the College of Cambray, who repaired on purpose to the spot. It results from their observations, that it is one of the most beautiful and best preserved ichthyolites ever found. It is from twenty eight to thirty one inches in length, and seven inches in breadth."

"Every circumstance gives reason to think, that it belongs to the class of the abdominals, and that it is a salmon. The scales are of a *violet colour mixed with yellow:* a latteral line of *a pale white,* and nearer the back than the belly, traverses the whole body, and describes on it a curve. The *colours of the impression* are the same as those on the relief."*

"Our country hath lately afforded (says Mr. Jones) what I apprehend to be the greatest curiosity of this sort, that ever yet appeared. It is the entire figure of a Bream more than a foot in length, and of a proportionable depth, with *scales, fins, and gills, fairly projecting from the surface* like a *piece of sculpture in relievo,* and with *all the lineaments, even to the most minute fibres of the tail,* so complete, that the like has not been seen before. It was taken from the stone quarries of Barrow in Linconshire, &c."†

From these few cases of fossil fishes selected from many, so palpable and strikingly interesting in their kind, we may reasonably infer that their inhumation

*Tilloch's Philosophical Magazine, Vol. 18, p. 371.

†See Parkinson's Organic Remains Vol. 3 p. 250.

and the subsequent process of their petrification must have been the result of an operation as rapid in its progress as incomprehensible in its nature: for, supposing the substance, of which the rocks that contain petrified fishes, are composed, were to be precipitated or deposited from any menstruum, according to our ideas of that process, it is both morally and physically impossible for any dead animal substance to retain all its natural characters, a sufficient length of time to admit the lapidification of the rocks and the animal substance itself, without a material change or alteration, except, at a temperature but little short of the freezing point.

Almost all dead animal bodies when entire, and particularly fishes, will remain but a very little time in fresh water, without being subjected to three material changes; neither of which are discoverable, that I know of, in petrified fishes.

In the first place, they all become more or less bloated, a mark which I have never seen mentioned as it respects fossil fish. This, however, would depend on the degree of temperature of the medium to which they may be subjected.

2dly. They very soon change in colour, and become of a pale white; the eyes sink and assume a livid appearance.

3dly. Every part except the scales in fishes soon discovers a progressive state of dissolution, which tends rapidly, to mutilate or destroy the characters essentially necessary to determine the species to which they belong.

Neither of these marks, we may reasonably conclude, are observable in the cases which I have quoted, for they are represented as being entire and perfect; and some of them transformed or changed, while in the very act of seizing and enjoying their prey.

It may be said, by some, that during the formation of those rocks, which contain the fossil remains of bodies so perfect, the earth was covered with salt water—but, even if admitted, it is no better calculated to preserve those bodies from dissolution, than if subjected the same time and at the same temperature, to fresh water. The water of the Ocean, although salt, does not constitute a pickle by which animal substances can be preserved; on the contrary, it is almost, if not equally as unfavorable to the preservation of animal matter as that of fresh water.

Hence the conclusion, that many of the secondary rocks, and perhaps some others, were, in their formation, regulated by principles, or subject to laws that were instantaneous in their operations, and during which, the whole mass of matter within the sphere of their action, whether stony, earthy, animal, or vegetable, was suddenly changed into a solidified mass.

That some invisible and incomprehensible means have been employed in this business, may be inferred from the opinions of several.

The learned Cuvier, when speaking "of incrustations" of bodies, observes, "But we have no evidence that the sea has now the power of agglutinating these shells by such a compact paste, or indurated cement, as that found in marbles and calcareous sand-stones, or even in the coarse lime-stone strata in which shells are found enveloped. Still less do we *now find the sea making any* depositions at all of the more solid and silicious strata which have preceded the formation of the strata containing shells."*

It is believed by some, that volcanoes or subterranean fires have been powerful agents in the production of these phenomena; and it is said of the specimen of the pike that was found at Vestena Nuova, and now in the museum of natural history at Paris, that its instantaneous death is supposed to have been produced by a sudden volcanick irruption into the water, at the moment of its having swallowed its prey.†

How far this opinion is entitled to credit, we are left to determine from the circumstance, that the Vestena Nuova contains thousands, and perhaps millions of fossil fishes of various kinds, in all situations, and at *different depth in the rocks.* Now it would have been, not only an unlucky, but truly a singular event, if so many myriads of them should have been caught by "a sudden volcanick irruption into the water" and preserved perfect and entire, until deposited in their

* Cuvier's Theory of the Earth, page 34, London edition.

† Parkinson's Organick Remains, vol. III. page 252.

different situations in the rocks, and there retained until the whole mass was lapidified.

But admitting that the pike in question, with all the others in the Vestena Nuova; with those found in the slate of La Bolca, and in the copper slate of Thuringia, which is full of them; also those in the stinkstone slate of Oenigen; and of Verona; the black slate of Glacis; of the white slate of Acihstedt, the plaster quarries about Paris, and numerous other places, together with the singular specimen of the bream and salmon which I have mentioned, was killed by a sudden volcanick irruption into the water, it does not explain, by any means, the modus operandi, by which they were preserved perfect, until they, with the surrounding matter were changed into rocks and petrified masses. I do not wish it to be understood that in all the instances which I have enumerated, the fishes are petrified; in many they only present beautiful and accurate impressions.

That thousands of fishes have been killed by submarine volcanoes, or by a discharge of electrick fluid from the depth of the ocean, there can be no doubt;*

* The following interesting facts are related by Mr. Salt as having occurred in his passage from Mosambique, to Aden near the straits of Babel mandel.—"At one o'clock in the afternoon, when distant about five leagues from land, we met with a shoal of dead fish, many thousands of which lay floating on the surface of the water, and we continued to pass through them about *five and thirty minutes*, sailing at the rate of *two leagues* in the hour. Many of these fish were of a large size, and of several species, chiefly of the

but to place them in the situation and order in which they are found, and to change their substance, with the surrounding matter, into solid stone, seems to require the existence of laws, and the operation of agents of which no human mind has, hitherto, formed a just conception.

What were the principles of those laws, or the nature and character of the agents employed in the production of these wonderful phenomena, it would be not only hazardous but the height of folly, in the present instance, to attempt a definition Opinions, however, have been advanced on a subject intimately, if not immediately allied, and some of which are truly worthy of notice.

La Place, in his "*Exposition du systeme du monde, tome 2d, page* 301, *in 8vo,* asserts that the terrestrial globe, with the other planetary bodies has been formed by the concretion of an aeriform fluid emanating from the sun.

Of this opinion, however, I have nothing to say, no further at least, than to observe, that from it, it is pre-

genera sparus, labrus, and tetrodon. They bore the appearance of not having been long *killed*, from the freshness of their colour and the redness of their gills.

"In the evening we passed another shoal of dead fish, which had become quite *white and putrid.*" Of the cause of the death of these fishes there can remain no doubt; yet, Mr. Salt observes, "an occurrence of this nature is extremely rare, especially in deep water, and I cannot in any way account for it." (Salt's Travels, page 81.)

sumed, Patrin conceived his ideas of the formation of many of the earthy and crystalline substances, ejected from volcanoes, which is not, however, by the operation of heat, but, by the combination of various gaseous fluids, assisted, or modified by electricity.

On this subject his reasoning is forcible, clear, and scientifick, and in many instances strengthened, by well attested facts, collected from the observations of several distinguised naturalists, as eminent for scientifick acquirements, as of sound philosophy.

Among these, *Buch*, in an excellent memoir, has demonstrated, with every appearance of truth, that the leucites, so very abundant in the lavas and tufas of Italy, are of a formation *subsequent* to the ejectment of the lavas.

Faber, and other enlightened naturalists are likewise of the opinion, that those crystals were of a subsequent formation, to that of the ejection of the lavas.

Mr. *Thompson* remarks, that he observed accicular crystals of augite, *sublimed and adhering to the walls* of a church, which was buried by the lava of Vesuvius in 1794. A circumstance *that proves, incontestibly*, the formation of crystalline substances independently of the agency of water; and most probably by a combination of aeriform fluids.

The interesting account which the learned Dolomieu has given of the volcano of Stromboli, in one of the Æolian isles, and Macalouba, near Agregente in Sicily, affords abundant proofs of the daily formation of earthy and stony substances, by the combination of aeriform, or gaseous fluids assisted, probably, by the operations of electricity.*

A short time after *Patrin* hadread before the National Institute his memoir or theory of volcanoes, *Guyton Morveau*, rendered to the Institute, at the setting of the 6 floreal, Ann. 3, (26th April, 1800,) an account of various experiments made under his own eyes, which proves, 1st. "That lime is composed of azote, hydrogen, and charbon."

2d. "That *Magnesia* is composed of lime and azote, (i e.) of the same elements as lime, with a superabundance of azote."

3d. "That *Soda* is composed of magnesia and hydrogen."

4th. "That *Potash* is composed of lime and carbonated hydrogen."†

Sir *Humphrey Davy* has, however, by a series of successful experiments, since proved what *Humboldt* and *Lavoisier* had long ago suspected of the earths in general, that, at least, some of them are composed of metallick oxids.

This may possibly be true, with respect to all the earths, without invalidating in the least, the opinion that all earthy and metallick substances may have been formed by a combination of aeriform or gaseous fluids, modified or assisted by electricity.

* See his account of the Lipari Islands, pages 113 and 153.

† Patrin, vol. V, page 223.

Humboldt found by experiments, that the gas which he had collected in the mines contained iron in solution.*

He likewise detected an earth in solution, in what is termed the electrick rain waters.†

But waving all comments on the above experiments, and admitting the possibility of earthy and metallick substances being formed in the small way, or upon a small scale, by a combination of aeriform fluids, modified or assisted either by electricity, or any other agent, we hazard nothing in saying that similar results may be expected from the operation of the same agents upon the large scale. Indeed, a careful and attentive view of the subject, at least, so far as relates to that class of rocks which I have mentioned, will justify the conclusion, that some analogous process must have been employed in the formation of those districts which contain, in the greatest abundance, and in an infinite variety, organick remains of animals completely lapidified, and in a state of preservation so perfect, that every essential characteristick of their several species is still retained.

Such a state of things seems, conclusively, to be incompatible with the igneous, or humid process of formation, particularly the latter, and for reasons which I have already advanced.

That a change of matter, or the formation of substances, upon a scale so extensive, and, at the same

* Patrin, vol. V, page 252. † Vol. V, page 255.

time, so stupendous in its kind and appearance, should be produced by the operation or agency of either electricity, or galvanism, separately or combined, seems, to our limited understandings, not only incomprehensible, but both morally and physically impossible.

But from the vague and imperfect knowledge which we at present possess, of the power and operations of those agents, particularly the former, we are incapable of forming an adequate conception of their operations and effects in the great scale of nature.

Yet from the knowledge we have acquired of the subject, if we reflect upon the surprising results produced by the operations of these two powerful agents, while under the management and control of man, and which are daily made manifest to our senses, what may we not expect from them, when under the direction and control of Omnipotence. Results the most stupendous and awful have been, but too often, witnessed in almost every part of the world, and such as to leave no doubt in the mind of any one, that others still greater and of a more novel kind, may have been the effects of their operations; such as the formation of whole districts, which have suddenly risen, new formed, above the waters of the ocean, embracing in their limits, millions of organised bodies, that have been caught in the solidified mass.

CHAPTER VIII.

A general current having prevailed, &c.—Not only does this continent present abundant and undeniable proofs of the prevalence of currents, both impetuous and extensive, over its surface, but also that of almost every other in the known world, that has been visited by men, capable of observing and tracing the effects of their operations. Yet, strange as it may appear, few indeed have ventured, after having pointed out their effects to explain the cause of these currents, the source from whence they flowed, the course which they pursued, or the periods of time at which they probably may have existed.

Had a Telas, Gmelin, Cronstedt, Faber, Pallas, Charpentier, Born, Werner, Arduino, De Luc, Saussure, Patrin, or a Dolomieu, turned their attention more particularly to this subject, they might have rendered still more important and essential services, to the science of Geology, by lifting the veil that obscures from our present view, the mysterious phenomena that are involved in this interesting subject, and thereby enabling us to contemplate it in a light, more consistent with truth and philosophy.

Had they, in their travels, sought after facts that point out the existence of once powerful currents which swept over islands and continents, lifted rocks from their firm foundation, and buried whole forests at an immense depth beneath the surface of new formed districts, that have been suddenly amassed by their operations, they would, long since have furnished us with numerous corresponding truths, which, on comparison, would be found to harmonize with those of a similar kind, in every district of the globe, and enable us to establish something like a rational theory or system by which to regulate our opinions, and direct our researches in those hidden and obscure operations of nature. Instead of which, however, their remarks on this head are few, vague, and unsatisfactory, and such as to afford but very little assistance in determining whether the currents which appear to have overrun different parts of the world, and the effects produced by them, were cotemporaneons with those that appear to have overrun our own continent.

This being the case, I shall proceed to notice some of the facts that have been stated, relative to supposed currents, and their effects, with a view to see how far they correspond with similar facts observable in various parts of the continent of America, (and which I have before mentioned) and also, to see how far they will warrant the inferences already advanced, relative to the cause of those currents, and the source or sources from which they flowed.

The great and cautious Geologist Saussure, observed in various instances, indications of the destruction of mountains by inundations—"that near the Kaptindei, in Siberia, had evidently its sides torn off by an inundation"*

La Metherie supposes that the fresh water shells and remains of quadrupeds, about Paris, were deposited in their present situation by *marine currents.*

Among the numerous indications of the prevalence of currents which present themselves in almost every quarter of the world, no one offers a stronger evidence or proof of their existence and operations, than the immense deposites of fossil wood that are found at considerable depths in the earth, and in every country upon it. They not only afford the strongest proofs of the existence of currents, but they afford, at the same time, the most striking correspondencies in relation to the period or time in which they were, in general, deposited, and also of the means by which they were accomplished.

In America, as I have before remarked, the deposites of fossil wood, are, upon an average, from 40 to 50 feet below the surface; and in many instances, *below low water mark,* in a bed of bluish clay, or mud, resembling sea bottom. Below this point, it is not probable that trees could ever vegetate and arrive to maturity. The same or very similar facts will be found to exist in Europe, Africa, and probably Asia.

It is stated that "trees, much resembling the laurel

* Kirwan's Essays, p. 380.

and the olive were buried in almost the whole of the mouth of the red sea; and which, during the ebb, were sometimes exposed and from the flowing in of the tide, were torn up."* This he observes is very astonishing; since even higher up in the country no trees are to be found.

Eratosthenes relates the same circumstance as observable in the Persian sea.†

De Boot remarks, that "near Bruges, in Flanders, upon digging to the depth of 50 feet, whole forests were found; the leaves and the trunks being so little altered, that the different species of the trees which had fallen yearly, might also be distinguished."‡

Buffon relates, on the authority of Rommazini, that for four miles round the town of Modena, on digging to the depth of twenty six feet, entire trees, as filberts with nuts upon them, and great quantities of branches and leaves are found, and at the depth of forty nine feet they came upon a second stratum of fossil wood and leaves, extending to the depth of sixty feet or more. This last or lowest stratum is probably the lowermost deposite of vegetable matter, and corresponds, not only with the preceding case, related by De Boot, but with numerous others of a similar kind that occur in America.

Dr. Plott remarks, that at Wattington Park in Oxfordshire, at the bottom of a pond, were found some

* Strabon Geography, lib. 16.

† Vide Parkinson's Organick Remains, vol. 1, p. 53.

‡ Vide Parkinson, vol. 1, p. 55.

tons of oak, and a pit being sunk *fifty* or *sixty feet* deep, many whole oaks were found, one of which was upright, and one also perpendicular, but *inverted*.*

In Dr. *Richardson's* account of the fossil trees at Youle, in Yorkshire, it is said, that some of them are one hundred feet in length, and their tops all lie in one direction.

Similar remarks are made of the subterraneous trees of Hatfield Chase, by M. *De la Pryme*: "Infinite millions of trees and roots are found under the space of one hundred and eighty thousand acres of land, the tops of which trees commonly lay north east."†

Subterranean forests have been described, by various writers, as being found in numerous instances in different parts of the world. The Rev. *W. Borlase* has given an account of subterranean trees found on the shores of Mounts bay, Cornwall.

Another is mentioned as extending under the sea on the coast of Lancaster, between Liverpool and Preston, (England.)‡

Another at Sutton in Lincolnshire, (England.)§

M. *Autenreuth* has discovered, near Canstadt, a subterranean forest of *Palms*, many of which, are two feet in diameter.¶

Mr. *Rennell* observes, that "when the great reservoir was dug in the city of Calcutta, whole trees were

* Dr. Plott, page 161.

† Vide Parkinson's Organick Remains, Vol. I page 65.

‡ See Bakewell's Introduction to Geology, page 260.

§ Organick Remains, vol. I. page 71 ¶ Vol. 3, p. 429.

found at a great depth."* These, and many more, are mentioned, but as nothing is said of the depth at which they are found below the surface of the earth, it is unnecessary to describe them, with a view to the correspondencies, which are observable between them and those of America.

Were other proofs, of the existence and operations of currents, wanting, I might quote whole pages on the subject of deposites of fossil organick remains of animals and vegetables, that are found in almost every country upon earth, and most of which, it is believed, have been wafted by currents, and promiscuously deposited with alluvion, &c. wherever they have been discovered; but I shall dispense with any remarks on that head, and appeal to the opinions of those whose observations and experience entitle them to the highest credit.

Among others, Mr. *Parkinson* makes the following remarks; "The fact, however, is, that although no (fossil) remains of man are found, the *surface of the earth,* which is inhabited by man, displays, even at the present day, *manifest and decided marks of the mechanical agency of violent currents of water.* Nor is there a single stratum, of all those which have been mentioned, which does not exhibit undeniable proofs of its having been broken, and even dislocated by some tremendous power, which has acted with considerable violence on this planet, since the deposition of the strata even of the last formation."†

* Rennell's Herodotus, page 514.

† Parkinson's Organick Remains, Vol. III, page 451.

I shall, in the next place, proceed to notice the few remarks that have been made, relative to the course or direction, in which, it is supposed, these currents may have flowed, and also of the cause.

In *Cuvier's* Remarks on the Environs of Paris, he observes, "A marked character of a great irruption from the *south east* is impressed on the summits, and in the direction of the principal hills."

Mr. *Carew* observes, that "the Cornish tinners hold a strong imagination, that in the withdrawing of Noah's flood to the sea, the same took his course from *east* to *west*, violently breaking up, and forcibly carrying with it the earth, trees, and rocks, which lay any where loosely, near the upper surface of the ground. To confirm the likelihood of which supposed truths, they do, many times, dig up whole and huge timber trees, which they conceive, at that deluge, to have been overturned and overwhelmed."*

Mr. *Kirwan* has taken a much more enlarged, and extensive view of the subject, and seems to be decidedly of the opinion, that the various changes, that appear to have taken place upon the surface of the globe, and which are believed to be the result of currents, have been produced by the operation of an "irruption of waters from the southern ocean," and further, that this irruption of the southern ocean was the cause, or consequence of the general deluge or Noatick flood.

In support of the first part of the proposition, he observes, "This is pretty evident, from such animals as

* Carew's Survey of Cornwall, 1602, page 7.

the elephant and rhinoceros being found, in great masses, in Siberia, mixed with different marine substances; whereas, no animals, or other substances, belonging to the northern regions, have ever been found in southern climates."

From the circumstance of the immense deposites, in Siberia, of the fossil remains of elephants, of rhinosceri, and other animals, peculiar to southern Asia, his conclusions are supported by a more than common degree of plausibility; for certain it is, that an almost incredible quantity of the remains of those animals is found buried beneath the surface of the earth, in the high northern regions of Siberia. That they were never common to that climate, is pretty certain. That they never migrated there voluntarily, and so opportunely as to be all destroyed at the same time, and all buried together, is equally as certain. That they were never carried there by the winds, is still more certain. But, that they were carried there by currents, and those too, flowing across the continent of Asia, is not only plausible, but conclusive; no other medium or means presenting itself by which a work, of such extent and magnitude, could have been accomplished; that of an absolute miracle excepted.

With respect, however, to the conclusions of Mr. *Kirwan*, "that by the breaking up of the fountains of the great deep, we are to understand, an irruption of waters from the southern ocean," by which the great deluge was produced, for the purpose of purging the earth of its impurities, and by which, with few exceptions, almost every living thing upon its surface was not only destroyed, but annihilated, it is a very different subject. But whether correct and true, or not, is more than any mortal living can ever prove. Nevertheless, his views of the subject were dignified and sublime; his researches were deep and extensive, and so intent was his mind upon this interesting topick, that he suffered it to be swept away by the resistless current, occasioned by the irruption of waters from the southern ocean, to attend to the frightful scene of burying alive, by thousands, elephants and rhinoceri, without thinking of any other part of the world.

What, let us ask, must or would have been the consequence of the waters of the southern ocean, leaving it, for the purpose of inundating or deluging every foot of earth upon the globe? It appears to me to need no astronomical calculations to determine, that its consequences must have been worse, than that of the deluge.

Had Mr. *Kirwan* been assisted by a knowledge of one-tenth part of the existing facts, that have a most intimate bearing on, and relation to the subject of currents that are supposed to have been connected with the universal deluge; had he bestowed a more minute and critical examination on these facts, and extended his views so far as to have embraced every continent upon the globe, in order to determine the relation and extent of their operations; he might, with the half of his intelligence and sagacity, have discovered such a series of analogies and correspondencies, presenting themselves at every avenue, as would have enabled him to establish a theory, that should harmonize in all its parts, and carry with it in the highest attainable degree, the semblance of truth, if not the seal itself.

As it is, his theory of the deluge, though plausible and supported by facts, in themselves highly interesting, is limited, imperfect, and destitute of that support which is necessary to enable us to clear up the existing difficulties which present themselves, and in a shape so formidable as to bid defiance to every attempt to reconcile them to his theory, consistently with the principles of truth and philosophy.

For example.—If the deluge, which was doubtless universal, was occasioned by an irruption of water from the Southern ocean, and which, in its course, swept from all the surface of southern Asia, the animal exuvia, and deposited them on the borders of the Arctick sea, how does it happen that nothing of the kind has hitherto been discovered in the same, or similar latitudes on the continent of North America?

On the contrary, the organick remains of animals appear to have been carried in a direction, from north to south across the continent of America, and deposited, as in Siberia, in the alluvion on its most southern borders.*

* It is not pretended, by any means, that all the animal remains are deposited in the alluvial region; it is well known that they are occasionally found in different parts of the country, as high as lat. 41°, perhaps higher, and particularly the remains of the mammoth.

This couclusion is founded on the incontrovertible fact, that the remains of the elephant and mammoth are found deposited in the great alluvial district on our Atlantick coast, which never could have been caused by a current, flowing from the Southern ocean; because in its course, following the direction of the Atlantick, no district or country presents itself, from which these animals could have been transported; besides, if from that source, they would have been transported still further over the continent, perhaps as far north as those in Siberia.

Not only are the remains of these animals found by mere accident, in our alluvial district, and which in all probability are nearly as abundant as the remains of the elephant and rhinoceros in Siberia; but the remains of the mammoth, which is an animal, beyond the shadow of doubt, peculiar to the high northern regions, are found beyond the great bay or gulf of Mexico, buried in alluvion on the continent of South America.

This difficulty alone, seems to present an insuperable obstacle to the adoption of the theory of Mr. *Kirwan*; that the deluge was occasioned by an irruption *only* from the Southern Ocean.

That a current may have flown from the Southern Ocean across the continent of Asia, is more than probable; the deposites of organick remains in the northern parts of Asia and Siberia, are demonstrative of such an event. That it may have been a consequence of the elevation of the waters of the ocean, for the purpose of inundating the entire globe, I am willing to admit; not only so, but I shall contend, that at the same time, and most probably from the same cause, a corresponding current flowed from the north pole, but with much greater rapidity, for the same end or intentions, and producing similar or corresponding effects.

It becomes necessary, in the next place, to explain the apparent inconsistency, seemingly attending the prevalence of two powerful currents flowing at the same time, in direct opposition to each other, in order to obviate any doubts that may be entertained as to the real existence of two such currents, and their simultaneous operations.

It will be recollected, that in the first part of these essays, I endeavoured to prove, by a variety of interesting facts that exist on the continent of North America, that a powerful current had flowed, at some remote period of time, over its whole surface from north east to south west, or from north to south—that one of the many results of this current, was the formation of the great alluvial district, skirting our Atlantick coast. And also, that the focus or probable source of this current, was the Arctick sea or north pole. And further, in order to account for the cause of the elevation of the waters of the ocean, and the consequent currents that flowed over the continent, I assumed the grounds on which *St. Pierre* explained the cause of of the deluge, viz. to the melting of the polar ices—not however with the view of advocating the theory of *St. Pierre,* but to explain the probable results that must inevitably have grown out of this new order of things. Neither did I assume it, under the smallest degree of conviction, that the ices at the two poles, if they were to be suddenly and completely dissolved, would be sufficient, in addition to the oceans, to inundate or deluge the earth completely; far from it. But if the waters of the deluge did flow from these sources, it is *more than probable* that the polar ices were dissolved and rendered tributary to this stupendous object; and that the same Almighty Power which governs the universe, could easily have increased the quantity of water at these two focusses to a degree sufficient to deluge the world.

That the deluge was decreed by the Almighty to accomplish the awful denunciations which he had pronounced against an impious race of men, there can remain no doubt. That it did take place with all its concomitant horrours is equally as certain.

That to have elevated the waters of the ocean above the tops of the highest mountains in the world, must have been the result, only of a miracle, will not be denied. That to have accomplished this work by the incessant fall of torrents of rain, is by no means probable, and for reasons which I have before advanced, in part, but which it may not be amiss to repeat: viz. —The fall of rains would not, probably, have produced the full and complete effect which was intended; for as the waters of the ocean rose in height, the currents from the surface of the land, and even from the mountains' height, would at last have been checked, as the tides of the ocean check the currents of rivers. Under such circumstances, thousands of districts would have retained their forest trees entire; for rains, in continued and incessant torrents will never beat down forests, unless assisted by currents; whereas, it is said in the appalling decree that "*every living substance that I have made,* will I destroy from off the face of the earth." Hence, we are justified in the conclusion, that currents of inconceivable force and rapidity were not only consequences, but the most efficient agents in the fulfilment of this decree.

That they flowed from the two poles of the earth is, after viewing all the exising facts, the most rational inference that can be drawn; and in fact, one that scarcely admits of any other conclusion.

Uuder these impressions, I shall proceed to obviate the apparent inconsistencies before mentioned, and to examine, still further, the probable consequences of these two powerful and opposite currents.

I have observed, that from the north pole, there are but two outlets; the one into the Pacific ocean through the comparatively, narrow channel of Bheering's straits; the other, through an immense channel, into the Atlantic ocean, between the coasts at Greenland and North Cape on the northern coast of Lapland. And that these two outlets are situated almost diametrically opposite to each other, on the two sides of the globe.

Under these circumstances, whether the waters that flowed from the north pole, were the results of the melting of the ices, or some other cause, it is immaterial; by far the greatest quantity of water flowed into the Atlantic ocean, and continued so to do, with increasing rapidity, until the continent was partly overflowed by its waters, and those of the Arctick sea, no longer restricted by their natural boundaries, overrun the whole continent from north to south.

At the same time, and from the same cause, and most probably too, for the same purpose, a corresponding current was flowing from the south towards the north pole; but being unrestricted in its course and sphere of action, and at liberty to flow in any direction, its force was weakened, and being opposed by the more powerful current of the Atlantic, which was limited between three great continents, it was divided; a part flowing into the Pacific, and the other into the Indian Occan. As the water increased in quantity, the currents were also increased in rapidity, still, having no influence on the unequal current of the Atlantic, it continued to urge its force into the Pacific, and Indian Oceans. Thus, while the current from the North Pole, through the Atlantic ocean, was overrunning all the continent of America, east of the Snowy or Rocky Mountains, and a part of Europe, the currents from the South Pole were overrunning all Asia and a part of America.

It now remains to describe the operations of these opposite currents, and to point out their visible effects. But how vain, and how feeble the efforts, even of the utmost stretch of human imagination, in attempting to delineate, or even "trace the circumstances of the most horrible catastrophe to which the human, and all animal species, and even the terraqueous globe itself, had, at any period since its origin been exposed."*

From the comparatively few facts that I have been able to obtain from reading and from observation, I have endeavoured to prove, that a current had flowed from the north or north east, to the south or south west, across the continent of America, embracing in its course, nearly its whole breadth. I have there endeavoured to make it appear, that almost all the high northern regions of North-America display but little else, than a superficies of bare rocks, from which, the soil had been taken by this overwhelming current, and carried across the continent, and deposited on the borders of the Atlantic ocean—That by it, whole forests, together with, probably, all the animals that then inhabited the land were swept away, and deposited in the alluvion which had accumulated in low depressed places;—but more particularly, in the great alluvial district at the south eastern extremity of our continent—I have endeavoured to prove that those districts of fossil wood and organick remains of animals, of different kinds, that are found *at and below low water mark,* are the result of the operations of this great current in its earliest stage, and before it had risen to the height of our ordinary mountains—That the stones which had been for ages accumulating on the bottoms of our rivers, were driven from their beds and wafted over the

* See Kirwan's Essays, p. 54.

country, or deposited in their western and southern banks—That facts of this kind are common in almost every part of America—But throughout the whole of this immense space, not an instance occurs, that I can hear of, that will favour, in the least possible degree, an opinion that a current had flowed in a contrary direction, (the present rivers excepted,) over any part or portion of our hemisphere. With Asia, however, it is not only different but directly the reverse; the strongest evidence of which, is that, which Mr. Kirwan has adduced in favour of his theory, (viz.) the immense deposites of elephants and rhinoceri, mixed with marine substances, in Siberia—These animals, it is well known, are, almost exclusively, inhabitants of the southern parts of Asia, from lat. 10° to 30 or 35° north; that from their enormous size and clumsy form, they are rendered extremely unwieldly, and, when exposed to the operations of an irresistible current, must be among the first that fall victims to its fury—Hence, the conclusion, that a current, flowing from the south pole, overrun the continent of Asia, and swept in its course these animals and buried them with the alluvion, in the high northern regions of Siberia.

Numerous other circumstances, doubtless, exist in every country comprised within the limits of this great continent, which will apply with equal force as proofs of the existence and operations of a current from the southern ocean or south pole.

But as yet, few travellers have visited these countries with a view to the promotion of science—and those who have, seem to have discovered but very little interest in this important subject, as scarcely any mention is made of facts that are connected with it.

In Europe however, numerous facts have been observed by the votaries of science, particularly by geologists, and mineralogists—and also some in Africa, and which lead to the conclusion that they are, not only, the result of currents of water, but of currents flowing from the southern ocean, at the same time as those which overrun all Asia.

These facts and results, I would explain on the following principles.

The currents from the south pole, as I have remarked, were principally thrown into the Indian, and Pacific Ocean; that of the latter, in consequence of the continent of America stretching away to the N. West, was naturally thrown in a north westerly direction across the continent of Asia. The former being thrown into the Indian ocean and being influenced in its course by that of the Pacific ocean, together with New-Holland and the Islands in the China Sea, was likewise urged in a north westerly direction, and with all its force thrown into the bay of Bengal, the Persian Gulf and the Red Sea—The countries in the neighbourhood of these last three seas, are probably among those that suffered most materially by these currents, in the early stage of the inundation; for as the waters of the ocean were elevated, the numerous rivers which run an easterly course, and are discharged into the bay of Bengal, and particularly the Ganges, were obstructed in their courses, and thrown back to inundate the whole country between it and the Arabian Sea.—While the same operations were going on throughout all Arabia and Persia, the currents were driven with great force through the Red Sea into the Mediterranean without obstruction; for it is more than probable that the Isthmus of Suez did not exist at that time.

Among the proofs to be adduced, in support of the currents from the Southern Ocean or South Pole, are the following.—

New Zealand, in a high southern latitude, presents an aspect similar to the high northern regions of America, being almost destitute of soil, as would appear from the description given by Dr. Hawksworth—" A prospect more rude, craggy and desolate than this country affords from the sea, *cannot possibly be conceived;* for as far inland as the eye can reach, nothing appears but the summits of rocks which stand so near together, that instead of valleys, there are only fissures between them."*

The south side of the Island of Java, which was exposed to the operation of the currents, is high, broken, and rugged—While the north side is low and of an alluvious formation, and extending thirty miles or more into the country, where it begins to rise into hills†.

The island of Tongotaboo in the Pacific Ocean, rises suddenly from the sea, on the *south east coast;*

* See Cook's Voyage round the World.

† Cook's Voyages.

while the *north west side* is alluvious, affording plains and meadows—Terre del Fuego, likewise, presents to view, an aspect which leads to the conclusion, that it has suffered by an agent, more general, if not more violent in its operations, than the volcano that exists in one of its highest mountains—Many other places discover the most decided and unequivocal marks of the operations of dreadful currents from the southern ocean, and which, as in all cases of the kind, occasioned the most sensible effects in parts most exposed to its operations.

The borders of the Red Sea seems, likewise, to afford proofs of the operation of these currents.

As the waters of the Indian Ocean were probably urged into this sea with inconceivable force and rapidity, the shelly tribes that had long held the undisputed prerogative of inhabiting its oozy bottom, were torn up and carried in a north westerly direction into the interior of Egypt—Hence it is, that great quantities of shells of various species are distributed over the country, and mixed with the soils and sands of Egypt."*

"Betwixt Suez and Cairo, likewise," says Dr. *Shaw*, "and all over the mountains of Lybia, every little rising ground, and hillock that is not covered with sand, discovers great quantities of the Echini, as well as of the bivalve and turbinated shells, most of

* These are doubtless the same as alluded to by Herodotus in book 2, chap. 12.

which *exactly correspond with their respective families still preserved in the Red Sea.*"*

Similar facts and appearances occur on the northern shores of the Mediterranean, and the districts adjacent, likewise exposed to the force and operations of the same current, some of which have recently been taken notice of by Mr. Allen in his geological sketch of the environs of Nice.

"The fissures I now talk of," he says, "seem to have been formed after the consolidation of the breccia, already described, and are literally filled, in some places, with sea shells, of a species *all now alive in the Mediterranean*". *(Page 14)*

In speaking of the shells in the clay, he says, "It is in this particular kind of clay that a considerable variety of shells are found, of kinds also which are *all to be met with alive in the Mediterranean.*" *(Page 17.)* And of the shells found in the sand near the village of Trinity he further remarks, "If they can be got out entire, they afterwards retain a slight degree of hardness; but even in their pulverulent state, they exhibit their varieties distinctly, and all I am told, *are kinds now living in the Mediterranean.* Indeed I have seen most if not all of them, in a recent state." *(Page 19.)*

Whence came these shells, but from the bottom of the Mediterranean, where their species are now living? And to what cause shall we attribute their removal, but

* Shaw's Travels, p. 383.

to the operations of a current setting in that direction, and by which they were torn up from the bottom and thrown upon the surface of that kind of Valley, at the foot of the eastern slope of the Alps? No appearances of the kind have ever, I believe, been taken notice of on the opposite shores of that sea; neither have the shells, mentioned by Dr. Shaw, as being spread over Egypt, the families of which are still living in the Red Sea, ever been observed on the eastern borders of that sea, or the Arabian deserts. It is true Mr. Irwin mentions, that quantities of shells, are found in the desert near Mocha, but he likewise says, that they are the *productions of the Ocean.**

That the shells in both these instances were removed by the force of currents from the south, I have no doubt, and this opinion is supported by similar facts, that occur in other parts both of Europe and Asia, where not only like cases occur, but they seem decidedly, to have been produced by the same cause, and most probably, at the same time.

In the immense deserts, at the northern extremity, of the Caspian Sea, numerous instances of this kind are to be seen, and of which Pallas has made particular mention in his travels in Russia.

"We have" he observes, "the following incontestible proofs, that the Yaikian desert, as well as those of the Kalmuks, and the Wolga, have been formerly covered by the waters of the Caspian Sea: first, the innu-

*Irwin's Voyages, vol. 1 p. 18.

merable shells that are scattered in every direction of these deserts, *exactly resemble those of the Caspian sea, and are not to be met with in the rivers.*"—*Pallas' Travels, vol. I. page* 78.

In speaking of the fossil shells on the banks of the Wolga, he says, "Several bivalve shells of the Caspian sea are found in great numbers on the high banks of this river."—*Vol. I. page* 113.

Near Yenatævka, "A quantity of decayed shells are every where found intermixed with this sand, and *some Caspian muscles* in a calcined state."—*Vol. I. page* 118.

In his description of the rolled pebbles and fossil shells at Arsagar, he observes, "This extensive base, and mountain itself, as far as the highest eastern knoll, are covered with small, black and white lenticular pebbles, which must have assumed that form under water. On the summit of the ridge, *I found the bivalve shells of the Caspian sea,* in a good state of preservation, a proof that the waters of this sea formerly covered the other Selenitick rocks, as well as this eminence, that rises from twelve to thirteen fathoms above its base."—*Vol. I. page* 144.

On the fossil shells near lake Byeloi Ilmen, he remarks, "On this border of sand banks we observed many *shells of the Caspian sea,* though we had not met with any in the low country, either because they were covered over with mire, or entirely decomposed, or, perhaps, *they had been drifted more towards the banks of the ancient sea.*"—*Vol. I. page* 307.

Mr. *Kirwan*, in speaking of the shells in the deserts of Naryn and others more southern, between the Wolga and the Jaik or Ural, says, "The shells which abound in this extensive flat, exactly resemble those of the Caspian, and are different from those of the adjacent rivers."*

To what shall we look for the cause of these extensive deposites of fossil shells, that are peculiar to the Caspian sea, whilst nothing of the kind has ever been observed, that I can find, either on the west, the south, or the east side of it? If that sea has receded, as is pretended, or fallen below its ancient level, we might reasonably expect to find fossil shells, once peculiar to it, on all its borders, except where rocks exist; but this is not the case. Whilst they abound in the banks, and in the neighbourhood of the Wolga, no mention is made of any thing of the kind near the mouth of the Oxus, or in its ancient course; neither do I find any thing of the kind, as having been observed in the great desert between the Caspian sea, and the sea of Aral.

That they were carried there by currents from the south, and deposited, is rendered still more probable, from the circumstance that in the same districts, the fossil remains of the elephant, &c. are found buried in the alluvion,† which is many degrees further to the north, than the countries to which they naturally belong, or which they have ever been known to frequent.

* Kirwan's Essays, page 91.

† See Pallas's Travels, volume I, page 108 and 115.

As* the waters of the ocean increased in height, and the currents in rapidity, the countries adjacent to the Mediterranean were inundated, and the waters propelled across the continent between the Alps, Pyrennees, and other mountains, whilst the animal and vegetable remains of Hindostan, Arabia, and Africa, were borne across the country, and deposited in many places on the continent of Europe; such as the ele-

* As respects the geological appearances in the neighbourhood of the Caspian sea, and the sea of Aral, it is difficult, from the few facts that are given us on this subject, to determine, with certainty, what were the effects of that great revolution upon it and the surrounding country. Yet, although the great extent of country, the Steppes, to the northward and westward of the Caspian sea, does not altogether favour the opinion, that the same currents have been instrumental in producing the changes, which we are led to suppose it has undergone; the country to the south east to a great distance affords many reasons to believe, that it has experienced material changes from the same cause; and that the great desert of Khilva or Kiva, (once perhaps a part of the Caspian Sea,) is the result of its operations. If we view the great ridge of Imaus on the east, extending to a great distance from south east to north west, and its subordinate ridges extending westerly a considerable distance; and then view the great range of Sariphi Mountains, commencing near the latitude 32° 50′, and running a similar course until meeting the Caspian sea, then turning north along its coast to latitude 42° or more, we shall see an immense valley, through which these currents must of necessity have flowed, and in which lies the great desert of Khieva, extending from latitude 37° 20′ to beyond 42°. This desert extends in breadth from the Caspian sea to the river Sihon, or Oxus. This river takes its rise in the Ghergistan Kuttore mountains, which run in a circular range from mount Seriphi on the west, to mount Imaus on the east.

phant and rhinoceros, the bamboo and palm from Hindostan; the seals, &c. from Africa.

These are mentioned as having been found in various places in France, Italy, and other districts on the continent.

The remains of the Hippopotamus, peculiar to the island of Sumatra, and Africa have been found in France.

Some of the lower hills of the Appennines contain fossil bones of elephants, rhinoceri, whales, and dolphins.*

Jussieu discovered in a stone, which he found in the earth near the coal, at St. Chaumont en Lionnois, an impression which bore the exact resemblance to the fruit and seeds of the Abor-tristes of travellers. This tree, it appears, grows *only* in the Canaries, and at Malabar, on the coast of Coromandel.†

The remains of the hyena, from the Cape of Good Hope, are found associated with those of the elephant, in the caverns of Gaylenreuth.

Remains of this same animal (the hyena) are found too, associated with those of bears, which, at present, exist only in the north.

"At what time," says M. *Cuvier*, "was it, that the elephants, and hyenas of the Cape, of the size of our bears, lived in our climate, and were shaded by forests of palms, and in which they took shelter in caverns, along with bears as large as our horses."‡

* Phillips's Geology, page 87 and 97.

† Parkinson's Organick Remains.

‡ Cuvier's Theory of the Earth.

In the great coal district near Cologn, not only the trunks of trees, deprived of their branches, are found, but "nuts which are indigenous to Hindostan and China, and a fragment of a resinous gum are also found in it."*

To the operations of these currents we may attribute the cause of the excavation of the rocks at Gibraltar, as mentioned by Major Imrie, "On the surface of the rock," he observes, "are seen pot-like holes, hollowed out by the attrition of gravel or pebbles, set in motion by the rapidity of rivers, or *currents in the sea,* some of the pebbles now remaining in them."

From this phenomenon Mr. *Imrie* concludes, that "however high the surface of this rock *may now be elevated* above the level of the sea, it has once been *the bed of agitated waters.*"†

Admitting these facts to be true, do we hazard too much in saying, that, probably, at the same epoch, in which these holes were formed, the great and important event took place, which the ancients have so often mentioned, and of which so much has been said, (viz.) the disjunction of Europe and Africa by "the labours of Hercules" so called :‡ and by which a communication was opened between the Mediterranean sea and Atlantic Ocean, at the straits of Gibraltar?

Whether this be true or not, it is worthy of remark, with respect to the excavations, or pot-like holes in

* Bakewell's Introduction to Geology, page 197.

† Parkinson's Organick Remains, vol. III, page 332

‡ See Natural History of Pliny, book 3.

the rocks of Gibraltar, that similar cases occur in different parts of the world, and, I believe, at nearly the same elevation above the present level of the ocean.

Mr. Mackenzie, in speaking of the portage of the Chaudiere des Francois, says, "It must have acquired the name of Kettle, from the great number of holes in the solid rock of a cylindrical form not unlike that culinary utensil."

"At the bottom of them are generally found a number of stones and pebbles."

These holes are represented, as being upwards of ten feet above the present level of the water at its greatest height. And further "They are indeed to be seen along every great river throughout this wide extended country."*

M. Henry, after describing the carrying place of La Chaudiere Francois, and the excavations in the rocks, observes, "but the phenomenon is not peculiar to this spot, the same being observable at almost every carrying place, in the Otaouais."

"Every where the waters appear to have subsided from its ancient level."†

On the Mohawk river, where it is supposed a dreadful disruption of the rocks has taken place, at some unknown period of time, these cylindrical excavations in the rocks, are numerous and deep,‡ and afford the

* Mackenzie's Travels, p. 37.

† Henry's Travels, p. 31.

‡ See Clinton's Introductory Discourses, p. 52.

most unequivocal proofs of the violent agitations of currents of water, at an elevation, much above the present bed of the river, and corresponding in height too, above the level of the ocean, very nearly with those in the rocks of Gibraltar.

Facts so palpable, and at the same time so numerous and interesting in their kinds, are calculated to impress a belief in the existence and operations of currents, in every quarter of the globe; and that too, far above the present level of the sea.

So decided are many in this opinion, that they have not hesitated, to attribute the cause of these interesting phenomena, to the operations of currents, without knowing or endeavouring to explain, by what means they were put in motion, or whence they probably originated.

Faujas considers the fossil remains, found at the quarries of Montabussard, as having been brought *from India*, by the same revolution which has removed these remains of elephants, which are dug up in the north of Europe, in Italy, France and England.

La Metherie supposes, that the fresh water shells and remains of quadrupeds, about Paris, were carried and deposited in their present situation, by the operations of marine currents.—And as before, *M. Cuvier*, in his remarks on the environs of Paris, says, that "a marked character of a great irruption from the south east, is impressed on the summits, and in the direction of the principal hills."

Of these facts, there can remain no doubt; almost every country in Europe and Asia affords similar appearances, and such as to justify the conclusion, that these mysterious and interesting phenomena, are attributable, exclusively to the force and operation of currents, that once overran every region and district of country, where such marks and appearances are presented to view.

CHAPTER IX.

Green ooze, or mud.—From time immemorial it has been, and still continues to be a custom with mariners, to regard the soundings (so called) which they obtain, as indicative of a particular part or portion, or even a whole range of coast to which they are advancing or along which they may be coasting. It is mentioned in the journals of most navigators, and by some historians; and it will be found in, by far, the greatest number of cases, that at the depth of sixty fathoms, the bottom of the sea is composed of mud, or by some, ooze.

Herodotus makes particular mention of this circumstance, and observes, "Of this fact there exists another proof: if from a vessel bound to Egypt, the lead be thrown, at the distance of a day's sailing from the shore, it will come up at the depth of eleven fathoms covered with mud, plainly indicating that it was brought there by the water."—*Book 2, Chap. 5.*

Pocock observes that "For seven or eight leagues from the land, they know by the sounding plummet if they are near Egypt, as within that distance it brings up the black slimy mud of the Nile, that settles at the bottom of the sea, which is often of great use in navigation; the low land of this country not being seen afar off."*

Dr. *Shaw* says, that at the distance of twenty leagues from the coast of Egypt the bottom is mud—"so far at least, by sounding this mud is found to extend.†"

It is more than probable, that from ten to twenty leagues from either shore throughout the Mediterranean, a similar bottom will be found to prevail. But whether or not, it is very much a matter of doubt, if the mud, mentioned either by *Herodotus* or Dr. *Shaw*, (which was about the same distance from land) was ever carried there from the Nile. The sentiments which Dr. *Shaw* has expressed, seem to indicate doubts in his own mind on this point. "Surely," says he, "the soil in Ethiopia (provided the Nile reacheth no further) must be of an extraordinary depth, in having, not only bestowed upon Egypt so many thousand annual strata, but laid the foundation likewise of a future addition to it in the sea to the distance of twenty leagues."‡

A similar inference is deducible from the expressions of Mr. *Bruce*, on finding mud by soundings at the distance of seventeen leagues west of Alexandria and which are as follows :—

"From this I inferred, that part of the assertion, that is the mud of the Nile, which is supposed to shew seamen their approach to Egypt, is mere imagination;

* Pocock's Travels. † Shaw's Travels, page 432. ‡ do. do.

seeing that the point where we then were, was really part of the sea opposite to the desert of Barca, and had no communication whatever with the Nile."

"On the contrary, the Etesian winds blowing all summer upon that coast, from the westward of north, and a current setting constantly to the eastward, it is impossible that any part of the mud of the Nile can go so high to the windward of any of the mouths of that river."*

If we examine the bottom of the ocean with a view to its character, we shall find, that in almost every sea and latitude, at a certain depth, we have an oozy or muddy bottom.

In support of this position, I might fill whole pages from the journals of different navigators in various parts of the world; but the following are considered amply sufficient.

In a voyage made by order of the King of France in 1771 and 1772, *en divers parties de l'Europe, de l'Afrique, et de l'Amerique pour Verifier l'utilite de plusier methodes et instruments serving â determiner la latitude, &c. par Verdun de la Creene, le Chevalier de Border, et Pingré Chancellor de Paris,* we find the following report.

Soundings on the coast of Spain.

"From the mole, the most eastern from the city (Cadiz) called point de St. Croix, at the distance of, from four to eight cables length, it is good anchorage, in six to eight fathoms, muddy bottom, (fond de vase.)

* Bruce's Travels, vol. I. page 85.

At half a league, before entering the pass, and in the pass even, quite to the anchorage, we find from eight to six fathoms of water, bottom muddy sand."
—*Vol. I. page* 43.

"In the lat. of the bay of St. Lucar and Sibeon, the bottom is a black mud," (vase noir.)

"In the lat. of Cadiz, the bottom is a brown mud and sand, mixed with mud.—*Page* 46.

"Near the Cape de Verd islands in ten and a half fathoms, the bottom is sand and corals."—*Page* 131.

"Near the island St. Jago the bottom is gravel and coral."—*Vol. I. page* 164.

On the coast of Newfoundland, from lat. 45½° to 46° 50′ the soundings are as follows: In twenty-eight fathoms, the bottom is coarse and fine sand and oursin, (sea hedge hog.)

In 32 fathoms, do. do. do.

In 38 fathoms, bottom rocky. In lat. 46° N. and in 35 fathoms water, bottom composed of flint stones.

In 42 fathoms, bottom is shells and flints.

In *eighty fathoms*, the bottom is of *black mud.*—*Vol. I. page* 236.

On the coast of Denmark, from lat. 64° 50′ the soundings are in 54 fathoms, a fine grey sand, flints, little shells and corals. In *eighty-five* fathoms the bottom is black mud. In lat. 63° 50′ at *one hundred fathoms* the bottom is a *black mud.*"—*Vol. I. page* 270.

"On the coast of Norway, in lat. 58° 50′ and at one hundred and seventy-five fathoms, the bottom is a soft mud. In lat. 59° 50′ and at eighty-five fathoms the bottom is muddy."

"In lat. 60° 50′ and as they approach the coast, the bottom, in seventy-five fathoms, is sand and gravel."—*Vol. I. p.* 274.

"On the coast of Jutland at a small depth, the bottom is sand and gravel. On the coast of Norway, on the contrary, the depth of water is considerable, and at the bottom, is of brown or black mud."—*Vol. I. page* 280.

"At Copenhagen at eight fathoms, is sand and mud."—*Page* 288.

"In the German ocean, from lat. 53° 50′ to 57° 50′ the soundings at thirty fathoms was mud,—on approaching the coast, mud and sand,—at twenty fathoms, the bottom sand and gravel,"—*Vol. I. page* 330.

"On the coast of Spain and Portugal, at the distance of three, four, and five leagues from Couronville, and at the depth of seventy, to seventy-five fathoms, the bottom was mud and some sand."—*Vol. II. page* 13.

"On the coast of Africa, from Cape Spartel, to Cape Blanc, near Assan, we find, from 28 to 30 fathoms of water, a grey sandy mud."—*Vol. II. p.* 33.

"On the coast of Salè and Fredale, at the distance of, one mile and a half to two leagues or more, we find at 15, 20, 25 and thirty fathoms water, a bottom of rock. At 2½ leagues the bottom is sand. From three to seven or eight leagues, and at from *fifty to one hundred fathoms, the bottom is mud.*"—*Vol. II. page* 37.

Off cape Courtin, latitude 33° 8′ north, at two leagues or more, there is, at forty and fifty fathoms of water, a bottom of mud.—*Vol. II. page* 39.

Off Mogador, at a league from land, we have twenty fathoms of water; at two leagues, bottom of rock; and at three and four leagues, and more, and at thirty-five and forty fathoms of water, the bottom is mud, with sand.*—*Vol. II. page* 40.

I have been thus particular to give the different soundings, in order to show, that almost uniformly, as we recede from the coast and come into deep water, the bottom of the ocean is mud; differing however in its characters, in different places, and seldom liable to change; hence the importance of a knowledge of the various soundings to navigators, who well know, if they are skilful, when they approach a particular part of a coast or country, by this highly important criterion.

On the coast of West Florida and of Pensacola bay, in 60 fathoms water, we have a sandy bottom. At about five leagues from Mobile bay in 120 fathoms water, we have a bottom of mud and sand.†

The soundings at a great distance to the eastward of George's banks, on the coast of America, and what is, I believe, called Boston channel, and at the depth of sixty or seventy fathoms, discover a muddy bottom, (or what is commonly called by mariners, green ooze,)

* See Valentia's Travels, vol. II, page 261, &c. on the Soundings of the Red Sea.

† See Mr. Darby's excellent map.

mixed with innumerable little shell-fish. This ever has been, and continues to be the same, from the time our seas were first navigated to the present day.

It is the same off Block Island channel, so called, some degrees to the southward and westward, and continues, with some variations, at a similar depth throughout a great portion of the Atlantic coast.

From whence then comes the sand, by way of the sea, to form our great alluvial district or even the *smallest part of it?*

George's banks comprize a very great extent of a pure sandy bottom, and in some places, at low water, to the very great injury of navigation, not more than from three to five fathoms in depth, and subject, during a gale from the southward, to be dreadfully agitated and torn by the billows of the ocean; yet not a bushel of this sand has ever been washed upon the coast due north, and west of it; if there has, no alluvial formation or accession to the coast is perceivable in those parts.

It may be said that George's banks are to the northward of the gulf stream, and consequently, beyond its influence. This is admitted; but the Bahama banks, as well known as the latter, are constantly subject to currents, and the agitation of the sea; yet they remain, and ever have been, the same. Capt. *Riley* says, "The water in this great bank, (the Bahama) in most places, appears as white as milk, owing to the white sand at the bottom gleaming through it, and is so clear, that an object, the size of a dollar, can easily be seen, lying on the bottom in four fathoms water, in a still time."* Yet, as before, although subject to currents, and those sometimes strong too, not one particle of this sand is seen to move on the bottom, or mixed with the water, and carried away by the currents.

Were we to admit that sand is thrown upon the shores of any country, by the sea, in a quantity, sufficient to form alluvial districts, we might expect to find similar results, by the operations of the winds and waves, in all large lakes; more particularly such as receive the waters and alluvion of a number of large rivers; but this is seldom the case, although the waves in many lakes rise to a great height, and, during the prevalence of severe and long continued storms, rage with a fearful violence, that often appals the stoutest heart, whilst they seem to threaten a total disruption of their natural boundaries.

There are many lakes and bays of very considerable extent, that afford no indications of alluvial formations, by the sand cast upon the shores by the waves; and if we examine the subject attentively, it is by no means to be wondered at, for the bottom of most lakes, except where rocks prevail, is, like that of the sea, composed of mud; and even in this there does not appear to be that wonderful and rapid accumulation, which some have supposed.

Considerable changes have taken place in the lake Mæotis, and which have, most probably, been produc-

* Riley's Narrative, page 23.

ed by the depositions from the Borysthenes and Tenais, which pass through a great extent of low alluvial tracts.

It was from this circumstance that Polybius was induced to believe, that the entire filling up of the Mæotis, was no very distant event. (*lib.* iv. *c.* 5.) Yet says Mr. *Rennell,* "The operation, however, is so slow, that it may reasonably be deemed a very remote event, at present, although nearly 2000 years have elapsed, since the date of his prediction. Polybius, it seems, was of the opinion, that in his time, this lake was not more than 15 to 20 feet deep, generally; but," says Mr. *Rennell,* "it is at present more than 30, and in the deepest parts, 40 to 48."*

In the lake of Geneva, which has been, perhaps, as long known as that of almost any other, no material change I believe is observable, although subject to the operations of torrents, that rush into it with inconceivable rapidity from the sides of the Alps.

In the lake of Bala, in Wales, which is 13 miles in length and six in breadth, and through which runs the river Dee, Mr. *Atkins* could find no indications of alluvion, nor scarce any earthy particles.†

The same is precisely the state of the Cumberland and Westmoreland lakes; of Lock Lomond, in Scotland; of the Locarno, in Italy; all well known for ages.

Of the sea of Tiberias, or sea of Gallilee, or the lake of Gennessereth, which has been as long, if not lon-

* Rennell's Herodotus, page 69.

† Atkins's Tour, page 24.

ger known than that of any in the world, no apparent change has taken place; neither is there any appearance of its being filled up; on the contrary, the water is represented as clear as the purest crystal, and the bottom covered with shining pebbles,* which never would have been the case, if the alluvion were constantly accumulating upon its bottom.

Many similar cases could be mentioned, all tending to prove that very few instances occur, in which alluvial districts have been formed, upon the borders of lakes, by the sand washed up by the waves; and also, that the mud, of which the bottom of most lakes is composed, does not increase in quantity so rapidly as is pretended.

These remarks are as applicable to bays and gulfs, of the sea, as to lakes.

Mr. *Kirwan* observes, that "No part of the alluvion of rivers is carried to any great distance into the sea. Mariners were accustomed for some centuries back, to discover their situations by the kind of earth brought up by their plummets, a method that would prove fallacious, if the surface of the bottom did not continue invariably the same."†

In the Adriatic gulf, which is surrounded with extensive and fertile regions in the highest state of cultivation, and the soil of which is tributary to the winds, rains, and mountain torrents, that are daily hurrying

* Clarke's Travels, vol. II, page 259.
† Kirwan's Essays, page 440.

it into this sea, we might expect to find an increase of alluvion upon its bottom; yet the Abbe *Fortis* relates, that "urns which were thrown into the Adriatic more than 1400 years ago, instead of being covered with mud, were found in the same situation, as they could be supposed to have been, the first day of their fall to the bottom."*

Hence, and from a variety of other circumstances, we may justly conclude that but a very small portion only of our alluvial coast, was ever formed by sand thrown upon the shores by the sea, for admitting that sand is suspended and wafted along by the gulf stream, a circumstance which I am inclined to believe no man will admit, who has ever crossed that stream in different places, and given himself the trouble to notice the water, as soon as it was carried beyond the influence of that current, for instance to the northward of it, between the gulf stream and the coast, and where there is no current, it immediately sinks to the bottom never to rise again; for sand, or silex, of which the sand of our sea shores is formed, being specifically three times heavier than water, it is both morally and physically impossible, that it can be long suspended in that element, unless where there is a current of no inconsiderable force and rapidity to keep it suspended, and waft it along with the stream. Of this any person may be easily convinced, by examining the currents of our rivers, in any part of our country, and perhaps those of any other.

* Abbe Fortis's Travels, page 282.

CHAPTER X.

Liable to Decomposition.—There is not, perhaps, a more prevalent opinion, or one more generally believed, than that which relates to the universal tendency of every species of rocks to a slow, but progressive state of disintegration, or decomposition. It is an opinion that has been long inculcated and received, and so deeply impressed are many, with a belief of the fact, that they hesitate not, to assert, that the solid materials which constitute the body of this earth, are but the debris of a former world that has undergone the process of decomposition, and from which, our present globe is composed.

Was it not that such an assertion is tantamount to a libel against the letter and spirit of Holy Writ—and also the tendency of such a declaration to encourage scepticism aud infidelity, it might be suffered to pass, with the idle winds unheeded and without comment or notice. But the tenor of such an hypothesis is too gross and improbable for belief, and deserves the pointed animadversions of—an abler pen than mine.

The tendency, or liability of the several classes of rocks to decomposition, in a greater or less degree, according to their character and structure, is a subject, of itself, highly important, and sufficiently ample, if properly treated, for a copious volume. But it is not consistent with the plan of this work, nor the views with which I set out, to enter into a minute examination of facts and opinions on this extensive and interesting topick.

I shall therefore content myself with endeavouring, by a few cursory observations and remarks, to prove that the decomposition of rocks is not a process so general and *so rapid* as many seem disposed to believe.

One of the principal circumstances that gave rise to the opinion, that our mountains are daily crumbling into dust, is, in part, the peculiar tendency of some imperfectly formed rocks to fall into decay; but more particularly, the amazing quantity of alluvial deposites that have, in time, accumulated at the mouths of numerous rivers; and which, it is believed, are made up of the debris of decomposed rocks which have been washed by rains into creeks, thence into rivers, and by the rivers wafted to the sea and deposited.

It is from this that *Herodotus, Pliny* and *Aristotle,* drew the inference, that Egypt was entirely the gift of the Nile.

It is from this, that the Ethiopians assume to themselves a share of credit, in saying that Egypt is indebted to them for its origin.*

It is to this, that *Peiresc* and *Colonne* predicted that Venice would, one day, be united to the continent.

To the same cause, *Kircker* and others attribute the formation of the alluvial district at the mouth of the Tiber ; and to the same also, *Piganiol* imputes the formation of the alluvial grounds, by the Vidourle and Vistre.

From this cause, it is alleged, that the plains of Roussillon have been formed at the southern extremity of the Pyrennees,† and it is from this process, which is supposed to be in active operation in those mountains, that Louis the XIV. was led to observe to his little son, that the time would arrive, when the Pyrennees would be reduced to a level with the vallies, or in other words, that posterity would one day say, the Pyrennees no longer exist.‡

It is pretended by some, and I have even heard it alleged, that this was not the true intent and meaning of the expression of Louis to his son : but, on the contrary, (as at that time it was hoped and expected that Spain would one day be united to France,) that the Pyrennees would no longer exist as a boundary between the two countries.

* Mineral de Pyrennees, by Palassau.

† Palassau, Mineral de Pyrennees, page 302. ‡ Do p. 87.

However that may have been, it seems more than probable, that in a familiar conversation on the phenomena of nature, Louis may have meant to convey to his son the idea, that by the changes of temperature the operations of heat and cold, promoting a decomposition of rocks; and also by the operations of winds and torrents of rain, which convey the debris into the vallies; the mountains would, at length, be reduced to a level with them. Be this as it may, it is not essential to the subject in view.

That almost every species of rock is liable to decomposition, in a certain degree, is admitted. That some are much more liable than others, is equally certain. That some kinds are subject to an entire decomposition, cannot be denied. But in order to determine the degree, or tendency of the several kinds of rocks to decomposition, and the extent to which they are liable; and also, the degree of influence which such a change may have had, in producing the wonderful results, that are supposed by many to have taken place, it is necessary to take a cursory view of the several kinds most prevalent, and of which the crust of our globe appears to be composed, in order that we may be enabled to form some correct ideas of the extent of this operation.

Rocks, it is well known, are divided into the following classes, viz. primitive, transition, secondary or floetz, alluvial, and volcanick. These are again subdivided into their several kinds. The different kinds of rocks arranged under the denomination of granite, are mostly composed of felspar, quartz, and mica. Of those three substances, the felspar and mica, are, from the character of their component parts, most liable or subject to decomposition; the former in particular, when it contains a portion of potash, as it sometimes does; and the latter when exposed by itself to all thé vicissitudes of temperature or weather—But when the felspar is of the common kind, and free from potash or any other substance out of the common order, calculated to promote a decomposition, and when the three substances are perfectly combined, so as to form compact granite, or any of its subordinate divisions, as gneiss, sienite, mica slate, &c. but very little appearance of decomposition takes place, though exposed to the changes of seasons for ages in succession, as I shall endeavour to prove in the sequel.

The only substance, then, that comes under the denomination of granite, most subject to decomposition, is the coarse imperfectly formed micaceous schistus, or schistose mica, in which the mica predominates, and is very commonly intermixed with sulphuret of iron, which, by its decomposition, promotes that of the whole mass. This substance commonly occurs among the strata of gneiss, and, except in some instances, is not very abundant. How little then can be derived from this source, towards the filling up of valleys, or the formation of alluvial districts? More particularly so, since neither this, nor either of the other three classes of rocks, are subject to decomposition, except being actually exposed to the atmosphere. By this expression, I do not mean to deny that some of the simple component parts of rocks, are sometimes, when exposed to waters filtrating through the great mass, found in a decomposed state; such may have been the case of kaolin, mica, and a number of other mineral substances; but not being subject to the operations of wind, rains, &c. afford little or no addition or increase, to the subjacent districts, nor to alluvial formations. Among the second class of rocks, or those of the transition kind, we find that there are but two species which are peculiarly liable to decomposition; (viz.) The porous, or imperfectly formed trap, and Gray Wack. The aggregate proportion which these bear, to that of the general mass of rocks that are presented to view upon our globe, is comparatively small; and although at first view we should be inclined to believe, from their structure, that they are liable in an eminent degree, to decomposition, it will be found, on a close examination of the several circumstances necessary to be taken into view, in order to ascertain the fact, that the progress of decomposition, even of these rocks, is not so extensive and so rapid, as is generally believed.

Among rocks of the third class, or those of secondary formation, and also those of the alluvial kind, which I am disposed to consider as of a ternary formation, the several kinds of red sand-stone, and the sand or free stone of more recent formation, are those most subject to decomposition. Of these the former do not constitute a very large proportion in the scale of rocks, and, although sometimes found in situations highly elevated, do not contribute so abundantly to the formation of alluvial districts, nor, by decomposition even, to the increase of the soil which they often overhang. With the latter I am ready to admit, that from its incompact and pulverulent texture, it is not only liable to be decomposed, but is rendered unfit, except in some instances, for the purposes of civil architecture. Yet however liable it may be to decay, it forms but a small integrant part in the great mass of rocks, and commonly lies low and is mostly covered; consequently contributes but little either in the formation of soil or alluvion.

Having briefly considered some of the rocks most liable to decomposition, it is necessary to take a slight view of such as are least subject to disintegration. Of these may be considered,

Granite,	Primitive trap,
Gneiss,	Do silicious slate,
Sienite,	Secondary lime stone,
Compact mica slate,	Green stone,
Clay slate (argillite)	Porphyries,
Primitive lime stone,	Quartzose rocks, &c. all

which are the most predominant in the great scale of rocks, and most of which are employed in the various departments of civil architecture, sculpture, statuary, &c.

Previous to entering into any remarks on the decomposition of these last mentioned rocks, it may not be amiss to consider what is the nature, or actual cause, or causes of the decomposition of rocks; and the extent to which we are to admit the term; for it seems not unfrequently misapplied.

The destruction of mountains or rocks, does not virtually imply the decomposition of either.

Mountains and rocks may be broken down suddenly, or gradually by the following causes: First, by repeated shocks of an earthquake. In this instance, they are generally displaced in large masses, and often removed to a considerable distance from their original *gisement*, particularly so, on the sides of mountains. Secondly, rocks of a columniform structure, fissurated or stratified, are often displaced and thrown down, by the slow and imperceptible growth of vegetables, which annually shoot the fibres of their roots further and further into the open crevices, and by gradual expansion, force, little by little, the ponderous mass from its balance, until it falls, frequently from an awful height, and with a tremendous crash. This is a powerful agent, not only in the disruption of rocks, but in the demolition of old towers and other buildings. Scarcely will it be believed that effects so astonishing could be produced by causes, in themselves so unimportant and seemingly trifling. But numerous are the instances in which the ponderous materials of lofty towers, antiquated abbeys, and splendid palaces, have, by slow and imperceptible gradations, been lifted, piece by piece, from the adhesive cement of their moss-grown walls, and tumbled, in promiscuous ruin, at their bases, where they remain, unimpaired and uninjured for ages, though exposed to all the vicissitudes of temperature ; and at the same time composed of the very materials as the rocks in the quarries, hills, or mountains, which are said to be rapidly progressing in a state of decomposition. This is a fact I wish may be kept in view.

These effects may appear strange, but the fact is no less true, that a single tuft of grass, implanted upon the top of a wall of masonry, will, in time, if not disturbed, injure its texture and break up its materials. What then may we not expect, where the ivy and other vines are spreading their luxuriant branches over the deserted walls, and annually forcing their numberless little wedges or tendrils, into every hole and crevice, and gradually expanding, and uniting their forces, in the destruction of the noblest works of man, who, with so much care, has reared them to increase his glory and perpetuate his fame.

Thirdly.—Rocks of a description similar to those last mentioned and such as are composed of irregular and amorphous masses lying in a juxta position, yet imperfectly united, are liable to disruptions, to be shattered and broken down, not only by the two latter causes, but by the alternations of heat and cold, wet and dry.

Almost all substances, rocks and stones as well as other things, are, on exposure to heat, liable to expansion in a degree proportioned to the degree of heat absorbed ; and to a shrinking on the reverse of temperature. This has a tendency to loosen the imperfectly connected masses of rock thus exposed and to facilitate the admission of water, during heavy rains, into the crevices. When this occurs at the temperature of the freezing point, the water is congealed, and by its expansion, rocks of an enormous size, as well as smaller masses, have often been broken up from their lofty situations and tumbled to the mountain's base. This being annually repeated, through a lapse of ages, occasions, in numerous instances, an immense accumulation of debris at the foot of the mountains, which, by the annual growth and decomposition of vegetable substances, and the sand and dust, brought by the winds and deposited in the interstices, assumes somewhat of an uniform appearance, such, at least, as to induce a belief that the whole mass thus accumulated is the result of decomposition.

But I can in no wise, view it as such. Were we to explore those new formed districts, by cutting a horizontal drift about midway up their sides, we should find the fallen masses lying, like the ruins of the ancient cities of Egypt, in promiscuous disorder, as unchanged in form and texture almost as when detached from the parent rock. This, therefore, cannot be called the result of actual decomposition ;—but rather the disruption, or breaking up of rocks by accidental causes, which are by no means common to all.

It now remains to consider the nature, causes, and extent, of the decomposition of rocks.

The very term decomposition *implies, in my view of the subject, the entire reduction of a rock or other mineral substances, in whole or in part, to its integrent moleculæ; at least so far as to be susceptible of being carried away by the winds, rains, &c.

* It may not be amiss to observe, that the word decomposition, in this instance, is taken or used in a limited sense, that is, as differing in some degree from that of disintegration.

For example, a rock or mass of imperfectly formed gneiss, granular lime-stone, dolomite, or sand stone, falling into small grains, may be said to have undergone the process of disin togration. But if the felspar which forms a constituent part of the gneiss, should fall into an impalpable powder or paste like substance, as is the case with petunze, when changed into kaolin, it may be said to have undergone a partial decomposition.

The decomposition of a substance, is a very common expression made use of to denote the wasting or gradual disappearance of some earthy or mineral substances. But the word decomposed, (whence decomposition) technically used, implies the resolving or dissolving of a mixed body, or in other words, the reduction of a body or substance, by some chemical or other process, to its *elementary principles*.

Hence, it would never answer to be applied, in its full exten t, in the destruction of mountains, the disintregration of rocks, or the wasting away and disappearance of earthy and mineral substances by which the common soil whence we derive our subsistence, is formed; for the integrant moleculæ of rocks, and of which we will *suppose* our soil to be composed, being *alike subject* to the operations of the same agent, would likewise be reduced to the clementary princi ples, and we should have no soil at all.

This fact ought to be kept in view by those who so strenuously advocate the perpetual decomposition or utter wasting away of the solid materials, of which the crust of this globe is composed; an opinion as absurd and inconsistent, as unphilosophical.

The cause or causes by which this change is produced, may be considered as two fold, (viz.) the one chemical, the other mechanical.

One of the instances in which the decomposition of mineral substances occur, by chemical causes, is that, perhaps, of Kaolin, or rather Petunze, which, by the quantity of potash it may contain, attracts moisture to a degree sufficient to reduce the whole to the state of Kaolin or a paste like substance.

Another instance is such as is mentioned by Denon, with respect to the mountains of the Lybian range, where the decomposition of the rocks is promoted, it is supposed, by the highly saline state of the air.*

The decomposition of rocks is again, supposed to be occasioned by a kind of lixivium that is formed by the decomposition of vegetable substances, and which infiltrates through the superincumbent soil down upon the rocks, producing thereby a kind of chemical decomposition, differing in some degree from the common process of disintegration.

There are some instances which, at first view, are calculated to favour this opinion, and give to it a great degree of plausibility—but a more general investigation of the subject will not justify the conclusion.

For example—It has often occurred that the soil, or earth on the sides of mountains, being almost saturated with water, slides down, in immense bodies covered

* Denon's Travels, vol. 2. p. 2d.

with verdure, into the valleys below, leaving the rocks beneath, apparently in a state of decomposition.

But this newly formed surface, composed of loose and confused fragments of imperfectly formed rocks and stones, mixed with earth, being exposed to the operations of rain and torrents of water, are hurried down the steep into the valley; until at length, the firm and solid mass is exposed to view, and no longer exhibits those striking appearances of decomposition.

Again, in digging a few feet into the earth over a bed of rocks, we come into a similar covering of the strata. As we descend, the mass becomes more and more compact, until we arrive at the solid and perfectly formed rocks.

These, and many more, are instances, calculated to favour the opinion, that the decomposition of vegetable matter, through a lapse of ages, may have had a considerable influence in producing this apparent change. But if we cut through a hill where the earth is fifty or a hundred feet deep above the rocks, and through which no menstruum could have been infiltrated, of sufficient strength to decompose any mineral substance, we find the same appearances.

Again. If we dig down to a small or great depth upon solid compact granite, lime-stone, and some other rocks, we find no such appearance, though but a few feet below the surface—Besides it frequently happens that the soil from the sides of mountains, slides down, as before, and leaves the above mentioned rocks exposed to view in a solid mass, with little or no appearance of a superincumbent decomposed matter.

Hence, it seems that this appearance in rocks, though similarly situated, is not general. Therefore could not have been the result of a chemical decomposition from the infiltration of any menstruum from the surface of the earth.

The instances in which those appearances occur, seem to be mostly confined to stratified or schistose rocks; and as they are thus found at various depths in the earth, I am disposed to consider it as the result of an imperfect formation—a consequence of the mineralizing powers acting with less force near the surface of the ridge of rocks, (though at a great depth in the earth) than below, where the deposition, or crystallization commenced. Of this, if we consider the formation of rocks as the result of deposition, or crystallization, we shall find analogous cases, sufficiently abundant in every chemical laboratory, to justify the conclusion.

The principal and most efficient cause then, of the decomposition of rocks, appears, without going into a further investigation of the subject, to be the following degrees of temperature, viz. moist, or wet and dry, heat and cold.

The effects of these, on a variety of species of rocks, is too obvious and palpable to be denied. But how few are they? What proportion do they constitute of the great mass of rocks that compose the outer crust of this globe? For I speak only of the rocks of our mountains and those near the surface of the earth, and not of those below the depth that have, as yet, been explored. To what extent is the process of decomposition carried, and what are the effects of those agents upon substances the most, as well as the least, susceptible of their operations?

To determine this question, it is necessary to examine the nature and capacity of the substances to be acted upon, and the force or influence, which those agents are capable of exercising upon these substances; and also the effects thereby produced.

All mineral substances have the capacity of imbibing, or rather of absorbing heat, or calorick: some in a greater, and others in a less degree; consequently, their constituent particles are more or less subject to expansion: by the abstraction of heat they are liable to a proportionate degree of contraction. Hence substances of a foliated, or granular texture, when exposed to a high or low degree of temperature, and frequently alternated, lose, in part, their adhesive quality, become weakened, and are disposed to disintegrate. Thus, a hexadral prism of mica, when taken from a rock, or its gangue, appears like a solid prism; subject it repeatedly to the operations of heat, even of the sun, and cold, and the laminæ will separate spontaneously, so as to be perceptible. The same effect is produced upon several of the granular substances destitute of cement: hence a gradual disintegration of the part exposed; but the several species of rocks liable, from this cause, to disintegration, are small in number and therefore extremely limited in these results.

There are, likewise, a variety of mineral substances liable, from their structure, in a greater or less degree, to the absorption of water. Repeated exposure of substances in this state, to the heat of the sun, is another cause of a slow disintegration; but the most powerful agent in the decomposition of rocks, of any perhaps to which they are exposed, is the operations of cold, when it arrives at the freezing point. Very few of the incompact or imperfectly formed mineral substances, when having absorbed a quantity of water, and being exposed to freezing, can resist the force of its operations, nor long preserve their form entire.

But even the effects of this agent, as powerful as it may be, are, nevertheless, limited; and it is only on such rocks as are destitute of a cement, that it can exercise its powers to a degree sufficient to destroy their texture, and cause a disintegration. Of this we have sufficient proofs in the effects which are produced on all mineral substances by its operation. A rock or stone having, by exposure to rains, &c. absorbed a quantity of water, and in that state exposed to intense cold, and repeatedly frozen, is gradually reduced to sand or dust; and in the following manner:—The water absorbed by mineral substances, insinuates itself between all the particles to a certain depth; by freezing, it expands, and the cohesion of the particles is thereby destroyed and broken up. As soon as the weather moderates so as to dissolve the ice, the stony particles being without support, separate from each other, and fall from the mass. This, it is universally admitted, is the manner in which the disintegration of rocks is produced, by the operations of cold, or by frost.

Having ascertained the manner in which this agent acts in the decomposition of rocks, or other mineral substances, we are enabled by certain criteria, precisely to ascertain, the substances liable to its effects, and the *full extent* of its power and influence upon all mineral substances.

For example, let a mass of sand stone, dolomite, or other substance, in the form of a cube of any dimension, be emersed in water, or subjected to rain, until the water has penetrated to the depth of one inch in every face of the cube; then let the mass be exposed to a degree of cold, that shall freeze it to the same depth that the water has penetrated; afterwards let the mass be subjected to a degree of heat, that shall operate uniformly upon each face of the cube, until the frost is removed, and the substance of the mass falls away to the extreme depth to which it was frozen.

What sort of a figure will the mass represent under such circumstances? Not, certainly, that of a regular cube; every point and angle thus exposed, will be rounded down, and if the operation be repeated, for instance, through a succession of seasons, the mass will become a sphere, and thus progress until reduced to a point, or completely dissolved.

This is precisely the effect of frost or intense cold, upon all mineral substances susceptible of its operations, and is that which constitutes one of the criteria, by which we are to determine the extent of its power, in the disintegration and decomposition of rocks.

It may not be amiss to explain (though it can scarcely seem necessary,) the manner in which heat and cold or frost operate to reduce a cubick mass of stone, to that of a spherical form.

It is, doubtless, well known, that when water is applied to two or more sides of a rock in the form of a cube, or any other angular body capable of imbibing it, the water is gradually absorbed; as it penetrates the mass from the two sides, it meets at the angles where it is thinest, and its force is then directed diagonally towards the centre, where the particles of the substance are disposed to receive it, until, perhaps, it becomes saturated; and that too to a greater distance from the point of the angle towards the centre, than from either of the two sides towards the centre.

The operations of cold or frost, and heat, are exactly similar. When the cold is sufficiently intense to freeze the mass, to the depth at which the water has penetrated, the particles of the substance are, by the expansion of the water, broken up and displaced. As the cold is abstracted by the application or absorption of heat, which penetrates the mass in the same way or manner, a disintegration of the substances takes place, and extends to the depth to which it was frozen. When this is finished, for the season for instance, the mass no longer presents a cube, but a figure materially reduced, and its corners or angles rounded and irregular. Thus if the process be frequently repeated, the cube will be reduced to a spherical form.

These are decidedly the specifick operations of wet and dry, heat and cold, in the disintegration and decomposition of all rocks, and other mineral substances, susceptible of their effects.

Of this fact we may, without going among the rocks, see a striking illustration in that of, what is called, a "slack burnt brick" exposed to their effects. In the course of two seasons, a brick of this description thus exposed, will be reduced from a parallelogram to an oblate elipsis

A similar effect is produced by the operation of heat upon wood. Subject a piece of wood, in the form of a cube, or that of a triangle, to heat, until it be ignited, and the angles, from the same cause, are the first to be on fire ; and if it be alternately ignited, and the carbon removed to the depth at which it has penetrated, it will at length be reduced nearly to that of a sphere.

Taking these facts for granted, let us see how far the several kinds of rocks, and, particularly, those of the primitive formation, are operated on or effected by those agents.

1st. The old red, the ferruginous, and variegated sand stones, are considered among those that are liable to disintegration by frost, &c.

If we examine these rocks in their natural or primitive situation, they frequently present appearances which favour the opinion that they have suffered, in course of time, a considerable diminution, and that from the accumulation of small irregular masses, and grains, apparently of the same substance, lying upon and about these rocks: but who can pretend to say that these are not the debris of the incompact or imperfectly formed mass that served as the covering as it were of the rocks, and which being destitute of a cement have fallen into sand. This part or portion, it is readily admitted, does not nor cannot resist the operations of those agents. But do the great masses of these rocks, when perfectly formed, betray unequivocal signs of disintegration from this cause? Are they all in the form of boulders with their corners rounded down as they *inevitably must be* if reduced by frost? On the contrary, are not their points and angles entire, presenting a rude and craggy surface? I will venture to answer that in most instances they are so. If not however, why is it that masses detached from a ridge of this kind of rock, and employed in civil architecture, and exposed to all the vicissitudes of seasons and temperature, should remain uninjured and without any visible change, for an immense period of time, though equally subject to the pelting of rains, the absorption of water, and the severity of the most intense cold and frost? Perhaps it will be urged that materials of this kind employed in perpendicular walls, are not so liable to the effects of wet and cold, as when buried under ice and snow through a succession of seasons: but why is it, that when employed in sepulchral monuments, and placed near the surface of the earth, they experience no material change. I could easily refer to a number of church yards in the northern states, where monumental tables of these materials, consecrated to the dead, have lain for more than a hundred winters, buried in snow and ice; yet every letter of their inscriptions remains unimpaired or almost as legible as when cut, except being covered with moss.*

Surely the pious act of rearing these humble monuments, and sculpturing them with pathetick strains, in prose and verse, to portray and perpetuate the amiable qualities of our departed ancestors, could add nothing to the durability of the materials. How is it then, that this substance, when employed for useful purposes is rendered so much more capable of resisting the operations of times and seasons, than when lying in its original bed, where it is supposed to be fast crumbling down to sand and dust, to form, or at least to become tributary to the soil?

Certainly there must have been some deception in this business, or some mistake in the calculations that have been made on that subject, and which I shall notice in the sequel; for if letters inscribed upon it can remain exposed flat upon the surface of the

* In describing the monuments in a church-yard at Dalmally, in Scotland, it is said that "the most modern one of the number, on which was sculptured a crucifix, was judged to be 500 years old; yet, though of steatite or lapis ollaris, was free from decomposition."—Travels of M. Faujas de St. Fond, vol. I. page 289.

ground for an hundred years without any material change, it would not lose one inch in thickness during the period of a thousand years: consequently, if all the rocks upon the surface of this globe had been composed of these varieties of sand stone, equally exposed and liable to disintegration from the commencement of time, or for six thousand years, we should not, at present, have ten inches of soil from this source upon the face of the earth.

Among the red sand stones, there is a species of a ferruginous *slaty kind* that is peculiarly subject to disintegration from the above causes. It occurs in a number of places in these United States, and perhaps in every other country: but mostly I believe in what are considered coal districts.

It occurs in Frederick county (Maryland) on the Monocasy, near Pipe Creek, having a declination of about 40 or 45°. It is also abundant in New-Jersey about New-Brunswick, on the Raritan river and elsewhere. It likewise occurs in Connecticut, running in a N. E. direction and crosses the Connecticut river between Suffield and Windsor. Also below, and in the town and city of Hartford. Where this rock is exposed to the weather, the covering or upper strata is particularly disposed to be broken up in small rhomboidal, or quadrangular laminæ, which in some instances form a complete covering to, and screen the rocks below from the further operations of the weather, by their being below the limits of frost. There are some other kinds of the schistic rocks which, in like cases, present similar appearances, but which, not being of very great importance in the present view, I shall not take into further consideration.

2dly. I shall proceed to examine the quartzose rock, compact mica slate, clay slate, primitive silicious slate, horn stone slate or the palaiopetre of Saussure, &c.

These substances, it is well known, when *compactly or perfectly formed*, have each an alluminous or silicious cement, which gives to the substance such a degree of elasticity or firmness that, if they do absorb a small quantity of water (and small indeed it must be) they are capable of resisting the operations of cold and frost. Hence, the extent of disintegration with rocks of this description is very limited. This conclusion however is drawn from the appearances which they generally present to view. That is, of being angular or sharp pointed, and extremely craggy.

Where this is the case, it is highly improbable that they can have suffered any material loss by disintegration: for, as before mentioned, it is next to impossible that this can take place, no matter what may be the agent employed, for the purpose, without the points and angles being reduced and blunted, thus gradually progressing to a rounded form.

3dly. I shall consider the green-stone, (or diabase of Brogniart) the porphyritic rocks, some of the amygdaloids, &c.

From all the opportunities which I have had of examining these rocks in place, and from the observations that have been made by others on their structure and general character, I am disposed to consider them among those the least liable to decomposition or disintegration.

The principal constituent part of the green-stone rock is hornblende. This substance often differs in its texture as well as in colour: but in general it may be considered impervious to water. The other constituent part is commonly felspar. This substance, as I have before mentioned, is, in some cases when combined with hornblende, subject to disintegration, which gives to the rocks the appearance of a slow, but progressive decomposition; and that by reason of the spicula of hornblende projecting a little beyond the surface of the rock, thereby causing a harsh and rough surface.

It not unfrequently happens, in digging through the earth upon a ridge of this rock, that we come upon a superincumbent mass, or stratum of a pulverulent, or apparently decomposed matter, having hornblende for its base; and similar to that mentioned of gneiss and some other stratified rocks: but where this rock is presented to view perfectly formed there is but little reason to believe that it has suffered any material diminution, or loss of substance from the period at which it was first formed to the present time: and this opinion is founded on the following circumstances.

Hornblende, being impervious to water, cannot be liable to decomposition from any possible change of temperature, that of ignition excepted. In proof of this, the spicula, exposed upon the surface, preserve all their points and angles, and are the same in form as those which are found *in the body of the rock*, when broken open, and which were never exposed to the operation of any agent whatever since its formation. Besides, they not only preserve their form, but even their fine lustre in its pristine degree. Nay, more, when perfectly crystallized, and thus exposed in the surface of the rock, the terminal angles are preserved as entire as at the moment when formed.

Another proof of the durability of the hornblende rock, or of hornblende which constitutes almost the entire mass, is, that in sienite it manifests not the smallest tendency to decomposition. This substance, it is well known, has been employed in every department of civil architecture, sculpture, and statuary, from the earliest periods of time; exposed to every possible change of temperature, and the operations of every active agent that could be formed by a natural process, among the accumulated ruins of ancient cities, yet it seems to have experienced no material change.

In the next place, the greenstone, or amphibolic rocks (for they are not always green) wherever they are presented to view in mass or in place, appear to have preserved all their points and angles almost as entire as when fresh broken, although exposed to every extreme of heat and cold, that the climate in which they exist may have experienced.

With this species of rocks may also be associated those of the amygdaloids, mandlesteins, or variolites,

&c. the basis of which is a hornblende porphyry, or porphyritic hornblende. Of these the South Mountains (or blue ridge) abounds in Virginia, Maryland, Pennsylvania, and, perhaps, throughout the whole extent of its range. The mamillary masses which they contain, are either quartz, felspar, or epidote, and in some instances other substances. These I have examined, in place, on different parts of the ridge, in Maryland and Pennsylvania, with scrupulous attention; and I have no reason to believe that they have suffered any more by decomposition, or that they are more liable to it, than any of the other rocks, in which hornblende is the predominant substance. This opinion is founded on the following facts which are observable in almost every instance where these rocks are presented to view.

The little irregular and isolated masses of quartz and epidote, which enter into the composition of these rocks, seem to pervade the whole body of their substance, and every surface that is exposed to view, appears studded with them; some of which project an eighth, and some a quarter of an inch above the substance in which they are enclosed.

These pebbles of epidote and quartz, not being liable to decomposition by exposure, have retained nearly their primitive form, whilst the basis of the rock has experienced, in the course of time, a slight diminution, which gives to the pebbles the projection which I have mentioned. But that the rock has experienced no further decomposition, is obvious from there being few or *no appearances of cavities* from which these globular masses have fallen, from the want of support.

Again, there are no appearances of these pebbles at the bottom or base of these rocks, at which they must have fallen, nor in their fissures, from whence they could not be removed by either winds or rain. Moreover, I could find no signs of them in the little streams that glided slowly round the fragments that had fallen from the rocks above.

But the most convincing proof that these rocks are not in a progressive state of decomposition, except in a *very slight* degree, is, that notwithstanding all the changes of temperature to which they have been exposed for ages, they retain all their points and angles, and every feature of a rude and craggy aspect, such, doubtless as nature first impressed upon them.

4thly. The real porphyry also occurs upon this mountain, and some other rocks, which it may not be uninteresting to notice in this view.

A very fine and beautiful porphyry occurs at Nicholson's Gap, in Pennsylvania, about half way across the mountain, and immediately on the road. It is of a pale red, brown, and purple colour, handsomely spotted with crystals of felspar.

This beautiful species of rock, in this, and I believe all other places, discovers but little, if any signs of decomposition. All the points and angles appear as sharp and entire as when first broken, although exposed in their present situation ever since they were formed. Nay, if we consider the firm and compact structure of this kind of rock, the nature of its materials, and the exquisite polish of which it is susceptible, we shall not be surprised that sculptured specimens of it have been preserved entire, amid the ruins of ancient cities, for three thousand years ; nor hesitate to admit, that if there be a substance in nature, capable of resisting the all-powerful influence of time, it is that of porphyry.*

Among the variety of other kinds of rocks that compose this ridge of mountains, and which have in like manner withstood the changes of seasons and the intensity of frost, is one that is highly interesting in this, as well as a geological point of view. It is a species of sandstone with an argillaceous cement, occasionally striped and handsomely variegated with the oxid of iron. It has been remarked, that it occurs opposite to, or about eight or nine miles east of Hagerstown, Maryland.† There is reason to believe, however, that it prevails at nearly the *same elevation* to a great extent. I have found that the top of the Sugar Loaf, a conical, high, and isolated mountain in Frederick county, Maryland, about seven miles east of the South Mountain, is composed of this kind of sandstone. I also find it upon the highest points, only, of the same ridge in Pennsylvania; so that in every instance it appears at

* In describing some of the ruins of Egypt, Lord Valentia observes, "near it was a Marabout, the dome of which was supported by four jasper columns, the polish of which was as *perfect as on the day they were finished.*"—Valent. Trav. Vol. III.

† Cleaveland's Mineralogy, p. 624.

the same elevation, preserving a horizontal line, and capping all the highest points of the ridge. The same kind of sandstone, it is believed, occurs again at the same elevation on the Laurel Hills: and it is more than probable that the sandstone mentioned by Mr. *Cornelius*,* as being found on the tops of the Cumberland, Lookout, and Rackoon mountains, (Tennessee,) is of the same kind, and at a corresponding elevation. Whether so or not, it is at least an interesting geological fact, and worthy of attention. These rocks, wherever they occur upon the South Mountain, do not appear, at a distance, to possess any thing novel or strikingly interesting; but when approached, or viewed from their base, they present an awful scene of confusion, disorder, and ruins. The masses, which are of almost every dimension, from a cubic foot to that of some hundred tons weight, lie piled upon each other to a great height, and in every possible direction or position that can add sublimity and horrour to the view. Some of them are standing upright; others of great length are poised upon a single point of a rock, and seem ready, by a small force, to be thrown down; yet the united efforts of many hands have not been able to displace them.

The circumstance which attaches to these rocks the greatest degree of importance in the present case, is that, notwithstanding they are of sandstone, exposed to the bleak winds of the north, and the combined

* American Journal of Science.

forces of frost and snow, they discover few or no signs of disintegration. I have examined them with particular attention, and neither in their crevices, fissures, nor cavities, could I find satisfactory proofs of disintegration: not even in the chasms down between the rocks, some of which appeared ten feet deep, were any grains of sand to be seen; on the contrary, their points and angles appear almost as sharp and entire as if recently broken up from the quarry.

5thly. Having taken a cursory view of some of the prevailing rocks that compose the crust of our earth, I shall examine, lastly, the several species that are considered as most abundant, and such as occupy the widest and most extensive range in the structure of this globe, viz. Granite, gneiss, sienite, and limestone, including their several modifications.

These likewise are believed to be in a progressive state of decay, and being most prevalent, must, of course, contribute most abundantly to the soil of the surrounding country. Nay, their decomposition is considered as *essential to the superincumbent soil, beneath which* they lie. This part of the subject is highly important, and deserves a more critical examination than is consistent with my present views; I shall therefore pursue the course at first pointed out.

In the first place, let us inquire what are the substances that compose these rocks? Granite, with its several modifications, is composed mostly of quartz, felspar, hornblende, and mica; the three first of which, when perfectly formed, may be considered as nearly impervious to water. The latter when combined with the former so as to form perfect compact granite, and its subdivisions, is therefore impervious to water.

Limestone, with most of its modifications, being a homogeneous substance, is likewise, when compactly and perfectly formed, impervious to water. Or, if it be contended that either of those rocks is slightly susceptible of the absorption of water, the cohesive power of its structure is such, that the most intense cold or frost does not, nor cannot promote its disintegration.

Having demonstrated, I think, that the disintegration of rocks in general, is not materially promoted by any chemical process, arising from natural causes, and which will apply in a particular manner to those of granite and limestone, I shall proceed to inquire whether these two species of rocks are really susceptible of disintegration from any natural cause and to what extent.

In assuming this ground, I do not mean to contend that granite has not, in some instances, been found evidently impaired in its structure, and apparently in a progressive state of decomposition. The beryl and apatite are both found near Baltimore, in a vein of loose granite, running through gneiss, and which is easily broken up and crumbled to pieces; but this is in consequence of its imperfectly formed structure: the quartz inclined to be granular; the mica in broad pieces; the felspar in large crystals, or rhomboidal masses; the whole unconnected and without any cement. Through this the water has penetrated, and, in time, injured its structure. Such instances occur in many places. The pinite is found at St. Pardoux, in France, in a pulverulent granite, which is evidently injured in its structure by some of the causes which I have mentioned; but this, most probably, is nothing more than a vein, exposed in the great mass of more perfectly formed granite; and of this and the limestone rocks en masse, I would ask, in general terms, where are the instances that bear the unequivocal marks of a progressive decomposition?

Dr. *Hutton* would have us believe that the mountains are in a progressive state of destruction, whilst their debris are carried away by the torrents into the ocean.

Mr. *Kirwan* seems also to be of the opinion that they are decomposing, "by being corroded by air and moisture," and hence concludes, that their summits were once *much* higher than at present.* Yet when combatting Dr. *Hutton's* theory, he endeavours to prove that those which are composed of granite do not decay,† and refers to the remarks of *Patrin*, on the indestructibility of granite, for support.

Pallassau makes frequent mention of the disintegration of the rocks of the Pyrennees, which are mostly of granite and limestone; and remarks that they are constantly yielding their materials, for the formation and extension of the soil in the valleys be-

* Kirwan's Essays, p. 98.

† Ibid, p. 436.

low: yet in speaking of the granite through which runs the Garrone, he says, "This species of rock braves the injuries of time, and the continual action of the waters."*

So prevalent is the opinion of the degradation of mountains, that some attempts have been made to ascertain the period of time requisite to accomplish their total destruction, or to reduce them to a level with their adjacent vallies.

M. *Gensanne* has found by observations, which he pretends are unequivocal, that the height of the Pyrennees is lessened, by a gradual disintegration, or decomposition, at the rate of *ten inches* in a century. Upon this, supposing their height to be fifteen hundred fathoms above the level of the sea, he calculates the time necessary for their destruction, admitting the progress to be perpetual, to be that of a million of years.†

Believing it unnecessary to notice the opinions of any other authors, who are in favour of the decomposition of rocks, I will observe that it appears somewhat singular that Mr. *Kirwan* should indulge the belief, when, from his own assertion, the Runic rocks "have withstood decomposition these two thousand years as their characters evince."‡

But on this point, I can see but little necessity for his having selected the Runic rocks as an instance of

* Mineral des Pyrennees, page 248. † Do. 87.

‡ Kirwan's Essays, page 436.

the indistructibility of granite, lime stone, and some other kinds. There are many instances in the British dominions, more immediately at hand, and equally as well, if not better adapted to the purposes of a critical examination, removing of doubts, and of deciding upon the fact, or of placing the subject in such a light as no longer to remain a theme of discussion. Of these, I will name Stone Henge, and other Druidical monuments which have withstood the operations of time through a period amply sufficient to have determined whether or not, they are in a progressive state of disintegration, or decomposition.

Whether they are of granite or not, I do not recollect, but the presumption is, that the circumstance of these enormous masses having been removed from their primitive bed and erected into a monument, could not lessen the tendency to decomposition if susceptible of it; therefore they are suitable objects on which to fix our attention and to regulate our opinions on the subject. If not, however, a single glance at the Giant's Causeway might have freed his mind, and that of every other person, from all doubts on this head, and left the matter at rest.

There are monuments, *en place,* erected by the author of nature, and which, though not of granite or limestone, have resisted the combined efforts of time unaltered and unchanged. This at least is presumed: for had they been susceptible of the operations of any natural agent, or of those which are supposed to promote the decomposition of rocks, there is not a basaltick column in the county of Antrim, or any where else, whose surfaces are exposed to view, that would now present a single angle entire. Whereas, in this instance, the faces and angles are as perfect and as susceptible of actual measurement, as those of any crystal to which the Abbe Haüy has ever applied his goniometer, though they have withstood the raging conflicts of the elements through a period of time, not to be ascertained by the records of man, but at least a lapse of ages frightful and appalling to the human mind.*

With respect to the opinions and remarks of *Pallassau,* although he says it is evident that the Pyrennees, from the ocean to the Mediterranean, have been prodigiously depressed by disintegration, since the epoch of their formation.† I could not have wished for better support, or stronger proofs of the stationary condition of mountains, or rocks in general, than are to be found in his writings.

Had he written expressly with the view of confirming the opinions of *Monnet,*‡ who denies the universal

* Of the basaltick columns near Glasgow, (Scotland,) it is said, "Its constituent moleculæ are so intimately united to each other, that *time* and *the severity of the climate*, have not injured *in the least*, either the faces of the prisms, which still preserve their hardness and colour, or the entire of the mass, which *remains unaltered, and without any perceptible appearance of decay.*—Faujas' Travels, Vol. I, page 312.

† Mineral des Pyrennees, page 121.

‡ Monnet's Mineralogy, page 61.

degradation of mountains, he could not have better established the fact, and, at the same time, set aside all the calculations of *Gensanne*, than by several circumstances related in his excellent and interesting work.

For instance, in describing "the innumerable and enormous rocks of granite," which surround the mineral springs at Railliere, on the Pyrennees, he observes, that "the destruction of these masses of granite would require the work of an infinite series of ages, *(siecles)* if we judge them by the superb obelisks of granite erected in Egypt, more than three thousand years ago; monuments which at this day embellish the city of Rome,* without having experienced *any alteration*."†

In the next place, in speaking of the city of Bagnères, situated at the entrance of the valley of Campan, and the mineral springs of that name, he describes several inscriptions discovered about the springs, as reported by *Oienard*, and which are considered as proofs, that the Romans were acquainted with, and frequented those baths; and that by them the inscriptions were executed, when they invaded that country.

"Among these, the stone," says *Pallassau*, "on which the following inscription is engraved, is to be seen, at this time at Bagnères, in the garden wall of M. *Duzer*."

* One of these monuments, I presume, is the obelisk transported from Egypt to Rome, by Caius Cæsar. Its height was a hundred cubits, or a hundred and fifty feet, and its diameter eight cubits, or twelve feet.—See Sonini, vol. I, page 127.

† Mineral des Pyrennees, page 143.

AGHoNI,	DEO.
DEO	GHONI.
LABVSIVS,	AVLINI.
VSLM,	AVRINI.
	VSLM.*

Besides these, a number of others were found of a similar kind at the baths de Luchon, or Bagnères de Luchon. These baths, it seems, enjoyed considerable celebrity, in the time of the Romans, as appears by the latin inscriptions which have been discovered about them. After the country was freed from the Roman yoke, this place was neglected, and by the falling of rocks, stones, and earth, these sources of health and comfort were buried beneath them. The buildings about them were likewise neglected, and fell to ruins. In more modern times, however, the city has been gradually rebuilt, and, at the same time, the inhabitants commenced the cutting of trenches by the side of the ancient baths, with a view to discover the source of the water, which, at that time, was discharged from among the rocks in small streams.

In doing this, they discovered a number of marble monuments, or votive altars, executed in the Roman style, and with exquisite taste; and on which were sculptured a variety of inscriptions in latin. No less than twelve of these inscriptions are given by *Pallassau* in his work.

Moreover, at the Pene d'Escot, one of the most remarkable places in the Pyrennees, being a high and

* Mineral des Pyrennees, page 192.

very steep mountain, over which it is said that Julius Cæsar cut a road through an opening or pass, which the Romans called Summum Pyrenæum, to facilitate the communication with Spain, the following inscription has been discovered, and reported by M. *Le Roi*, Engineer des Ports, et Arsenaux de la Marine.

I. IAL. IERNUS CER
Ō VIR BIS HANC
RIAM RESTITVIT
LAM IIIMV
S. AMICUS C.

This inscription is represented as being a little effaced by time; not however so much, but that M. *Le Roi* obtained from it a correct copy, and which *Pallassau* has published as copied.*

From these facts, what is the inference to be drawn? What man in his sober senses will, on mature reflection, pretend that the Pyrennees, or any other chain of mountains, are experiencing a degradation of ten inches, in a hundred years, or one twentieth part of it, by the disintegration of the rocks, while the simple characters of which those inscriptions are composed, and superficially cut in limestone, have remained exposed to the operations of all the agents to which rocks in general are liable, for more than eighteen hundred years, (if executed by the Romans of which there can be no doubt) without being effaced or materially injured? Perhaps it will be urged, that they have remain-

* Mineral des Pyrennees, page 80.

ed a great portion of this time buried beneath rubbish, or the surface of the earth, and therefore not subject to the operation of the agents, which are supposed to promote the decomposition of rocks. If this plea be admitted, it establishes, incontestibly, a very important fact, viz: that the decomposition of rocks beneath the surface of the earth, is not promoted by any chemical agent, formed by the decomposition of vegetable or other matter upon the surface of the earth. Otherwise, in all probability, those inscriptions must have been totally effaced.

In the present instance, however, it is not necessary, to confine our views to the inscriptions discovered at the Bagnères de Luchon. Let us examine that which was found at La Pene d'Escot, as reported by *M. le Roi*, Engineer, &c.

This inscription is represented as being sculptured on a lime stone rock, of which kind this part of the mountain is composed; and by the side of the road leading into Spain, through the forest du Pact, and which road is said to have been cut by Julius Cesar; since whose time, (being more than 18 hundred years,) this inscription has remained exposed to all the vicissitudes of time and temperature, without a single letter being effaced, as is implied by the language of the author, who says, "*les restes d'un inscription en partie effacèe par le tems.*"* From these circumstances then, the inference is very obvious and plain, that in-

* Mineral des Pyrennees, page 80.

stead of millions of years being required to complete the destruction of these mountains, according to the calculation of *Gensanne*, or to level them with the vallies, it would require as many million of millions, upon a moderate calculation.

The few preceding remarks are intended to apply, more immediately, to the opinions advanced by *Pallassau* and *Gensanne*, relative to the disintegration of rocks, and gradual depression of the Pyrennees, but which, however, I considered equally applicable to every other chain of mountains, and the rocks of which they are composed, that can be found upon the surface of the globe.

Where I to assume the instances in which rocks of various kinds, and such as are most prevalent, have been employed in the arts, from the most remote periods of time, to prove the non-decomposition of those materials, and which, by the by, having experienced no change in composition or structure, by being removed from their primitive situation, or from having received new forms by the hand of the artist, are cases as decidedly in point, and are as suitable criteria, on which to form an opinion on this subject, as if they still lay exposed on the mountains.—Were I permitted to resort to the ruins of ancient cities, for monuments and monumental inscriptions, that have for ages resisted the agents of decomposition, and with which to combat the advocates for the disintegration of rocks, and the degradation of mountains, proofs the most palpable and convincing could be adduced to establish the fact, beyond all question, that such an opinion is erroneous, or almost without foundation.

The specimens of Roman sculpture, and the inscriptions discovered at Bagnères de Luchon and la Pene d'Escot, are appropriate and seasonable, and ought to have convinced *Pallassau* and *Gensanne* of the indestructibility of those materials, and of the errour of their opinions, respecting the gradual depression of the Pyrennees.

If, however, doubts should be entertained of the age of these specimens, or the authenticity of the facts, we need only examine the cities of Greece and that of Rome, to find instances enough of the ruins of theatres, triumphal-arches, temples, and palaces, the existence and age of which, being registered upon the faithful pages of authentick history, are enough to set doubts at defiance, and convince the most sceptical, that the materials of which they are composed, are proof against the insidious agents of time, though exposed to the full force of their operation for thousands of years.

Among these may be seen the remains of massy walls, mutilated columns, and broken entablatures, on the friezes of which are sculptured inscriptions, and bas reliefs of exquisite workmanship ; yet as entire, or almost as free from marks of decomposition, as when turned from the hands of the artist ; though they have lain mingled with rubbish, to be acted on by all the natural agents of destruction, for nearly or quite three thousand years.

Amongst these ruins, which bespeak the pomp and luxury of ancient kings, we also find the same materials, which compose the rocks and mountains, that are said to be undergoing the gradual process of disintegration and decay. Such as granite, sienite, porphyry, marble, verd-antique, serpentine, &c.

Antique specimens of these materials are sometimes exhibited to our view, which fully demonstrate, that they have withstood the injuries of time for ages, and are yet unimpaired.

It is not long since the busts of Niobe and Socrates, executed in red antique porphyry, and obtained from the ruins of Pompeii or Herculaneum, were offered to view in this city. These specimens of art, which discovered all the freedom and beauty of outline, that characterise the Roman and Grecian statuary, had experienced no other injury, than a kind of etching upon the surface; although, in all probability, fifteen or eighteen hundred years had elapsed, since they were executed, for it is well known, that for several hundred years, the art of sculpturing in porphyry was totally lost or unknown.

Specimens of this description, abound in almost all the museums and cabinets of Europe, and are of themselves, sufficient to prove the indestructibility of rocks, or materials of this kind, though exposed for ever so long a period to the injuries of time.

Still, if stronger evidence should be required, there are innumerable examples in Asia, Africa, and particularly in the ancient cities of Egypt; the imperishable ruins of which, that have lain for more than twenty centuries would, alone, require volumes to enumerate.

Some of the very first objects that meet the eye, as we approach this celebrated country, attest the truth of what I have asserted. *Dolomieu* says that the rocks, which stood at the entrance of the port of Alexandria, have withstood the buffetings of the ocean, these two thousand years, and still retain, *unaltered*, their ancient form and integrity.

The obelisk of Cleopatra, and Pompey's pillar, (the shaft of which is granite; its base and capital of lime stone, or marble,) those objects of wonder and astonishment, exhibit few or no marks of decomposition, and much less, of disintegration, although they have been standing thousands of years.*

* With persons who may have read the interesting travels of Dr. Clarke, and particularly his remarks on the Alexandrian obelisks, or Cleopatra's Needles; and also on the decomposition of granite, some doubts may still be entertained of the correctness of my views on the durability of granite, or, of its liability to disintegration, or decomposition.

Of Cleopatra's Needles he observes "They are covered with hieroglyphics, cut to the depth of two inches into the stone, which consists of *red granite;* but, owing to a *partial decomposition* of the felspar, its red colour has *faded* toward the surface. A similar decomposition has frequently hastened the decay of other ancient monuments; and it offers proof of a fact worthy the notice of persons employed in national architecture; namely, that granite is less calculated for *works of duration*, than pure homogenous marble, or common limestone. The action of the atmosphere conduces to the hardness and durability of the two latter; but it

The walls of Alexandria "which defended its industry and riches, *still defend* its ruins,"* yet the stones of which they are constructed, are not decomposed.

never fails to corrode and to decompose substances where *felspar* is a constituent. Examples may be adduced of marble, after continual exposure to air and moisture during two thousand years, still retaining the original polish upon its surface unaltered; but granite, under similar circumstances, has not only undergone alterations, but, in certain cases, has crumbled and fallen into the form of gravel."—*Vol. III. page* 170.

In my remarks on the decomposition of granite, I have expressly admitted that, in certain cases, it is liable to disintegration, so much so that, in time, the whole mass will crumble and fall into sand and gravel; and of such, most probably, were the instances which he mentions as being seen among "the ruins of Alexandria, Troas, and over all the district of Troas in general."—*Ibid.*

I have also admitted that, (whether in granite or porphyry,) if potash forms a constituent of felspar, as it does in some instances, it is apt to promote the disintegration and, perhaps, decomposition of the felspar. But the far greater part of the felspar that enters into the composition of granite, porphyry, &c. is *not of this* description, and particularly that which forms a constituent part of the granite, of which Pompey's pillar and the obelisks are composed. Hence we are led to infer, that the slight change which the felspar, in Cleopatra's Needles, had undergone in so many ages, (and slight it must have been indeed, since only its *red colour* had faded,) must have depended, in an eminent degree, on local circumstances.

It is a well known fact, that monuments of art composed of these materials and placed upon the borders, or in the vicinity of the ocean or a sea, and exposed to the saline vapours that are al-

* Baron de Tott, volume II, part II, page 36.

The twenty beautiful marble columns of Grecian workmanship, discovered by *Niehbur* at Bolbitine, no traces of which could be found recorded in the pages of history, and of which no traditionary legend, of the

most constantly floating in the atmosphere, are more liable and even more subject to marks of decay or decomposition, than the same substances when placed in situations more remote from the sea. It is, doubtless, from this circumstance, that the parts of these monuments which are exposed to the air, and being situated not far from the port of Alexandria and the Mediterranean sea, have experienced some change at their surfaces, which indicates a slight degree of decomposition; while the parts not exposed, discover *no marks* of the kind.

This conclusion is warranted by the remarks of Dr. Clarke respecting the attempt made to remove and transport one of these obelisks to England; in which he observes, "The work went on rapidly; the obelisk was turned, and its *lower surface*" (which was buried in the sand and rubbish,) was found to be in a *high state of preservation*."—*Vol. III. page* 170.

This conclusion is, moreover, justified by another circumstance, equally, if not more interesting in its character, though of a like nature. It is the obelisk of Heliopolis, or pillar of On, supposed to be alluded to in Genesis, chapter xii. 8th, and xiii. 4th verses; and of which Dr. Clarke, as well as Norden and Shaw, has given a description.

"This superb monument," he says, "is the only great work of antiquity now remaining *in all the land of Goshen;* standing on the spot where the Hebrews *had their first settlement*." Its height, according to Dr. Clarke, is between sixty and seventy feet: agreeably to Dr. Shaw, sixty-four feet. Its diameter, at its base, six feet; and composed of *one entire* mass of granite. And farther it is observed, "From the coarseness of the sculpture, as well as the his-half civilized Turks or Egyptians, could give any account, are described as possessing all their beauty of proportion and symmetry, as well as exquisite style of execution, though exposed to aggravated scenes of violence, and the destructive agents of time.

tory of the city to which it belonged, there is reason to believe it the oldest monument of the kind in Egypt."*

Now although this monument is, at present, situated at a considerable distance from the Mediterranean ; standing at a small distance north east of Cairo, and above the head of the Delta ; it is highly probable, that for many centuries, it was as near the borders of the Mediterranean sea, as Cleopatra's Needles are at present ; consequently we might expect to find some change upon its surface, as well as upon that of the latter, and from the same cause. Moreover, if we add to this, the amazing length of time, during which it has stood, ever exposed to the changes of times and seasons, we might reasonably expect, if granite be susceptible of decomposition, that we should find it literally mouldering and falling into dust. Instead of which it only discovers marks of decomposition in the sides most exposed to the Etesean winds, that, for nearly half the year, sweep over the Mediterranean sea ; and to which this monument, as well as Cleopatra's Needles, is constantly exposed.

Dr. Clarke says "Each of its four sides exhibits the same characters, and in the same order. Those which face the south have been the *least affected* by the decomposition of the substance in which they are hewn ; and it is from the southern side that the author's design is taken."†

Whatever may have been the state of this interesting monument, when examined by Dr. Clarke ; it seems that Dr. Shaw, who saw and made an accurate drawing of it about eighty years before, gives a different account of the state of it. He says "The obe-

* Clarke's Travels, vol. III, page 68. † Do. vol. III, page 69.

As we advance upwards on the borders of the Nile, frequent instances occur, in which models of Egyptian taste and Grecian excellence, wrought in granite, porphyry, and marble, appear to be struggling into

lisks, which I have mentioned at Alexandria and Heliopolis, have been described by various authors. The hierogliphicks upon the latter, (which are the same on all sides) are exceedingly fair and legible; and indeed the whole pillar is as entire and beautiful, as if it were newly finished. But the Alexandrian obelisk, lying *nearer the sea*, and in a moister situation, hath suffered very much; especially upon *that side, which faceth the north ward.*"*

It is by no means improbable that the Alexandrian Obelisks, from their proximity to the sea, and from the circumstance of their having been long prostrate upon the earth and among rubbish, may discover some signs of decomposition, and from this circumstance, most probably, Dr. Clarke has drawn the conclusion, that all granite, or the felspar which forms a constituent of granite, is liable to decomposition. This inference, however, is doubtful, as will appear by a careful and more extensive examination of the subject.

The obelisks of Cleopatra, and Pompey's pillar, are composed of what is denominated Egyptian granite : (the granites durus rubescens of Linneus) of this kind, most of the granitical monuments, as well as other edifices in civil architecture, in Egypt, are composed, and were obtained principally from the same quarries, or range of mountains.

Now although the Alexandrian obelisks exhibit some signs of decomposition, the pillar of On, or the obelisk of Heliopolis, which in all probability is of *much greater* antiquity, is still less so. The splendid ruins of the temple of Bahbeit, in Egypt, and which are described as being composed of three kinds of granite, discover

* Shaw's Travels, page 412.

birth, from hillocks of sand and ruins, and seem to say to the gazing traveller, *save us from this womb of oblivion*, and we shall survive the wreck of time! With such examples, and with half ruined temples, the cities of Bubastis, Oxyrynchus, Memphis, Luxor, Tentyræ, Thebes, and many others are filled; the ma-

no signs of decomposition, although the date of its construction, or the period of its execution is unknown. All the hieroglyphicks appear in the highest state of preservation, and "nothing could be more admirably executed than the bas relievo of this part of the temple, which probably formed the front of the wings; the polish remained perfect on the faces."* The three massive columns of granite with their capitals and entablatures, discovered at Alexandria, "have resisted the ravages of time, and of the still more destructive caprice of the present masters of the country."†

The two stupendous obelisks, described by Denon as standing at the entrance of Luxor, and which are of the same kind, or rose coloured granite, are, with all their figures, represented as entire and perfect. The quarries, likewise, from which the ancient Egyptians obtained the granite, for those and other stupendous works, exhibit traces of the ancient workmanship, "as fresh as if they had been left but the day before."‡

In this instance, no mention is made of the marks of decomposition of the felspar. Moreover, the beautiful obelisk, of the same granite, and which was removed by Caius Cæsar, from Egypt to Rome, remains entire, "without having experienced any alteration,"§ although executed more than three thousand years ago.

* Lord Valentia's Travels, Vol. III, page 436.
† Do. do do do 461.
‡ Denon's Travels, Vol. III, page 206.
§ Pallassau, Mineral des Pyrennees, page 143.

terials of which have resisted, alike, the process of decomposition for hundreds of centuries.

Fragments, and entire specimens of sculpture, from the ruins of Carthage, are exhibited in the museums of almost every civilized country, yet notwithstanding their exposure for two or three thousand years, they betray few or no marks of the corroding agents of decomposition.

If we examine the gloomy recesses of the Catacombs at Necropolis, we find their walls, of granite, or limestone, sculptured with inscriptions and hieroglyphics which, though subject to the nitrous, or ammoniacal exhalations, arising from the remains of the dead, or the accumulated filth of jackals, and other animals, which, as well as man, seek safety and refuge in these silent retreats, have remained unhurt by the operation of any natural agent, although the date of their construction is at a period so distant, as to be almost as much involved in obscurity, as the births and names of the ghastly tenants, that are deposited in their dreary mansions.

On such facts we might rest the final decision; but our views of the subject must not be confined to a single district, however numerous and favourable the cases may be, which it affords; since a difference of climate and other circumstances, may produce very different results, in the opinions of some, even on the same materials. Let us cross over the Mediterranean, and examine the ruins of Telmessus, an island in the gulf of Glaucus.

Here again are the theatres and palaces, falling and mixing in promiscuous ruin, whilst the materials, composed of the several rocks which I have enumerated, have resisted the scourge of the elements, almost unhurt or unchanged by decomposition. The most positive and interesting proofs however, of their durability, are to be seen among the colossal tombs and mausoleums, excavated and formed in the solid rocks, upon the almost inaccessible heights of what may be truly and emphatically called "the everlasting hills," fronting the sea or port of Macri.

Here, while the eye wanders through the echoing recesses of these vast and gloomy chambers of death, the mind is carried back through a frightful lapse of ages, by the inscriptions at the entrance, which mark the period of their duration, their use, and for whom constructed.

One of these, it seems, was prepared or built for the reception of Helen, (the grand daughter of Diogenes,) her son, and grand daughter.

As Diogenes was born four hundred years before the christian æra, it is more than probable, that this stupendous sepulchre had been constructed, more than twenty-two hundred years. Yet every letter of the inscription is represented as entire.*

Another of those tombs Dr. *Clarke* calculates, from the inscription, to have been constructed twenty four hundred and forty-one years; yet not a letter appears to have been effaced, except in some few instances,

* See Dr. Clarke's Travels, volume II, page 132.

where, in all probability, it was occasioned by violence; for if two or more letters were actually destroyed by decomposition, we have reason to believe that the whole inscription would have suffered alike: but it appears that this is not the case; on the contrary, they are represented as having few or no marks of decomposition. The columns and sculptured ornaments which adorn their fronts, or sides, are described as possessing a peculiar freshness.

"In those that were almost plain," says Dr. *Clarke*, "the hewn stone was as smooth, as if the artist had been employed upon wood, or any other soft substance. The exterior form of almost every one of them, cannot, perhaps, be better described, than by comparing them with a familiar article of household furniture, to which they have a great resemblance; namely, the book-cases with glass doors, seen upon bureaus, surmounted by ornamental rail-work over the front and sides."*

Not only were the ornaments and inscriptions free from marks of decomposition, but the grooves, which were cut with the greatest precision in the stones for the reception of the slabs, that constituted the doors, and which closed the entrances into those sepulchres, were almost as entire as when first executed.

Leaving this, let us take a superficial view of the ruins of some of the cities of Palestine; such as Jerusalem, Galilee, and Napolose.

Here again we find the ancient ruins of Jewish temples and other works, of granite and lime stone, exe-

* Dr. Clarke's Travels, vol. II, page 136.

cuted long before the christian æra, still uninjured by decomposition. Here also we find the tombs of the kings of Judah, of Joshua, of Zacharia, of Jehosaphat, of Absalom, of Joseph of Arimathea, of the Virgin Mary, and the Sepulchre, (as identified by Dr. *Clarke*,) of our Lord and Master; and a number of others, of which Dr. *Clarke* observes, "It has never yet been determined, when those sepulchres were hewn, nor by what people. They are a continuation of one vast cemetery, extending along the base of all the mountainous elevations, which surround Jerusalem upon its southern and eastern sides; and their appearance alone, independently of every other consideration, denotes the former existence of a numerous, flourishing, and powerful people."*

These monuments, which carry us back to the earliest ages of time, and which are calculated to inspire the beholder with an awful reverence, have survived the attacks and vicissitudes of time, entire and unchanged. Even the very inscriptions are still preserved in legible characters, and mostly free from marks of decomposition. Nay more, "These are monuments," says Dr. *Clarke*, "on which a lapse of ages *effect no change: they have defied, and will defy, the attacks of time; and continue as perfect at this hour, as they were in the first moments of their completion.*"†

Independently of these, there is still to be seen on the plain of Rephidim, at the foot of Mount Sinai,

* Clarke's Travels, vol. II, page 321. † Do. vol. II, page 281.

the rock which Moses smote with his rod, and from which flowed springs of pure water.*

"Here," says Dr. *Shaw*, "we still see that extraordinary antiquity, the rock of Meribah, which hath continued down to this day, without the *least injury*, from time or accidents."†

Returning into Africa, we find upon the mountains of Ethiopia and Abyssinia, the habitations of Cush, the grandson of Noah, and his descendants, chiselled out of the solid rocks, in the sides of the mountains, still entire and unaltered by time ;‡ and corresponding with the habitations of the ancient shepherds, cut in the rocks upon the mountains of Palestine.§

As another instance of the durability of rocks, we find, on examining the quarries, from which the ancient Egyptians obtained the immense masses of granite and marble, for the building of cities and temples, the marks of the holes that were drilled in the rocks, and into which, wedges or bolts of wood or iron were driven, as at this day, for the purpose of breaking up the mass; and as fresh as when first exposed to the light of day.

"All those of the neighbouring rocks," says M. *Denon*, "whose surfaces are level, have been wrought in the same manner; and the traces of the ancient

* Exodus, 17, 6. † Shaw's Travels, page 352.

‡ See Bruce's Travels, vol. II, page 12, and Salt's Description of Abyssinia, in Lord Valentia's Travels, vol. III, page 250.

§ See Clarke's Travels, vol. II.

workmanship are preserved *as fresh*, as if they had been left but the day before."*

But one of the most important proofs of the indestructibility of those materials, and of their capacity to resist the united efforts of the agents of decomposition, are those situated upon the plains of Geeza,—the Pyramids of Egypt.

These awfully grand and stupendous monuments, which have set time at defiance, whilst they frown indignant upon the wrecks of ages, seem to say to the astonished spectator, leave us alone and unhurt, and we will survive the consummation of time, and enter afresh upon the verge of eternity.

In order to place the subject of the decomposition of rocks, and particularly those last enumerated, in their proper light, I have, in this hasty and imperfect sketch, selected cases in which they have been employed in civil architecture, sculpture and statuary, under the full persuasion that in this state or situation, they are equally as much exposed to the changes of temperature and the agents of decomposition, as if they lay upon the mountains, or under the soil; and hence, from the present shape and form of the materials, being able to judge of their primitive form, or such as when delivered from the hands of the artist; and knowing the date of their execution and period of past duration, we are enabled to determine, with a sufficient degree of accuracy, the extent of the injury

* Denon's Travels, vol. III, page 206.

which they have sustained by decomposition, disintegration, or that of any other kind.

From the view then which I have taken, and the facts which I have stated, (and facts, I trust, they mostly are) who can or will contend, that the mountains of our earth are becoming more and more depressed by the disintegration of the rocks of which they are composed? Is it not evident that if the calculations of *Gensanne* were true, viz. that the depression of the mountains, by the disintegration of the rocks, is at the rate of ten inches in a hundred years, one of the great plans of nature would have, long since, been defeated? For is it not evident that the towering heights of Imaus, of Taurus, of Libanus, of Atlas, of the Alps, of the Pyrennees, of the Peak of Teneriffe, of the Andes, and many others, were intended expressly to be covered with eternal frost and snow, for the specifick purpose of modifying and tempering the heated atmosphere in those burning regions? If so, it is obvious that, from a loss of ten inches in a hundred years, and admitting the age of the world to be, according to some, twelve thousand years, the height of the mountains would be between seven and eight hundred feet less than at first: consequently in many places, upon their heights, not a particle of snow or ice would now be seen. Therefore these countries would be left, to be almost set on fire by the insupportable heat of a vertical sun.

Fortunately, however, it is not so. The Great Author of Nature intended it otherwise; and they are, and ever have been, the same in height, in all human probability, that they were from the commencement of time. This I think will appear from the following facts.

1st. These heights, I believe, are at an elevation so great that neither animals nor vegetables have been known to exist upon them; consequently the disintegration of the rocks could never have been occasioned by the decomposition of the latter.

2dly. There having been no variation of temperature, such as heat and dry, or wet and dry, by which the particles of rocks were alternately expanded and contracted, thereby causing them to fall to pieces; no disintegration could possibly take place from this cause.

3dly, and lastly. They having been ever clothed with perennial snow and ice, ever *frozen and never thawed*, no decomposition or disintegration could possibly have been occasioned from this cause. Therefore they must, of necessity, have remained, as was intended, always the same from the period of their ultimate completion to the present day.*

* To the kind attention of Dr. William Howard, of this city, who lately ascended Mount Blanc, I am indebted for a fine specimen of granite, obtained by himself from the rock en masse, at the hoary summit of that beacon of Aurora, the highest point in Europe.

It is impossible to conceive any thing better calculated to confirm the opinion which I have advanced, on the indestructibility of

In relation to the cases which I have mentioned as existing in Egypt and other parts of Africa—in the island of Telmessus, and in Palestine; it may be said that they are mostly situated in a climate where cold and frost, the most powerful agents in promoting the disintegration of rocks, are wholly inoperative: therefore it is not unreasonable to suppose that materials of such a kind and in such situations may have withstood decomposition for an almost incredible length of time.

In reply to this, I will observe that although I have restricted my views, as to the general mass of evidence on this subject; yet I am not disposed to be partial, or to shrink from an examination of cases, or facts, that may occur in any parallel of latitude in the known world. I shall therefore assume a higher latitude, where intense cold alternates with heat of nearly an equal degree of intensity, in order to determine, to what extent they have the power to promote the disintegration of rocks.

The coast of Norway, for nearly nine hundred miles in length, is defended by an impregnable ram-

rocks in similar situations, by the vicissitudes of temperature, or any other natural cause.

This specimen of granite is composed of a beautiful white felspar, quartz, and hornblende; each of which substances is *in a perfect state of integrity*, and the whole mass perfectly free from the smallest sign of decomposition, or disintegration; although from its situation, it has probably been gilded by the *first tints* of each diurnal sun for thousands of years.

part of rocks, against which the whole of the Atlantic ocean from the pole is incessantly lashing its waves with inconceivable force. For seven months or more, these rocks are covered with ice, and frozen, perhaps, to the centre. Now there is no other way of resolving this ice, that I know of, but by the operation of heat, which commences about the beginning of April, or at the approaching summer solstice, during which they are left bare and exposed. Yet although these changes have been annually repeated, probably for thousands of years, they discover few or no signs of decomposition. On the contrary, they are as free from it as that of a similar range which protects the coast of Brazil, in the *torrid zone*, for more than two thousand miles in length. This we are enabled to determine by these facts alone, in which there is *no deception;* that is they are still craggy, angular and pointed.

"By such a rampart (says *Pont Oppidan*) consisting of, perhaps, a million, or more, of massy stone pillars, founded in the very depth of the sea, the chapiters of which rise only a few fathoms above the surface, all Norway is defended to the west, equally against the enemy, and against the ocean."

Mr. *Heriot,* in describing the country to the north of the river St. Lawrence, says that no country can present a more wild aspect; that it is composed of rocks, and "cannot boast of an acre of soil capable of yielding any useful production."*

* Heriot's Travels, page 58.

Mr. *McKenzie* represents the whole coast of Labrador, and the country east of the lakes, or what is called East Main, as little else than an immense region of rocks and fresh water lakes, with a very scanty portion of soil, and which is *still less* in the interiour parts.*

Of the French river he says, as before mentioned, "There is *hardly a foot of soil to be seen from one end of the French river to the other ; its banks consisting of hills of entire rocks.*" (*Page* 37.)

Mr. *Hearn* confirms the report of *McKenzie* by saying, that neither the coast of Labrador and Hudson's straits, nor the east coast of Hudson's bay have any herbage or trees upon them.†

Of the Stony mountains lat. 68° 14′ north, he says, "No part of the world better deserves that name, as they appeared a confused heap of rocks and stones utterly inaccessible to the foot of man." Even of the whole of those regions inhabited by the northern Indians he says, "The land throughout that whole tract of country is scarcely any thing but *one solid* mass of rocks and stones, and in most parts very hilly."‡

In all these cases, if I am correct in my views of the operations of the agents of disintegration and decomposition of rocks, there is but little or no appearance of a decay of the materials with such exceptions

* McKenzie's Travels, page 427. † See Hearn, page 7.

‡ Hearn's Journey, page 327.

however as I have already admitted. The rocks are every where represented as being rude, angular, pointed and craggy, and often terrifick even to behold.

If, according to some, the soil which covers the far greater portion of the earth, and which renders it the fit habitation of man, be owing to the gradual disintegration of rocks; why is it that this portion of the globe, which probably embraces all the different formations which are known in geology, is so far behind every other in this respect? If we examine the extremes of temperature which prevail in those latitudes, and on which depends almost entirely the disintegration of the rocks, we shall find ample reason to believe that this part of the globe would have been the most abundantly fertilized of any upon earth.—Yet it is *destitute*, notwithstanding its being for more than half the year frozen, as it were to the centre; and during the other half or portion, it experiences the genial influence of the sun to a degree so great, as to produce, in the crevices of the rocks, the leafing, the budding, and the luxuriant blooming of the rose, as well as in any other part of the globe: still these rocks are naked and destitute of soil; although they have lain exposed to all the revolutions of time probably from the beginning of the world.

Such being the facts, who will persist in advocating the opinion, that the height of our mountains is annually and gradually decreasing, to be ultimately levelled with the vallies; or pretend that the soil which covers the face of the earth was produced by the disintegration of rocks?

Such an opinion appears to me unfounded, both in natural, as well as moral philosophy, and seems to betray a want of attention to the plans of Omnipotence, as well as a neglect to allow Him, whose power is unbounded, and whose foresight is unerring, that degree of intelligence, homage, and credit, for his wisdom and providence, which might reasonably be claimed, if not awarded, by any one of our citizens: for who could expect, that a man would erect the frame of an elegant mansion, for the habitation and residence of his son, and compel him to live in it without a shadow of covering, or the means of subsistence.

The decomposition of rocks is a subject that has engaged the attention of many, and the opinions that have been offered seem mostly to agree, that the process, though depending on different causes, is universal.

It would seem, however, that those opinions were calculated to favour particular views; or, that they were regulated by some local circumstances, that would perhaps justify such a belief. Such, no doubt, there are. But a more general view of the subject, and a more critical examination of facts, which are offered in abundance in every quarter of the globe, will not fail to satisfy the most sceptical, that such a doctrine cannot be established, nor supported by reason or facts. This conclusion receives additional support and confirmation, from the following remarks of Dr. *Hutton*, who, though one of the most strenuous advocates for the disintegration of rocks, and the degradation of mountains, has very unwisely, or in an unguarded manner, advanced an opinion, which, if not a refutation, militates very much against one of the fundamental principles of his own doctrine.

"We have mountains in this country," says Dr. *Hutton*, "and those *not made of more durable materials*, than what are *common to the earth*, which are *not sensibly diminished in their height with a thousand years.*"

"The proof of this are the Roman roads made over some of those hills.* I have seen those roads *as distinct as if only made a few years*, with superficial pits beside them, from whence had been dug the gravel, or materials, of which they had been formed."†

In reply to this, professor *Murray*‡ observes, "If in so long a period, the disintegration is so inconsiderable as not *to be perceptible*, what must be required to level those mountains with the sea? *Millions of years would not suffice.*"

* The Abbe Fortis likewise makes mention of the remains of Roman roads, in his travels in Dalmatia. One in particular he describes, as leading from Lika, across the country to Salona, and which, near Perussich, is quite entire, though, probably, of much greater antiquity than those mentioned by Dr. Hutton.—Abbe Fortis' Travels, page 524.

† Theory of the Earth, vol. II, page 140.

‡ The reputed author of the "View of the Huttonian and Neptunian System," which see, page 55.

The contemplation of the structure of the globe, and the various geological phenomena that are presented to view, have given rise to numerous opinions, and various theories; many of which, from their plausibility, are calculated to induce a belief that the whole fabrick, as far as relates to the nature, order, and arrangement of its materials, is not only the result of chance, but subject to its unlimited control. But we shall find, on a more *general* and *attentive* investigation of the subject, (and such is indispensably requisite; for opinions, founded on a superficial examination of local facts, will never constitute a theory, that will answer for the whole,) that the economy of this earth, and the regulation of its parts, are not governed by a chain of fortuitous circumstances, nor by the whims and caprices of ephemeral theorists; but by infinite power and intelligence supreme.

CHAPTER XI.

By no means so common and so extensive, &c.— This declaration will doubtless be considered as amounting almost to an insult, to the understandings of observing men; or, at least, a flagrant dereliction from truth, and every principle of sound reasoning and of established facts; in proof of which the Deltas of the Po, the Arno, the Indus, the Tigris, the Ganges, the Mississippi, and many others, but particularly the Delta of the Nile, will be considered as affording unequivocal and irrefragable evidence.

I am fully sensible of the powerful force that stands arrayed against me, and of the numerous instances, in various parts of the world, where it is supposed that the Deltas of rivers have been formed exclusively by the alluvion brought down, in the course of time, by their currents, and deposited at their mouths: but I am not disposed to shrink from the contest, though it should end in defeat, since my only object is the developement of truth, by a fair and candid exposition of facts.

That Deltas have been formed at the mouths of many rivers, and, in some instances, to a very great extent, is a well known fact. Yet, on the other hand, there are many rivers of nearly an equal size and extent, where there are no deltas, nor even the appearance of alluvial deposites.

Indeed it is admitted by that indefatigable historian, Major *Rennell*, that "all capital rivers do not form deltas."*

And further, Mr. *R.* observes, "However, the formation of such deltas, even by rivers of the first magnitude, is by no means universal; on the contrary, some of them terminate in deep inlets, or estuaries, instead of projecting forms: or, if the expression may be allowed, they terminate negatively, instead of positively. Of this class may be recorded the great rivers of the Amazons, Plata, and the Oronoko; besides many others, which bring down an equal quantity of matter of alluvion, with the Nile, the Ganges, or any other river that may form the most projecting delta."†

Thus, finding that all great rivers do not, alike, produce, or exhibit deltas at their mouths; we have reason to believe that their formation is not the natural result of the deposition of alluvion, brought down by their currents, but rather of a combination of causes or circumstances: these I consider of three different kinds, viz:

1stly. The alluvion of the river.

2dly. That produced by the winds, and

* Rennell's Herodotus, page 481. † Do. page 483.

3dly. That occasioned directly or indirectly, by the labours of man.

Under these circumstances I shall proceed to examine the delta of the Po, a case as interesting in its kind, as that of almost any other, and on which much has been said, to prove that it is, almost exclusively, the result of the alluvion brought down by the current of that river, and deposited at its mouth.

In order to determine the quantity and extent of the alluvion, *naturally* formed by this river, it is necessary to ascertain, as near as possible, what were the situation, and appearances at its mouth and in its vicinity, when first known, and before the settlement and cultivation of the surrounding country.

This it is difficult, nay impossible, to determine with any degree of accuracy: we have, however, a datum afforded, which will enable us to form an opinion, sufficiently correct for our present purpose. It is that which relates to the city of Hatria, now Adria.

M. *de Prony,* in his researches on the Hydraulick system of Italy, observes, "We are, however, certain, that the city of Hatria, now called Adria, was *formerly* situated on the edge of the coast; and by this we attain a *known fixed point* upon the *primitive shore,* whence the nearest part of the *present* coast, at the Adige, is at the distance of 20,000 metres."*

* Equal to 27,340 yards and 10 inches English measure, or fifteen and a half miles, and sixty yards.

At what period of time this city was founded, it is not in my power to determine; nevertheless, it claims a rank of very high antiquity.

M. *de Prony* observes, "The inhabitants of Adria have formed exaggerated pretensions, in many respects, as to the high antiquity of their city, though it is undeniably one of the most ancient in Italy, as it gave name to the *sea* (the Adriatic) which *once washed its walls.*"

Whatever claims to antiquity may be asserted by the present inhabitants of the city of Adria, it is more than probable, that an immense period of time must have passed away, before the smallest marks of human industry could have been traced upon the borders of the Eridanus, or Po. If we extend our views over the wide space, that lies between the Adriatic sea, and the residence of the primitive inhabitants of our earth, and consider the slow progress of civilization and population, extending westerly towards the borders of the Arabian Gulf, or Red Sea, we may reasonably conclude, that not until the Phœnicians had extended their views of maritime commerce, to more distant regions down the Mediterranean, was the Adriatic sea even known, much less navigated, by any people then in existence. Hence we may suppose that a period of 2000 years, and perhaps much more, had elapsed, before the site, on which Adria was fixed upon for a commercial city, was known. At this period then, it appears, there was no such thing as a delta formed, or forming at the mouth of the Po, for they had established a "fixed point upon the *primitive* shore, for the building of the city, and that too, on the edge of the coast of that sea, which once washed its walls."* This circumstance, (one that might naturally be supposed by every thinking mind,) rendered highly probable, discovers, on the part of the founders of that city, no common degree of sagacity and foresight; for had there been the commencement of a delta, that was annually increasing by alluvial deposites from the river, it would have betrayed a great want of judgment, in building a city at a point which, in the course of a century or two, must inevitably be left at some distance inland, and from the sea, where their commercial pursuits must naturally centre.

As soon as the city had assumed a more respectable stand, in point of extent and population, and the busy hum of commerce had engaged the enterprising spirit of its inhabitants, we may date the probable commencement of the formation of its delta, and for reasons hereafter.

But what was the rate of its slow and gradual increase, during a series of ages, no means are left to ascertain.

"The most ancient notices," says M. *de Prony*, "that I have been able to procure respecting the situation of the shores of the Adriatic, at the mouths of the Po, only begin to be prècise in the twelfth century."

At this period, which we will suppose to be more than three thousand years after the founding the city

* M. de Proney's Researches.

of Adria, the shore of the Adriatic had been removed to the distance of about ten thousand metres* from it.

This intrusion of the delta, will give an annual average increase of about ten feet and a half.

But it must be recollected, that the increase of the alluvial formation, at first, was scarcely perceptible; and that its subsequent extension was almost in a geometrical proportion; so that the gain of the last five hundred years, must have been, perhaps, nearly equal to the whole gain during the preceding period, as will appear in the sequel.

Let us now examine the rapid increase of the delta at the Po, from the end of the twelfth century to that of the sixteenth, and so on, to see the proportion which the gain of the latter bears to the former, in order to determine whether it has been produced by the alluvion brought down by the current of the river.

"During four centuries," says M. de Prony, "from the end of the twelfth to that of the sixteenth, the alluvial formation of the Po gained considerably upon the sea."

The northern mouth, which had usurped the situation of the Mazzarno canal, becoming the Ramo di Tramontana, had advanced in the year 1600, to the distance of twenty thousand metres† from the meridian of Adria; and the southern mouth, which had taken

* Equal to ten thousand nine hundred thirty-six yards, or six miles and three hundred sixty-four yards.

† Equal to twenty-one thousand eight hundred seventy-two yards.

possession of the canal of Toy, was then seventeen thousand metres (or eighteen thousand five hundred ninety-one yards,) advanced beyond the same point. Thus, the shore had become extended nine or ten thousand metres (or ten thousand nine hundred thirty-six yards,) to the north, and six or seven thousand to the south, (equal to seven thousand six hundred fifty-five yards.) "Between these two mouths there was formerly a bay, or part of the coast less advanced than the rest, called Sacca di Goro. During the same period of four hundred years, previous to the commencement of the seventeenth century, the *great and extensive embankments of the Po were constructed;* and also, during the same period, the southern slopes of the Alps began to be cultivated."

From this, it appears that the extension of the delta at the Po, had increased, in the space of about four hundred years, nearly eight thousand yards; a distance nearly equal to eight tenths of what it had gained during the whole period, from the founding of the city of Adria to the twelfth century. An enormous disproportion, as must be admitted on all hands. But let us examine the subject a little further, in order to comprehend the full extent of this rapid increase.

"The great canal, denominated Taglio de Porto Viro, or Podelle Fornaci, ascertains the advance of the alluvial depositions in the vast promontory now formed *by the mouths* or delta of the Po."

"In proportion as their entrances into the sea extend from the original land, the *yearly quantity* of alluvial depositions *increases in an alarming degree,* owing" (in his opinion) "to the diminished slope of the streams, which was a necessary consequence of the prolongation of their bed, to the *confinement of the waters between dykes,* and to the facility with which the increased cultivation of the ground enabled the mountain torrents, which flowed into them, to carry away the soil. *Owing to these causes, the bay* called Sacca di Goro, *was very soon filled up,* and the two promontories, which had been formed by the two former principal mouths of Mazzarno and Toy, were united into one vast projecting cape, the most advanced point of which is now about thirty-three thousand metres* beyond the meridian of Adria; so that in the course of *two hundred years,* the mouths or delta of the Po, *have gained* about fourteen thousand metres† upon the sea."‡

Hence it appears, that the delta of the Po has gained upon the Adriatic sea, (by a rough calculation) in the last two hundred years, about eight miles and a half; almost twice as much as it had gained in the preceding four hundred years, from the end of the twelfth to that of the sixteenth century; and more (in proportion as eight is to six,) than it had gained from the founding of the city of Adria to the twelfth century, a period, probably, of about three thousand years.

* From nineteen miles seven furlongs and fifteen yards, to twenty miles four furlongs and three yards, English measure.

† About eight miles and a half.

‡ See Cuvier's Theory of the Earth, Amer. edition, p. 281—2.

To what shall we attribute this surprising difference, this amazing disproportion? Not, certainly, to the alluvion brought down by the current of the river Po. If its waters had been rendered turbid with mud or alluvion, from one end of the year to the other, for the space, of two hundred years, which is a case unheard of or unknown, we could scarcely believe, that it would afford a sufficient quantity to produce that difference; for it must be recollected, that as the delta advances into the Adriatic, or any other sea, the depth of the water is very much increased, and, particularly, when we advance to the distance of twenty-one miles from the shore; at least it is so in most seas.

M. *de Prony* has attempted to account for this rapid increase of annual deposites, by two causes.

First, the cultivation of the southern slope of the Alps, and the districts on the borders of the Po, and, consequently, by the facility with which the mountain torrents, which flowed into the rivers, conveyed away the soil.

It is very natural to suppose that these circumstances would tend much indeed, to increase the quantity of alluvion, since but very little is ever seen to be carried away from uncleared, or uncultivated lands, although exposed to the full force of torrents of rain.

In a country covered with forest trees, and a bed of leaves, or upon land covered with a thick sward, the water, during a torrent of rain, is seen to run off in all directions, almost as clear as it fell from the clouds. This may be observed, in such situations at all times during long continued and heavy rains; but if it should happen to collect in a point at the head of a valley, where the banks are a little broken away, it is sure to increase the breach, and carry with it much sand or alluvial matter.

With cultivated grounds, however, the case is materially different; and, in every instance, where the earth is newly broken up and exposed, it is liable to be carried away, both by wind and rain: every furrow of a corn field becomes a conduit, through the channel of which, the rain waters are conveyed away, saturated with alluvion, into larger streams, from thence into creeks, and from creeks into rivers to be wafted down their currents.

Hence, it will readily be admitted, that the improvement and cultivation of districts on the borders of rivers, and in the vicinity of their embrochures, will have a tendency, under certain circumstances, to promote the increase and extension of deltas, and to these we may, in a certain degree, attribute their annual gain in an increased ratio.

To this last however, (viz.) the annual extension of deltas in an increased ratio, Mr. *Rennell* seems to be opposed, and on the subject of which, and the progressive diminution of the soil of mountains, he makes the following observations.

"We never fail to remark (says Mr. *Rennell*) on a survey of the naked summits of mountains, that the rain has in a course of ages, washed away the earth that covered them; or, in other words, that there is a progressive motion of the finer particles of earth from the mountains, towards the valleys."

"Admitting this to be true, and also that a proportion of it is swept away by the torrents: the longer the rivers continue to run, the less quantity of earth they must carry away with them; and therefore the increase of the deltas and other alluvions of capital rivers, must have been *more rapid in the earlier periods of the world's age*, than now."*

This, however, is evidently a mistaken opinion; for we may confidently assert, that the annual extension of deltas or alluvial formations, is in an increased ratio, proportionate to the improvement and cultivation of the districts in their vicinities, and particularly so in that of most maritime cities, situated at, or near, the mouths of rivers; nevertheless, it does not depend, but in part, on the increased quantity of alluvion brought down by the currents of such rivers.

I have remarked that the formation of deltas in general, depends on three causes:—The first is that of the alluvion of rivers, so called, being that which is held suspended and brought down by their currents. This I shall proceed first to consider.

The alluvion of all rivers, in the earlier periods of time, and even at the present, when they run through a country, overgrown with forest trees and covered with leaves, or a thick sward, that extends to the utmost extremity of their auxiliary branches, must necessarily

* Rennell's Map of Hindoostan, page 257.

have been comparatively small; for we may observe at the present time, in deep forests during long continued and heavy rains, the water running off, as I have before remarked, into brooks that are scarcely rendered turbid by alluvion.

As the waters increase and descend from one channel to another, into the principal stream or river, its waters are elevated; and its shores, by being softened, and in some instances excavated by currents, occasion the banks to break off and fall down. This, mixing with the current, adds to the quantity of alluvion, which is borne away by the rapidity of the flood. But a part, only, of this, as I have already stated, is wafted to a very great distance; for as soon as the current is slackened, or checked in its progress, the silicious part, or sand, is precipitated to the bottom; while the alluminous or clayey part, being much lighter, is held long suspended and carried to a great distance.

In this I am supported by the opinion of that very acute observer Mr. *Rennell*, who says, "The mud and sand suspended in these waters, during this motion, *are deposited* when that motion ceases; or rather, they are gradually deposited as the current slackens: *according to the gravity of the substances that are suspended.*"*

* Rennell's Herodotus, page 489.

Hence it is, that we have sand bars, or alluvial formations below projecting points of land ; at, or near, and below the entrance of one river into another.*

As soon as the current of a river receives the check of a strong and high tide, the sandy particles, however little or great the quantity, are deposited at the bottom ; hence, it may be presumed, we have no deltas at the mouths of all our northern rivers, where the tides are strong and rise high.

Here again I have the support of Mr. *Rennell*, who sometimes advances an opinion at variance with the theory which he is endeavouring to support.

Speaking of the deltas of rivers he says, "Which rivers, having brought down with their floods, vast quantities of mud and sand from the upper lands, deposite them in the lowest place in the sea; at *whose margin* the current which has hitherto *impelled them, ceasing, they are deposited by the mere action of gravity.*"†

With rivers, on the contrary, however large or small, that fall into deep bays or gulfs, where there are but little or no tides to check the force of their currents, as with the Mississippi, and the several rivers in the Gulf of Mexico ; the Nile, the Po, and other rivers that are disharged into the Mediterranean sea, the case is materially different, and it will be admitted that under

* See Lewis and Clarke's Travels up the Missouri.

† Rennell's Herodotus, page 484.

such circumstances, the alluvion of rivers is rendered, in some degree, tributary to the formation of deltas; but it is comparatively less, in relation to the Po, the Indus, the Nile, &c. than that occasioned, 2dly, by the improvement and cultivation of lands, and also by the existence of sandy deserts in the vicinity of such deltas.

The improvement and cultivation of lands, in almost all situations, on the borders of rivers, and at their mouths, renders the soil peculiarly liable to be carried away, both by rains and wind, into the rivers or sea; which tends greatly to the increase of alluvion, and the formation of sand bars, banks, and deltas; the latter in particular is a powerful agent in this business, though but seldom, or but little attended to.—Indeed the phenomena of winds, as they relate to this subject, seem not to have received that degree of attention which they justly merit, and which is required by every principle of truth and sound philosophy. But a little attention and observation will soon convince any person, susceptible of conviction, that the same phenomena accompany the winds, or currents of air, as do currents of water. If the current of a river flow majestically along, though at the rate of four or five miles in an hour, not a grain of sand is disturbed or lifted from the bottom; for the current of water is often so clear, that we may see to the depth of one and even two fathoms; nay, it is said from eight to ten fathoms in a clear day. If we trace up its auxiliary branches, even to the smallest brooks, we find their currents flowing with a steady course, though in some instances with great rapidity, plunging over rocks and precipices, yet no alluvion or a grain of sand is seen to disturb the pellucid streams. If a rock, or an island obstruct its course, its current is changed. If it should pass through a strait, or be contracted by projecting points of land, its velocity is increased, yet it is steady in its course. The same, with some small difference, may be observed in the currents of air, or wind.

On the contrary, when, by the melting of snows or the falling of rains, the waters rush in torrents into the auxiliary branches, and thence by latteral courses into the rivers, their currents are agitated, their velocity increased, the sand and alluvious matter is torn up and wafted away with their streams.

If there be an island, or islands, or other obstructions in its course, they occasion a counter current, or eddy at their lower extremity, where the current is slackened, and the alluvion is deposited; and where there is an annual, and sometimes semi-annual recurrence of these causes, and repeated for ages, need we wonder that shifting sand banks, bars, and islands, should be formed in the beds of rivers? However it may be, the *same* results are produced by violent and unsteady, or variable currents of the air, or winds.

If the winds rush, in unsteady and violent gusts, over the land, no matter from what quarter or point of the compass, not only the dust but even the sand is hurled into the air with the same facility as by a current of water, and wafted in clouds over the land, varying on its course, until meeting with some obstructions by which its current is slackened, it immediately deposites its alluvion, (for it is nearly the same thing) to the leeward of whatever object may interrupt its course. It may be said, who does not know all this?

But there is a variety of other phenomena of a similar nature accompanying the operations of winds, one of which is particularly worthy of notice in the present instance.

It is, that when a river running through a country is confined for any considerable distance from its influx into the sea or bay, between high ridges of hills, or banks, there is a current of wind rushing down its course, differing one or two points from the general course of the wind that may be prevailing at the time, or blowing in nearly a corresponding direction.

Thus if a river runs in a southerly direction, and the wind is blowing fresh from the north east, and raising the dust and sand in its course, when it meets with the current of air flowing down the river, under the circumstances which I have mentioned, the same phenomena may be observed, as when the rapid currents of two rivers unite; the sand and dust are whirled around in the most confused manner, and at last let fall upon the shore, and in the water, where, if the tide is setting towards the shore, the sand will be again thrown upon the beach. Hence it is, that we often see narrow projecting points of sand at the mouths of rivers running through a sandy country. They may be observed at the mouths of rivers on the Chesapeak bay, and particularly at the mouth of the Severn; the current of which, during the heaviest rains, was, perhaps, never sufficiently strong and rapid to float the sand, of which the flat is composed at the entrance of that river, one mile; and for reasons which it is not necessary to mention here.

The increase of alluvion from this cause, may be thought to be very small indeed; and as bearing no comparison with that brought down by the current of rivers; but it must be considered, that a recurrence of this cause may happen every week, or continue for a week. Whereas, rivers seldom bring down much alluvion, except during the heavy autumnal rains, or the melting of the snows in the spring, which rarely occur more than twice in the year.

Having briefly considered the phenomena of winds, and their operations in increasing the quantity and extension of alluvial formations, I shall proceed to examine, 3dly, that which is occasioned, either directly or indirectly, by the labours of man.

That which is caused directly by the labours of man, is by dyking, filling up, &c. and that which is occasioned indirectly, is the accumulation of filth and offals from a city, which, when it is a large and populous one, amounts, in the course of a few hundred years, to an inconceivable quantity.

These may not be considered strictly as alluvion; nevertheless, they both constitute powerful auxiliaries in the increase and extension of deltas, or made ground, where the means are resorted to, or otherwise afforded; and such is the case with that of the Po, the Nile, and many other places in similar situations.

As soon, almost, as a city is founded, at the entrance of a river into a bay or gulf, the inhabitants, in order to favour their commercial views, commence the operation of wharfing, dyking, &c. as occasion may require. If a part of the city happen to be on each side of the river, a corresponding course is pursued, and the river is not only confined to a less breadth, but is soon extended into the bay or gulf, beyond its usual limits. The bed of the river, having no longer a descent, and the waters of the bay or gulf retaining the same height and level, the current of the river is checked; the small quantity of alluvion that may have been suspended in its current above, is deposited; the offals and washing of the streets of a city by rains, being thrown into the river, are likewise deposited, and greatly increase the quantity.

In a few years, as dyking and wharfing are extended, the evil is found to increase; for the waters of the river, having a still greater distance to pass beyond the original limits of the bay, where the river formerly discharged itself, are still more retarded, and only the lighter particles of alluvion are suffered to pass off into the bay or ocean. In this state of things, while the sources of alluvion are constantly augmenting, in proportion to the increase of population, and the cultivation of the lands in the vicinity, the navigation of the river is found to be obstructed, from the elevation of its bed by alluvion, and it becomes indispensibly necessary to remove it, for fear of worse consequences. This being thrown upon the dykes, helps to increase their extension and elevation, and also to increase the quantity of made ground.

Thus, as these operations are continued and repeated, the alluvion is found to accumulate in an increased ratio, and the bed of the river becomes elevated again, even above or higher than where the river formerly united with the bay, and there is no descent to carry off the water. The consequence is, that if the obstruction be not seasonably removed, and there occurs an unusual high tide, the waters or current of the river, defying opposition, makes a breach or more through the dykes, and forms lateral canals or courses into the gulf. The earth or alluvion thus accumulated, either directly or indirectly, is conveyed still further into the gulf, and it becomes necessary to clear out the bed of the river, repair the breaches, and fill up the new canals, in order to confine the river to its original bed, and secure the advantage of its navigation.

Another consequence attending the division of the waters of a river by a breach, or irruption through its banks or dykes, is, that when the breach is repaired and filled up, at one or both extremities, the ground being on a descent from the river, or lower at a little distance than at its margin, small lagunes or lakes are formed.

These, however, are, in a few years, filled up by the operations of rains upon the surrounding new made grounds, and that of the winds, which, in dry seasons, elevate the dust and soil in clouds, from high and exposed situations, and deposite them in those which are tranquil and low.

Thus the progressive work is continued through succeeding ages, deriving its materials from the sources which I have described, and forming new districts beyond the ancient limits of the ocean, for the improvement, cultivation, and residence of man.

To these causes we may look, for the formation of the delta of the Po, in support of which, I shall offer some of the remarks of *M. de Prony.*

In speaking of the great canal, denominated Taglio di Porto Viro, or Podelle Fornaci, he observes: "In proportion as their entrances into the sea extend from the original land, the yearly quantity of alluvial depositions *increases in an alarming degree*, owing to the *diminished slope of the streams, which was a necessary consequence of the prolongation of their bed, to the confinement of the waters between dykes,* and to the facility with which the increased cultivation of the ground enabled the mountain torrents which flowed into them to carry away the soil.*

Here the increased cultivation of the grounds, which enabled the mountain torrents to carry away the soil, is considered as the principal source of the alluvion,

* See Cuvier's Theory, American edition, p. 181.

by which the bed of the river or canals, was elevated, the currents retarded, in consequence of the diminished slope, and the delta extended; but is it not probable that this source existed previous to the commencement of the twelfth century, when the average annual increase of the delta was only about ten feet and a half? It may be said that the cultivation of the surrounding country, at that period, was comparatively small and limited, (which by the by is much doubted) but admitting this to be the case, we will assume the period of four hundred years, or in other words, from the end of the twelfth century, to that of the sixteenth. Is it probable that the increased cultivation of the neighbouring districts was such as to cause an annual average increase of twenty-five metres, or twenty-seven yards, one foot and one quarter of an inch, (more than eighty-seven feet) when the annual average increase, previous to the twelfth century, was only ten feet and a half?

Or is it possible that it could have been such, during the last two centuries, as to give an average increase of extension, to the delta, of seventy metres, equal to seventy-six yards, one foot seven inches and a half, or two hundred twenty-nine feet, seven inches and a half; a difference exceeding that of the preceding period by one hundred and forty-one feet, five inches annually? To me it seems impossible.

On the contrary, if we examine attentively the causes which I have mentioned; the nature and source of the materials, and the means employed in these operations, we shall not hesitate in acknowledging that they are amply sufficient, to effect the great and wonderful change which, in the course of time, has been produced at the mouth of the Po, without refering it to the alluvion brought down by the current of that river and its auxiliary branches.

In support of this, I might add many interesting facts, all tending to prove that the operations of the winds and rain, on the cultivated grounds in the vicinity of the mouth of the Po, and the direct labours of man immediately upon the new formed district, have been the principal cause of the increase and extension of the delta at the mouth of that river.

It may be thought by some, however, that these two latter causes, are altogether insufficient, if they exist, to produce that difference; and it may even be asked from whence came the materials to cause this surprising change, since they are no where missed?

If I might be allowed to compare great with small things, or to reason from small to great things, I would answer by the following fact.

We observe on some of the alluvial plains of the northern or eastern states, sometimes in the open ground, but more frequently in the depth of forests, a cluster of mounds, or pyramids of sand, which, in some instances, have the resemblance of a miniature encampment. They are the result of the labour and perseverance of a large species of the red and black ant, probably the Formica media rubra, and Nigra, of Ray, and which, in the warm seasons, when they are active and busy in their labours, cannot be approached with impunity by any person. These mounds are generally of a semi-spherical form, and from five to eight feet in diameter, and from two to four feet in height. There are but few persons who would not say, on a slight examination of these mounds, and without being acquainted with the habits of these little animals, that it was impossible they could have been built or formed by such means without producing a correspondent depression of the earth in their immediate vicinity. Such, however, is not the fact. On the contrary they have been raised, to the above size, sometimes in the course of two or three years, by the industry and perseverance of these comparatively minute animals.

What may we not expect then from the labours of men, through a series of ages, when assisted in the work by such powerful auxiliaries as wind and rains?

CHAPTER XII.

Having briefly examined the delta of the Po, I shall proceed to notice those of the Ganges and the Indus.

Unfortunately, however, it so happens, that from the paucity of materials, it is difficult, nay impossible to give a true and correct exposition of the subject. But with such as we have, and a slight reference to analogy, we may hazard a decision that will not, perhaps, be much at variance with trnth.

It is unnecessary, in the present instance, to describe the sources of the Ganges, the Boorampooter, and the Indus, or the magnitude, extent, and meanderings of their streams; nor the different countries through which they severally flow. Suffice it to say, that the river Indus is equal in size to the Nile.*

On the subject of its delta Mr. *Rennell* observes, "From these data, together with the aid of the chart of the coast, published by Mr. *Dalrymple,* it may be collected that the delta of the Indus is about 150 British miles in length, along the sea coast: and about 115 in depth, from the place of separation of the superiour branches of the river, to the most prominent point of the sea coast,"†

* See Rennell's Map of Hindostan, page 182. † Do. p. 181.

The river Ganges is much larger than the latter, and receives, at no considerable distance from its original influx into the sea, the whole of the Boorampooter, likewise a very large and extensive river,—from thence they flow, in one body into the sea, or Bay of Bengal.

"About 220 miles from the sea, (says Mr. *Rennell*,) commences the head of the delta of the Ganges, which is considerably more than twice the area of that of the Nile."*

What the nature of the soil is on the borders of these rivers, it is not easy to determine. Most probably, however, it is similar to that of most other countries, and composed of every kind.

And as to the origin of their inhabitants, the commencement and progress of population, or the degree and extent of improvement and cultivation, in the earlier periods of time, it is perhaps impossible to ascertain with any degree of accuracy. Nevertheless it is highly probable that these countries were the first on which were bestowed the labours of men, as it is said they inhabited the borders of the Ganges,† and that these inhabitants were the first to inculcate lessons on agriculture and practical husbandry.

As population increased and extended to the east, the west, and the north, we may reasonably conclude that the improvement and cultivation of the lands were

* Rennell's Map of Hindostan, page 338.

† See Kirwan's Essays.

proportionably increased; consequently contributing to the increase of the alluvial depositions at the mouths of those rivers.

The next circumstance of importance that we have to examine in this case, is the nature, extent, and operation of the tides, on the currents of those rivers.

The river Indus, discharges its waters into the gulf of Scindi, on the eastern border, and nearly at the extremity, or bottom of the Arabian Gulf.

"The tide in the Indus," says Mr. *Rennell*, "is *perceptible* at about sixty-five miles *above its mouth*, according to the information of Mr. *Callender*, who resided a considerable time at Tatta, near the head of the delta of the Indus."*

This, we have reason to believe, is true; for it is said that the Red Rea, in about the same parallel of latitude, does not rise one foot perpendicular in the middle of the sea.

"The rise of the tide, at new and full moon, is about three feet and a half at Suez," (here the waters are driven into a contracted part of the sea, at its extremity, and compressed; consequently raised higher than in the open sea, where it is broader.) "but less than one foot in the middle part of the Red Sea. At the entrance it is four feet."†

Here too the tide waters of the sea are again compressed, at the straits of Babelmandel, or between the coast of Africa and Arabia. So that if we admit the

* Rennell's Map, p. xxiv. † Rennell's Herodotus, p. 476.

tide to rise to the mean height of the two extremes, it would give only eighteen inches, or two feet.

Admitting it to be nearly the same at the mouth of the Indus, we cannot suppose that the tide had any influence in checking the current of that river. Indeed, if Mr. *Rennell's* account be true, the tide, at present, does not extend up so high as the head of the delta, or the ancient mouth of the river, by fifty miles: for the delta being one hundred and fifteen miles from its head to its extremity, and the tide being perceptible only sixty-five miles from, or above its mouth, leaves a difference of fifty miles.

If, in this instance, Mr. *Rennell* meant that the tide was only perceptible, at the distance of sixty-five miles above the original or ancient mouth of the Indus, it would make some difference. But this, I have reason to believe, he did not, from what he says of the Ganges.

"In the Ganges the tides are perceptible at two hundred and forty miles up."*

Now the head of the delta of the Ganges being two hundred and twenty miles from the sea,† gives an excess of the tides above the head of the delta, or ancient mouth of the river, equal to twenty miles, which is highly probable, from the known height to which the tide rises in those seas. This being the case, it must appear evident, that the tides had but little or no influence, in checking the currents of those

* Rennell's Map of Hindostan, page xxiv. † Do. page 338.

large rivers. Consequently the alluvion, which was held suspended in their waters, was propelled to some distance beyond the mouth of the rivers into the gulf or sea; and as the currents of the rivers were slackened, the alluvion was deposited "by the mere action of gravity."

Here was the commencement of those deltas which, like that of the Po, were for ages scarcely perceptible. But as the beds of these rivers were elevated and extended, the currents were still more retarded, and banks were formed and extended at their sides.

Subsequently, on the occurrence of an unusual high tide, opposing and elevating the current of the river, it bursts its natural bounds, and makes an irruption through its banks, thus causing lateral branches, and carrying the alluvion still farther on, and in different directions. On the subsidence of the waters, the sands are exposed to the operations of the rains and winds, which in some instances have, in the course of time, with the assistance of alluvial deposites from the river, filled up the canals or lateral branches. At a subsequent period, and on a like occasion, other breaches, or irruptions are made through the banks, and new branches are formed. In this way the work gradually goes on, until these new formed grounds, in time, become habitable. On being located, for the convenience of fishing or trade, and perhaps both, the inhabitants commence the operation of dyking, with a view to secure themselves from the inroads of the sea, or the overflowing of the river, and every instance of this kind is the cause of an obstruction to the winds, and forms a nucleus, around which the dust and sand, which are wafted over these districts, are deposited, elevating and extending the ground, and thus, annually encroaching on the ancient limits of the sea.

That this has been, in part, the nature and progress of the formation of those deltas, there can be no doubt; for they have been, from the earliest periods of time, and are still, inhabited; for Mr. *Rennell* observes, when describing certain tides, or irruptions of the sea in those parts, which rush in with great violence, that the people, inhabiting the parts of the delta most exposed, are under the necessity of repairing, with their families, immediately to boats kept for that purpose, and in which they are compelled to stay, until the subsidence of the waters. Those who are so unfortunate, as not to secure their safety in boats, from the dreadful violence of these irruptions, called by the natives Bore, are inevitably swept away and perish.*

But neither the alluvion brought down by those rivers, nor the labours of man can be considered in any other light, than as having contributed, in part, to the formation and extension of those deltas.

Another more powerful auxiliary presents itself, as having afforded its constant aid, in the accomplishment

* See Rennell's Map of Hindostan, page 229, on the sudden rise of the tides at the Indus; in the gulf of Cambray and Cutch, and also at the Ganges.

of this great work—I mean the great and extensive deserts, in the neighbourhood of these rivers.

"The province of Scindy," says Mr. *Rennell*, "in many particulars of soil and *climate*, and in the general appearance of its surface, resembles Egypt: the lowest part of it being composed of rich vegetable mould, and extended into a wide delta; while the upper part is a narrow slip of country, *confined* on the Persian side by a *ridge, or ridges of mountains,* and on the *other by a sandy desert.*"

Again, "Owing to this, (the want of rain,) and to the *neighbourhood of the sandy deserts,* which *bound* it on the east; and not *far removed from it on the north west; the heats are so violent, and the winds from those quarters so pernicious,* that the houses are so constructed, as to be occasionally ventilated, by means of apertures on the tops of them, resembling the funnels of small chimneys."*

Further, he says, "*A sandy desert bounds Scindy on the east, and extends the whole way from the territory of Cutch, to the confines of Moulta; being near five hundred and fifty miles in length, and from one hundred to one hundred and fifty wide.*"†

If we take into view the situation of these barren deserts, rendered still more sterile by the intensity of a vertical sun, that blasts every effort of vegetation upon these oceans of sand; and their exposure to the violence of the eastern Monsoons, which are, for more

* Rennell's Map, page 182. † Do. page 183.

than half the year, sweeping over these heated wastes, and raising the sand in clouds, and bearing it across the gulf of Scindy, and the mouth of the Indus, need we question the sources from which the materials were derived to form those deltas?

If we add to this the labours of man, upon these new forming districts, in dyking, and raising mounds, or other obstructions to the winds thus charged, need we, or can we pretend, that the alluvion of rivers is the source by which these deltas were formed and extended, and that too in an increased ratio annually? I presume not, and for a very obvious reason: Mr. *Rennell* observes, that "The mean rate of motion of the Ganges, is less than three miles an hour in the dry months."* That of the Indus, and also the Booram-pooter,† is nearly the same.

This, it must appear evident, is by no means sufficient to bear up and convey sand to any considerable distance. And as it is but once a year, and that, "during the wet season, and whilst the waters are draining off from the inundated lands," the currents are accelerated in any considerable degree, we may reasonably conclude, that the alluvion derived from this source is comparatively small, to that which is supplied from the other two sources, (viz.) the direct or indirect labours of man, and the operations of winds, &c. on the cultivated grounds, and deserts, in the vicinity of deltas.

* Rennell's Map, p. 340. † Philosophical Transactions for 1781.

On this point I am again strongly supported by the remarks of Mr. *Rennell,* who, in speaking of this subject, says:

"And hence it may be supposed, that the state of a delta, is that of an imperfectly formed country, and that the progress of matters towards completion, is, that of the river forming itself into one channel."

"That is, from a *mud bank,* it becomes a marsh; then a field *intersected by drains,* and deeply inundated, at particular periods; and finally a firm field, subject to *slight* inundations, but *without any natural derivations from the river.*"*

From whence then, I would ask, are the materials derived, that *continue to elevate the delta,* in some instances, far above the overflowing or inundations of the river? From the same sources, that have continued to yield their materials from the commencement of the formation of a delta, and will continue so to do until their ultimate completion.

* Rennell's Herodotus, page 511.

CHAPTER XIII.

In the next place, I shall proceed to examine the delta of the Nile. The land which, from a marsh, became the birth-place of emperours and kings, whose ephemeral sway was marked with despotick rule; and under whose reign, millions of vassal subjects dragged a miserable existence.—That land, on the surface of which, numerous and splendid cities have been reared, whose sumptuous palaces and temples, with their gorgeous summits, were, from afar, seen towering in the air.—Whose sculptured walls, and massy columns, were richly wrought to glut the insatiable pride and pageantry of man.—That soil, on which fostered genius shed her choicest gifts.—That emporium of the arts—that seat of science, whence Greece and Rome derived their boasted wisdom.*—That—once the wonder of the world.

But this has since become the land, over which the frantick genius of war hath spread her baleful influence,

* See Herodotus, Diodorus, Shaw, and others

and into its bosom poured her sanguinary hordes.—Its cities were destroyed.—Its temples and palaces demolished.—Its monuments, laid prostrate.—Its thrones, where once the golden sceptre swayed, erased.—Its subjects left to mingle with the dust.—Its arts fled—Its science languished, and became extinct.—And now—but little left to greet the eye, save an extended plain of mouldering ruins—a scene of awe and desolation.

Thus, it remains—an object of eager gaze to the anxious traveller.—The burden of the poet's strains. The theme of historians—and still the wonder of astonished man.

Such has been, and such is now, the delta of the Nile, which has been considered, by almost every writer, that I can find, as exclusively the gift of that almost peerless stream.

While I revere the memory of the numerous authors who have written on this subject, from *Strabo* to the present time, I cannot help expres ing my surprise, that they should have, almost uniformly, adopted the same opinion, as to the formation of that delta, whilst there existed so many facts, staring each of them in the face, calculated at least to weaken or render doubtful their opinions, if not tantamount to an absolute refutation of them.

That I should presume to question the opinions of men of such high antiquity, and established reputation, may seem the result of obstinacy and scepticism; or an instance of extreme heresy. But I trust and hope, for a more favourable opinion, when all the facts are fairly stated and duly considered.

The first thing to be taken into consideration, in relation to the delta of the Nile, is the original state of that district, now occupied by the delta; and the ancient mouth, or point at which that river originally mingled its waters with those of the Mediterranean sea.

It seems that *Herodotus* learnt from the Egyptians that *Menes* was their first king; and that in his time, *all Egypt*, except the country of Thebes, was *one continued marsh.* And that no part of the present land then appeared below the lake of Myris.*

From this circumstance, without doubt, *Herodotus* was inclined to believe that the whole of lower Egypt, or at least the part occupied by the delta, was once an arm of the sea.†

It seems that *Diodorus Siculus*, was of the same opinion, as were also *Pliny*,‡ *Volney*,§ and Dr. *Shaw*.‖ And when all the circumstances which I shall endeavour to bring into view, are taken into consideration, it will appear highly probable; and also, that at the period mentioned by *Herodotus*, "the *whole* of Egypt, except the province of Thebes, *was one extended marsh.*"

* Herodotus Euterpe, chap. 4.

† See Herodotus Euterpe, chap. 10.

‡ Plin. Hist. Nat. lib. 2. cap. 85.

§ Volney's Travels, p 34.

‖ Shaw's Travels, p. 339, and 437

In the second place, it becomes necessary to examine the rate at which the current of the Nile generally flows.

On this subject, neither historians nor travellers have been sufficiently explicit. The conclusion, however, is, that, except at the period of its inundation, its current is in general rather sluggish.*

M. *Volney* observes that in sailing up the Nile, "the declivity is so gentle, that the water does not flow faster than a league an hour."†

Mr. *Brown* says that "Its motion is even slower than the Thames, and does not exceed three miles an hour."‡

We are not to conclude from this, however, that the rate of its motion is the same, generally, throughout its whole course. Nevertheless, it is represented as being clear and unmixed with alluvion, except during its rapid increase and elevation. Mr. *Irwin* says "For a league or more from the bar, (of the Nile) the water *retains its crystal* hue and fresh quality, of which we convinced ourselves by an experiment."§

We are informed by travellers, that Abyssinia and the neighbouring part of Africa, are inundated

* "Who that beholds thee, Nile, thus gently flow,
With scarce a wrinkle on thy glassy brow,
Can guess thy rage when rocks resist thy force."—*Lucan.*

† Volney's Travels, page 13.

‡ Brown's Travels, page 63 to 66.

§ Irwin's Voyage up the Red Sea, vol. II, page 99.

with rains during the months of May, June, and July.*

But it is not until about the month of July, that any difference is perceivable at Cairo. On the first of July, 1714, for instance, the water of the Nile was raised two inches. It continued to rise, alternating, however, from two to eight, until the 17th, when its rise was as high as fifteen inches. It again alternated, from the 19th to the 26th, between fifteen and six inches per day. From the 27th to the 31st, its increase was rapid, from ten inches to forty-eight per day, amounting in all to a little more than fifteen cubits.†

Now according to Denon's account, there was no appearance of alluvion until the 17th; for he says, "The Nile, after having risen for some time at the daily rate of two inches, came at length to an increase of a foot each day; at which period, the water *began to be muddy*, which appears to shew, that the Nile, in its course, traverses some large lakes, whose limpid waters are forced down the stream by the torrents of rain, from the Abyssinian mountains, and that the discolouration of the Nile does not happen, till the arrival of these last in Egypt."‡

* It is said to continue even through August, and that it requires three weeks, after the commencement of the rainy season, before the effects of these rains are seen at the plains of Egypt. Labo's History of Abyssinia.

† Shaw's Travels, page 434.

‡ Denon's Travels, page 19.

From these circumstances we may infer that, although the rains continue three months in Abyssinia, it is only during about two months that the rise of the Nile is rapid, and its current greatly accelerated; in which time, no doubt, great quantities of alluvion were brought down by its current, and deposited at its mouth.

3rdly. It is necessary to examine the tides of the Mediterranean sea, with a view to their influence on the current of the river.

On this subject there seems to be a difference of opinion. *Herodotus* mentions the ebbing and flowing of the tides; which, he observes "may be seen every day."*

Mr. *Rennell* says, that "the waters of the North Atlantic *eternally* flow into the Mediterranean."† This, he seems to suppose, is a consequence of the Mediterranean being lower than that of the Red Sea. But if "the waters of the North Atlantic eternally *flow into* the Mediterranean," it is almost impossible that there can be such a thing as an ebbing of its waters: but setting the question of the level of the Red Sea and Mediterranean aside, we can scarcely conceive that the evaporation of the waters, from the intensity of heat, in those regions, can so far exceed the quantities of water poured into that sea on all sides, as to occasion a current *constantly* setting in from the Atlan-

* Polym 198.

† Rennell's Herodotus, page 476.

tic ocean. Therefore it must be admitted that, since there is an ebbing and flowing of the Atlantic of several feet at the straits of Gibraltar, there must be an ebbing and flowing of tides in the Mediterranean. Indeed it is, though barely, admitted by Mr. *Rennell*, who says, "It is a common idea, that there are no tides in the Mediterranean. Nor do they indeed rise, in any part of that sea, in a degree sufficient either to effect the usual purposes of laying ships on shore to careen; or even in many places, so as to effect the senses of those, who are accustomed to view the ordinary rise and fall of tides, on the coasts of the ocean. But that a tide does exist *is certain;* and that it rises five and six feet in particular places."*

This difference is owing to the following circumstance. ' The wave of tide," says Mr. *Rennell*, "is suddenly opposed in front by the eastern coast of Tunis; and also *compressed laterally* by the island of Sicily."†

He further says, that "Modern observations point out a rise of about five feet at Venice," the northern extremity of the Adriatic gulf, "but only twelve or thirteen inches at Naples, and at Euripus."‡

The Marquis *de Chabert*, during the time of his residence on the coast of Africa in 1766, observed that the tides rose three feet; but the marks on the shore

* Rennell's Herodotus, page 647. † Do. page 657.
‡ Do. Do. page 659.

discovered a rise of five (french) feet, at the highest tides.*

M. *Volney* says that the tide, at the influx of the Nile, rises a little more than three feet.†

Admitting the ordinary height of the tides, at the eastern extremity of the Mediterranean sea, to be two feet, or even three, we cannot suppose that it would have any material effect in checking the current of the Nile, particularly during the period of its inundation, when it is greatly accelerated. Hence we may reasonably infer, that the alluvion brought down by the Nile, was carried to a considerable distance beyond its mouth, and widely diffused in that ancient gulf or arm of the sea, and constituted one of the causes of the formation of the delta. It is to this cause, in part, that we must attribute the existence of an extended marsh, in the time of Menes.

As to the commencement of this operation, it is, doubtless, coeval with the existence of the world; or, at least, we may safely date it from the period at which the waters first subsided from off the face of the earth, and from the time rivers began to flow. As to the nature and progress of its formation, it differed in no material circumstance from that of the Po, the Arno, the Indus, the Ganges, or that of any other, situated where the tides do not rise sufficiently high, to check or control the current of the river.

* Histoire de l'Academie des Sciences, 1767.

† Volney's Travels, page 137.

4thly. I shall now examine the effect produced by the direct and indirect labours of man, in the formation and extension of this delta.

The point at which the waters of the Nile first united with those of the Mediterranean sea, was that at which the greatest quantity of alluvion was deposited, and, of course, the point where the bed of the river first began to be elevated. On the subsidence of the annual inundations of the rivers, its banks were, in the course of time, gradually elevated and extended on its borders. As soon as they had become sufficiently so, to admit of cultivation and improvement, they were probably located by the first inhabitants who established their residence in that region.

Where this point was, or who the first inhabitants were, or what the degree of progress in improvements and civilization, it is not in my power to determine; nor is it necessary, or essential to my purpose, in the present instance. It is sufficient to know, that *Menes* or *Osiris*, was, at least represented to be, the first king who reigned in Egypt; and was, perhaps, the most zealous and active, in improvements of every kind, of any sovereign that may have preceded him; though much may have been done before his time, as, according to Bishop *Clayton*, other kings had reigned before him in Egypt: and *Diodorus* says, that Memphis, (which was founded by *Menes*,) was not built till eight generations after the building of Thebes, and

and that the rise of Memphis, was the downfall of Thebes.*

Be this as it may, *Menes* appears to have been the first who was engaged in raising mounds, digging canals,† and actually changing the course of the Nile,‡ which formerly flowed along at the foot of the Lybian mountains, and which I shall notice in the sequel.

This constitutes the æra from which we ought, probably, to date the commencement of the formation of the delta, and also the point at which it began.

Menes, in order to accomplish the above object, caused a bank to be constructed at the distance of a hundred stadia (two leagues and a quarter) from Memphis, towards the south, and by digging a new canal through the valley, between the Lybian mountains and those on the Arabian side, diverted the course of the Nile.

A consequence of this new change was that, notwithstanding the great height to which the embankments were raised, by the immense quantity of earth which was removed to form a channel for so large a river, the banks were subject, at every inundation of the river, to irruptions from the force of the waters, which caused breaches through the banks, carrying

* Herodotus Euterpe, chap. 99.

† This was carried to such an extent in the time of Sesostris, that the Egyptians laid aside the using of wheel carriages, which they had till then employed. *Herodotus*, book 2.

‡ Herodotus Euterpe, chap. 99.

away the earth, and depositing it on the adjacent grounds; thus threatening with defeat, the very object which *Menes* had in view, viz. the preservation of Memphis. Hence it is, that they were annually under the necessity of fortifying these mounds by filling up the breaches, and keeping them in repair. *Herodotus* says, "Even at this present period, under the dominion of the Persians, this artificial channel is annually repaired, and regularly preserved. If the river were here once to break its banks, the whole town of Memphis would be greatly endangered."*

Not only was this the practice long before, and in the time of *Herodotus*, but it has been regularly and necessarily pursued, from his time, to the downfall of Egypt, and even to the present time; and that too, perhaps, upon every inch of ground, from Memphis to the mouth of the Canopic branch.

This attention was annually and necessarily increased; for as the prolongation of the embankments was extended from the mouth of the river, into the gulf or arm of the sea, the descent of the river was lessened, its current checked, and its bed gradually elevated by the deposition of alluvion, as at the Po, the Indus, &c. Consequently, in proportion as the bed of the river was elevated, so must have been the banks; for as nearly the same quantity of water flows annually, it follows that the banks, unless raised in proportion, must be overflowed, and torn away.

* Herodotus Euterpe, chap. 99.

It must not be understood, however, that the elevation of the bed of the river was occasioned, simply, by the deposition of the alluvion natural to the current. We are now to take into view the enormous quantity which is supplied indirectly through the labours of man; as the offals and rubbish of every kind that daily fall into it from Thebes, and other cities above, as well as from Memphis. This circumstance ought to be kept in view, as it respects all the cities, that were subsequently built on the borders of the Nile; and throughout the entire extent and formation of the delta. Thus, from the check opposed to the current of the river, the elevation of its bed, the annual inundations, the irruptions through its banks, the digging of canals, the cultivation of the grounds, thereby exposing them to the operations of the winds, which are almost constantly raising and shifting the soil, from one place to another, the low lands adjacent to the river were gradually filled up, and new districts formed for cultivation, and for the building of other cities; which, as soon as commenced, formed another source from which the low grounds were filled up and extended by the direct and indirect labours of man. That is, by building and improving; and in the course of time pulling down and rebuilding, and that too through a series of ages.

There are but few persons, perhaps, who would imagine that any material difference could be produced from this cause. But it must be recollected, that almost the entire quantity of materials employed in the building of those cities, was brought from the Lybian mountains, and from those of the Arabian side, in the vicinity of Cosier, on the Red Sea. The granite from the former, and the porphyry, jasper, and verd antique from the latter.

Who then can possibly conceive the quantity of materials and rubbish supplied by the city of Memphis alone, which was one hundred and fifty furlongs in circumference; almost equal to nineteen miles, or a little less than five miles square? All must admit that it was enormous; and when we consider that, according to Baron *De Tott's* account, there were nine thousand villages, and twelve hundred towns, in Egypt,* we shall not hesitate to say, that the direct and indirect labours of man, have had a great and powerful agency in this stupendous work.

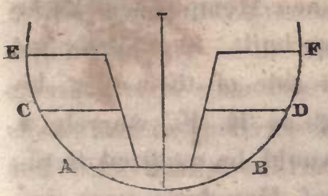
From this imperfect view, we may form a pretty correct idea, how new districts were formed and elevated, and the land extended, until the Nile was divided into two branches, and the formation of the delta commenced, which, as it increased, was cultivated and extensively improved by the building of large cities. Since that time, the same course has been pursued, as at the commencement; the same operations continued, and the same rules and regulations observed, in relation to draining, dyking, cutting canals, raising mounds and keeping them in repair; and that too,

* Baron De Tott, p. 2—p 63.

through a long lapse of ages, as well with the delta as the districts on the opposite borders of the Nile.

Dr. *Shaw*, who has been as particular on this point as almost any other author, has endeavoured to prove and that too by a diagram, that the *whole extent* of territory which Egypt has, gained, in the course of time, is almost exclusively the result of the alluvion brought down by the Nile and gradually deposited. In this, the circumstances which he relates, and the arguments which he has advanced, are at variance with his theory, which, under existing circumstances, all the ingenuity and sophistry of man can never establish.

"Let the annexed figure (says Dr. *Shaw*) be a



section of this valley, with a Niloscope placed in that part of it, where the Nile afterwards directed its stream. —For about the space of one or two centuries after the deluge, or till such time as the mud brought down by the inundation, was sufficiently fixed and accumulated to confine the river, we may imagine the bottom of this valley A B, (*i. e. the whole land of Egypt*) to have been entirely overflowed; or else, being in the nature of a morass, was not fit to be either cultivated, or inhabited. Egypt therefore, at this time, was in a proper condition to receive the assistance of Osiris, who by *raising mounds and collecting the water into a proper channel*, kept the river from stagnating, and thereby prepared the land for that culture and tillage which he is supposed to have invented.

"But in process of time, the *annual strata* would raise the country as high as C, D. Whereby the Nile would not only be sufficiently confined within its own banks, but the superfluous moisture, also, that was left by the inundation, would be easily drained off.

"Agriculture therefore, and husbandry, would have now their proper encouragement; and in this condition we may conceive the country to have been at the building of Thebes; the parts where Memphis and Zoan were afterwards founded, having not yet attained a sufficient depth of soil to bring down a colony to till it.

"Some centuries after, when Memphis and other cities of the lower Egypt were built, the banks, together with the land on each side of them may be supposed to be raised as high as E, F, whereby a still greater height of water would be required to refresh them; which in the time of Herodotus, was sixteen cubits.

"In this manner therefore, it may be presumed, that the foundation of the land of Egypt was first laid and *afterwards augmented*, the inundation *bringing along with it, every year*, an addition of soil, whereby, not only the land already made would be raised, but the soil would be likewise extended to the very skirts of the valley, the sea gradually excluded, and consequently a foundation laid for new plantations."

That the original site, on which both Thebes and Memphis were built, was such as has been represented, there can be no doubt. The authority which we have. for the gradual increase and elevation of the land at those places, forbids our withholding assent to the truth of the reports which we have received on that point. Nay more, if we extend our views back a few centuries more, our imaginations will represent those places to us covered at *all times* with water. And, however strange and absurd the idea may appear, had not the labours of man been introduced to alter or defeat the plans of nature, we should not behold the frightful difference that is now presented to view.

We might, if the formation of the alluvial grounds depended only on the alluvion of the river for its increase, see it somewhat elevated and greatly extended, as in many places; but not thrown up into mounds and high banks, suited to the building of cities and other works.

"The meeting of two masses of fluid, (says Mr. *Volney,*) produces nothing but a mixture, from which a common level soon results." "Running waters level much more than they heap up."*

With a view to the better understanding of this subject, I will examine some of the conclusions which Dr. *Shaw* has drawn from these premises.

Volney's Travels, page 26.

"That *Egypt* was raised and augmented in this manner, viz. by the inundation bringing along with it, every year an addition of soil, whereby not only the land, already made, would be raised, but the soil would be likewise extended to the very skirts of the valley, &c. appears from several circumstances. For, whereas the soil of other plain countries is usually of the same depth, here we find it vary in *proportion to the distance from the river;* being sometimes near the banks more than thirty feet high, whilst at the utmost extremity of the inundation, viz. at the skirts of the valley and next to the hills, it is not the quarter part of so many inches."*

Now the waters which overflowed the valleys or lands adjacent to the banks, on each side of the river, were those which flowed round the extremity of the banks, at the mouth of the river, and up the valleys; or such as were designedly drawn off from the river, through canals constructed for the purpose,† into the valleys, with the express intention of irrigating the lands and profiting by the alluvion.

The waters thus derived direct from the Nile, and charged with their full quantity of alluvion, naturally settled first upon the lowest ground; as they increased they became deeper, and the grounds remained longer submerged than the more elevated lands that were inundated but a short time; such as those from twenty to thirty feet high, and such as were but slightly over-

* Shaw's Travels, page 439. † Do. page 441.

flowed. Consequently the deeper the water, thus charged with alluvion, and the longer it remains upon lands thus inundated, the greater must be the quantity of deposites, and the increase of their elevation. This fact is too palpable to need any comments.

"Yet (says Dr. *Shaw*,) here we find it vary in proportion to the distance from the river; being sometimes near the banks *more* than thirty feet high, whilst at the utmost extremity of the inundation, it *is not a quarter part of so many inches*."

These facts alone, are amply sufficient to prove that the delta of the Nile and the plains of Egypt were never produced by the alluvion of that river. If any other were necessary, the following is no less conclusive.

"It may be presumed," says the Dr., "that *all the cities of Egypt were originally built upon artificial eminences, raised for that purpose.*" *Herodotus*, from whom Dr. *Shaw* probably derived his information, says, "that during the reign of Sabacus, king of Ethiopia, the ground on which the cities of Egypt stood, was more and more elevated by *manual labour*: and that, although they were somewhat raised under the reign of Sesostris, by the digging canals, they became still more so, under the Ethiopian."*

Now if those were artificial eminences, they could not have been the results of annual deposites of alluvion. Further, "When the circumjacent soil came to be so

* Euterpe, pages 137 and 138.

far increased, as to lie nearly upon a level with those cities, the inhabitants were then obliged *to mound them* round, or else to rebuild them. The former experiment seems to have been *often repeated* at Memphis, the want whereof hath been the reason, no doubt, why we are not sure, at present, even of the place where this famous city was founded."*

From the superficial remarks which I have made on the current of the Nile and its alluvion; and also the effects of the tides of the Mediterranean, in opposing this current, together with the result of the direct and indirect labours of man, in the formation of the delta of the Nile, and, I may add, the plains of Egypt, some general ideas may be formed of the respective agency of each, in this stupendous work. But in order to have a more comprehensive view, and correct ideas of the subject, it becomes necessary to examine lastly, the operations of the winds, and the agency which they may have had in producing, and presenting to view these phenomena of nature.

The winds, that mostly prevail in those countries, are of two kinds—the one called the Levant winds; the other the Etesian winds. The first of these blow from the south east and east, varying sometimes to the north east, and blowing with great violence. Dr. *Shaw* says that at Algiers the east winds prevail from May to September.†

These easterly winds, or Levanters, so called, when of long continuance, sometimes increase with such vio-

* Shaw's Travels, page 439. † Do. p. 218.

lence, that "the water is blown away to such a degree, from the coast of Syria and Phœnice, that several ranges of rocks, which in westerly winds, lie concealed, do now become dry and leave exposed to the water fowl, the Urchins, Limpets, and such like shell-fish, as stick upon them."*

He further says, "I observed, in the port of Latikea, that there was two feet less of water whilst these winds raged, than afterwards when the weather was moderate, and the winds blew softly from the western quarter."†

At the period of the autumnal equinox, the wind changes to the north and west, and is not only more frequent, but blows stronger. These are succeeded by the west and south west winds, "which prevail from November to February,"‡ During their prevalence, as in almost all other latitudes, they are accompanied by violent gales, such as are described by travellers, when whole caravans are buried up in crossing the deserts.

These latter winds are left to sweep, uncontrolled, not only over the wide expanse of the Mediterranean, but over the whole northern coast of Africa; the deserts of Saharra, Barca, Saccara, and Lybia, from the dry and desolated surfaces of which they are, in one place or other, almost constantly driving the sand in torrents, still farther on by each succeeding blast.

* Shaw's Travels, p 361. † Do. p. 362.

‡ Volney's Travels, page 200.

The Levanters, or easterly winds, on the other hand, are driven from the Persian Gulf across the deserts of Arabia, (which in extent, says M. *Volney*, are nearly equal to the Mediterranean,) and also across the Red Sea, and that part of the Arabian desert, which lies between the Red Sea and the Nile; and are attended with the same or similar circumstances, as with the Etesian winds.

To these powerful agents, which have been employed, perhaps, from the commencement of time, we may look for the principal cause of the great change, which has been made at the mouth, and on the borders of the Nile.

In order, more fully to explain the nature of their operations, and the result of their agency, we will suppose, (what every candid mind, on a careful examination, will admit to be true,) that the whole valley of Egypt, at least from the province of Thebes to the present influx of the Nile, was once, actually, a gulf or arm of the Mediterranean sea, and under the influence of the flux and re-flux of the same tides, which prevail, on the same meridian, in that sea.

This being the case, it is impossible that "the whole of Egypt, except the province of Thebes," could have been made one extended marsh, from the alluvion only of that river; and that for the following reasons.*

* On this subject Lord Valentia observes, "After having passed through the delta; after having examined its whole line of sea coast, and viewed both the great mouths of the Nile, I confess

The tide of the Mediterranean, though moderate, operating, in some degree, as a check to the current of the Nile, its alluvion would, as before, be deposited in a much greater quantity, where it received this check, as at A, than at any point below. Consequently, when the alluvion had increased by the deposition of successive strata, so far as to appear above water at A, the alluvion at B, a half a league, or league below, where the water is deeper, would remain as much below the surface of the water in the gulf or bay, as the difference in the depth of the water at those two points.

2dly. The depth of the water in the Mediterranean, at a little distance from the mouth of the Damietta river, or the ancient Phatmetic's mouth, is, at present, eleven fathoms in depth,* and admitting the depth of the Nile, below Thebes, to have been originally three fathoms, and the descent of the bottom of the gulf, from the one to the other, to have been in a direct line, there remains a difference of eight fathoms. If at about half this distance, as at Memphis, or opposite the lake Mœris, we divide the depth of the water, which is five and a half fathoms, it gives a difference of two and a half fathoms, in the depth of water from Thebes to Memphis. Under these circumstances, and without

that I cannot discover a single argument in favour of the idea, that this fertile district has been formed by the mud of the river. For if, in ancient times, this had actually been the case, how happens it, in these days, the same cause does not produce the same effect."—Valentia's Travels, vol. III, page 448.

* Rennell's Herodotus, page 487.

having any reference to the influence which the tides may have had, in checking the current of the river, but, on the contrary, admit that as much alluvion was deposited at Memphis as at Thebes, we shall find, that when the successive deposites of alluvion were elevated to the surface of the water at Thebes, it would still remain two and a half fathoms, or fifteen feet *below* the surface at Memphis. And that when it had gained the height of two and a half fathoms above the river at Thebes, it would only have arrived at the surface of the water at Memphis.

This inequality or disproportion, if it depended on the alluvion of the Nile, must necessarily have existed. Consequently, such a wide extended marsh, as is said to have spread over all Egypt, except the province of Thebes could never have been produced, and that upon a uniform level, as the very name implies, by the alluvion brought down and deposited by the Nile.

Hence it follows, that the materials in this work must have been derived, in part from another source: and that, too in a quantity sufficient to fill up the difference, whatever it might have been, in the depth of water between Thebes and Memphis, or any other two assumed points, in order to produce a *level* and *widely extended* marsh.

These materials will be found to have been derived from the operation of the winds on the desert of Arabia, which lies on the east side of the Nile, between it and the Red sea, and the deserts of Lybia and Barca on the west.

It will, perhaps, be said, that the valley or space on each side of the river below Thebes is too narrow to afford a sufficient quantity of materials to cause any sensible difference, admitting it to be dry and barren.

However that may be, it is said that the distance from the river to the hills is eighteen miles or "six leagues," making the valley twelve leagues in breadth, or thirty-six mi es, sometimes less; and this too, nearly all the way from the cataracts "*

Besides this, a great portion of the Lybian range of mountains in this part of the country are represented as barren, and in a rapid state of decomposition. "I had seen (says Mr. *Denon*) two ranges since I left Cairo, without having been able to risk climbing any one of them. I found this, as I had supposed, a *ruin of nature*, formed of horizontal and regular strata of calcareous stones more or less crumbling, and of different shades of whiteness, divided at intervals with large mammillated and concentric flints, which appear to be the nuclei, or, as it were, the bones of this vast chain, and seem to keep it together, and prevent its total destruction. This decomposition is daily happening by the impression of the salt air, which penetrates every part of the calcareous surface, decomposes it, and makes it, as it were, *dissolve down in streams of sand*, which at first collected in heaps at the foot of the rocks, and are *carried away by the winds*, and encroaching gradually on the cultivated plains and the

* Shaw's Travels, page 341.

villages, *change them into barrenness and desolation*."*
"At twelve miles distant (says Mr. *Bruce*) there is a ridge of mountains, (near Gabba) of no considerable height, perhaps the most barren in the world."

"There is not even the trace of any living creature, neither serpent, lizard, antelope, or ostrich, the usual inhabitant of the most dreary deserts."†

In speaking of the mountains between the Nile and Red Sea, Mr. *Bruce* observes :—

"It was one of the most extraordinary sights I ever saw. The former mountains were of considerable height, without a tree or shrub, or blade of grass upon them; but these now before us had all the appearance, the one of having been sprinkled over with Havana, the other with Brazil snuff."‡

Hence it will appear that not only the plains of the valley, but the mountains themselves were yielding their supplies to this great work. For, their height not being great, the winds were wafted up their sides and over their summits, loaded with sand, to replace the wastes of the plains below.

Having pointed out, and examined the sources of these supplies, I proceed to explain the effect of the winds, and the results of their operations, in promoting

* Denon's Travels, vol. II. page 2.

† Bruce's Travels, vol. I. page 175.

‡ Bruce's Travels, vol. I. page 190. See also Ali Bey's Travels, vol. II. page 136.

the elevation and extension of the plains of Egypt to their present limits.

As soon as the newly formed lands became elevated above the surface of the water, sufficient to admit of improvement, and the inhabitants of Egypt began the work of digging canals or drains, raising mounds and dikes for the purpose of improving and cultivating the grounds, every work so raised became, in a degree, an obstruction to the winds; and all the space contained within their limits, a depository for the dust and sand which were wafted by the winds from the mountains and across the plains, or from the deserts; and more particularly so, as soon as vegetation began to cover the land; for every plant became a nucleus around which the sand had collected and by which it was retained. The date, and lofty palm trees, when arrived to a sufficient height, contributed their share in arresting, holding fast, and screening from a further removal, the sands collected at their roots, and beneath their branches. "The plants, (says Mr. *Denon*) which are produced, in the first place, by the new land, are three or four kinds of sea weeds, round which the *sand* throws itself up in heaps. From its surface they spring up afresh; and subsequent decay furnishes a manure which *favours* the vegetation of reeds. These reeds give a greater elevation and a greater solidity to the soil.*"

* Denon's Travels, vol. I. page 169.

This drifting of the sands had been in operation, probably, from the beginning of time, and had contributed no small portion to the elevation of the bed, or bottom of this gulf to the surface of the water, and which was necessarily so, or the plains of Egypt, had they been formed of the alluvion of the river alone, would probably have remained to this day as barren as a slate roof, or the mountains in their vicinity.

The alluvion brought down by the Nile, and most other rivers, as I have before remarked, is, in general composed of the alluminous, or clayey portion of the soil above, which, being light, is carried to a great distance, and, when deposited in a sufficient quantity, forms a slimy mud, such as that of the Nile is described to be, and which, most probably, differs but little from the slimy mud which is collected and formed by the same process, in all our docks and slips.

The mud, or alluvion of the Nile is represented as being "of an exceedingly light nature, and feels to the touch like an impalpable powder."* This is the character of clay when dry; and such is the mud of the Nile, that when deposited in low places, and in a sufficient quantity; or when dug out of the canals and left exposed to the intense heat of the sun; it becomes hard, (unless tempered with sand,) and cracks open, as do almost all lands where clay predominates.

Hence, the necessity of its being tempered with sand to render it productive: and hence it is, with-

* Shaw's Travels, page 432.

out doubt, that the Egyptians are *sometimes* obliged to temper the soil by bringing sand to it.*

But to return to the subject: as soon as advances were made in civil architecture, every effort had a direct tendency to promote and accelerate the elevation and extension of the soil; since every house, or buiding, whether small or great, became an obstruction to the winds, around which, the sands, during the windy seasons, were constantly accumulating.

Nothing can be better calculated to strengthen this opinion, and enforce the truth of the fact, than the observations of M. *Denon* respecting Rosetta.

"Its original compass," he says, "is ascertained by the sand banks, *by which it is covered* from west to south, and which have been *formed by the walls and towers* that serve as *a nucleus* to those accumulated heaps of sand."†

When the lands had become sufficiently elevated to justify the founding of a city; the first step to be taken, as we are informed by Dr. *Shaw* and others, was the raising an artificial eminence of a height and extent suited to the purpose; and also a mound around the whole, to secure the city from the inundations of the Nile. The city thus built, though secured from the overflowing of the Nile, and annual deposites of alluvion, was, nevertheless exposed to the drifting sands from the surrounding plains and adjacent deserts. But it may be presumed that, (as in

* Pocock's Travels. † Denon's Travels, vol. I. page 140.

many other cities which are sometimes inundated with sand) this was regularly removed, and the level of the primitive foundation of the city preserved; whilst the neighbouring lands without the mounds were constantly gaining in height by the annual deposites of alluvion, and sand brought upon them by the winds.

When in the course of time, the lands became elevated to a height equal to the mounds, and the city threatened with destruction, by an inundation over them, the inhabitants were obliged to demolish the buildings, and raise the foundation of the city, and also the mounds, in order to secure their future safety.

This, says Dr. Shaw, "seems to have been often repeated at Memphis," and no doubt with many other cities of Egypt; but in particular with that of Bubastis. "When this city was rebuilt, and raised higher, to secure it from the inundation; the temple, for the beauty of it, was left standing in its primitive situation, and being therefore much lower than the new buildings, they looked down upon it from every part of the city."*

This is a striking instance of the difficulties with which the ancient Egyptians had to contend, in this respect, and one that is calculated to prove that the formation of the plains of Egypt, and also the delta, did not depend so much upon the alluvion of the Nile, as upon the winds, as I shall endeavour to shew.

* Shaw's Travels, p. 439.

The city of Bubastis was situated on the left bank of the ancient Pelusiac branch, at the distance of about fifty miles above its mouth, and about the same distance below Memphis; and also in nearly the same latitude as Menouf, likewise an ancient city situated between the Sebbenitic and Canopic branches. Hence, a considerable way below the head of the delta.

From these circumstances, and the slow progress of the new formation, we may infer that the founding of the city of Bubastis was of a much more recent date than that of Memphis, and other cities above. Consequently, it did not experience so many revolutions and changes as those of a much higher antiquity. However that may have been, we have no knowledge, that I can find, that Bubastis was ever re-elevated a second time.* Therefore it must have remained, at its downfall, like an immense excavation in a plain, or like a city in a valley, from the surrounding heights of which, the inhabitants "looked down upon it (the temple) from *every part* of the city."

Being thus formed and protected, it had probably remained secure from any inroads from the inundation of the Nile, until overthrown by hostile bands, or other causes, and deserted; when, either through design, or the gradual elevation of the surrounding plains, the

* Herodotus, in speaking of the temple, says that its situation had never been altered, although every other part of the city had been elevated. Euterpe, p. 137, 138.

waters of the Nile were let into it. From this time, we may date the commencement of the filling up of the great basin, in which that city stood; but which, however, could not, it is presumed, have depended on the alluvion of the Nile, and for the following reasons:

When the waters of the Nile rested upon the plains of Egypt, (and it was only during an inundation, that this could happen, and the waters flow into the city,) the elevation of the plains, by the deposites of alluvion, would increase nearly as fast as that of the basin of Bubastis.

Consequently, it must have still remained an excavation or depression, below the plains of Egypt, which is not the case. On the contrary, it presents a level plain of sand, beneath the surface of which, perhaps, every vestige of the city is buried so deep, that whoever wishes to contemplate or examine its ruins, and in particular its temple, will probably have to dig to the depth of thirty or forty feet below the present surface of the earth.

Could we be made acquainted with the regular gradation and succession of events, from the building of Thebes, to the downfall of Egypt; numerous other instances, and much more in point, would probably present themselves, to prove that the winds, by transporting the sands from the deserts, have been the principal agents in filling up, and extending the plains in the valley of Egypt. But enough still remains on the faithful pages of history, to convince the most sceptical, of the truth of this fact.

From these I shall select a few, as being not only favourable to my views, but conclusive in themselves, of the truth of my assertions.

During the reign of Necos,* (the son of Psammetichus,) he commenced the cutting of a canal, leading from the Nile to the gulf of Suez; and in the prosecution of which, under Necos, no less than one hundred thousand Egyptians perished. It was afterwards continued by Darius, king of Persia; and, according to *Diodorus*,† finished by Ptolemy, the second of that name. This canal is said, by *Pliny*,‡ to have been one hundred feet in breadth, by thirty in depth. Yet, strange as it may appear, few or no traces of it are now to be seen, except near the gulf of Suez, where it terminated.

That it has been filled up principally by sand, we may reasonably infer, from the circumstance of the desert through which it was cut, being almost entirely a vast plain of moving sand. *Pliny* says, that unless there are reeds stuck in the ground to point out the course or direction, across the desert, the way could not be found, because the wind blows up the sand, and destroys every trace of footsteps.§

This fact is corroborated by the remarks of M. *Sonini*, on the desert of Lybia. "There no road,

* Herodotus Euterpe, chap. 158.

† Diodorus, lib. i. chap. 3.

‡ Pliny, lib. vi. chap. 29.

§ Pliny, lib. vi. chap. 29. See also Rennell's Herod. p. 453.

no path remains to guide the traveller's course; the impressions of his footsteps are effaced almost as soon as made, and billows of sand, raised by the impetuous winds, sometimes swallow him up."*

Another canal, called Trajan's, was cut, leading from the Nile, near Cairo, to the gulf of Suez; and also another, said to have been dug by Omar, still further down the river. These are all filled up, and have disappeared; and that too, so far in the time of Cleopatra, that her ships were dragged across the isthmus by land.†

The ancient Pelusiac branch of the Nile, on which stood the city of Bubastis, has long since been deserted by its stream, except during the height of the inundation of the Nile, some water flows in the slight depression which marks its former course. Several others, of smaller magnitude, have also disappeared, and no traces of them left. Mr. *Volney* says, "the canals which conveyed these (waters) were destroyed; for in this shifting soil, they are rapidly choaked up, both by the action of the winds, and by the cavalry of the Bedouin Arabs."‡ But the most important instance in this view, is that of the ancient bed, in which the Nile flowed at the foot of the Lybian range, before the time of Menes.

This channel, in which the whole body of the Nile once flowed, is nearly filled up to a level with its

* Sonini's Travels, vol. 2. p. 128.
† See Life of Anthony.
‡ Volney's Travels, p. 135.

banks, although nearly one thousand yards in breadth; and that too without much assistance from the alluvion of the Nile.

On this subject, Mr. *Rennell* observes: "A proof of the length of time, required to fill up such a channel, (if ever it be completed at all) is, that the deserted bed just mentioned, remains visible, although the change happened before the foundation of Memphis. It must however be considered, that the mound, by *preventing* the *free access* of the Nile water, charged with its mud, has doubtless retarded the operation in this instance."*

The mound, of which Mr. *Rennell* speaks, is that I presume, which was raised by Menes to turn the course of the Nile. If so, we can scarcely suppose, that there was *any* access of the waters of the Nile into its ancient bed, in that direction, much less a free access; for had the waters been suffered to flow through, or over that mound, in any degree, it would ultimately have made a breach through it, and defeated every purpose that was intended. Consequently, we may reasonably conclude, that but very little aid was derived from that source, in filling up the old channel, or, in fact, from any other, by deposites of alluvion; for he says, *(page 504)* with respect to the level of the sand hills through which the channels run, that they "are far above that of the present river, whose bed must once have been a vast deal lower than it now is."

* Rennell's Herodotus, p. 502.

Hence, it is urged, that this ancient channel, which stretches along from south to north on the very borders of the deserts, and exposed to every blast that sweeps over their surfaces, has been filled up by the sands brought by the winds, and deposited in its bed.

The lake Mareotis is another instance, which in point of analogy, in this case, differs but very little. It is situated still further from the Nile to the west, and, if possible, more exposed to the drifting sands of the deserts, particularly those of the violent south-westerly gales. This lake, in the time of *Strabo,* formed an expanse of thirty miles. It is "now filled up, nearly to the level of the country; and the lakes by Canopus much in the same state."*

That the sands of the deserts have been the principal cause of this, as well as the elevation and extension of the plains of Egypt, we may conclude from another circumstance. The lands on the west side of the ancient Sebennitic branch, or Damietta river, are represented as being more elevated and more perfectly formed, than the land on the eastern side of the delta, where there are still small lakes, and low grounds not yet filled up.

This difference is attributed, by Mr. *Rennell,* to the discharge of a greater quantity of water by the Nile to the north and north west, than towards the eastern part of the delta; consequently, a greater de-

* Rennell's Herodotus, page 542.

position of alluvion, which, in time, has produced this effect.

But I should impute it to a very different cause. The winds that sweep over these trackless regions to the west, laden with sand, naturally let fall, or deposite the greatest quantity at the immediate termination of the eastern borders of the deserts. As they were carried farther on, the quantity let fall would lessen in proportion to the distance passed over : so that, by the time they had reached the eastern side of the delta, (which at its base is sixty-one miles in breadth,) they would have deposited nearly, or quite all the sand thus brought from the deserts on the west ; in the same manner as a river that flows into the sea or a lake, deposites its alluvion in the greatest quantity immediately at its mouth, and gradually diminishing as it advances into the sea. And, in the same manner, as the sands taken up from the land by the winds, and carried over a bay or sea, are let fall as the wind loses its force.

Hence it is, most probably, that the eastern and lower part of the delta, which depends mostly on the sands brought by the easterly winds, or Levanters, across the Isthmus, or desert lying between the Nile and the Red Sea, which is comparatively narrow, is lower and less perfectly formed, than the districts further west and nearer the deserts.

From this view, we need not wonder why the lands on the lower and western part of Egypt, should be more perfectly formed, and increase faster, than those on the lower and eastern part, nor by what means the ancient bed of the Nile has been filled up, and also the lake of Mareotis; while those of Brulos, and Menzala are more slowly progressing to the same, or a similar state. Neither need we wonder why the ancient Canopic branch, from the ancient Milesian wall, or the city of Deirut to the sea should be filled up, and a new channel formed; since, besides what I have stated, Dr. *Pocoke* says, that "all the country here, (near the Canopic branch,) is a sandy desert; it might be otherwise, when this branch of the Nile annually overflowed, but there being a ridge of low sandy hills running from north to south, near the Nile, it is possible that the fruitful soil may have been covered with sand blown from these hills. The sand *changes so often*, that it would be difficult to find the way, if they had not built eleven pillars across the plain, which I conjectured might be about half a mile apart, in order to direct the way, which otherwise it would be difficult to find at such times, as the *wind raises great clouds of sand*, as it often does in Egypt."*

It is, almost exclusively, to this cause, that we are to look for the extension of the land between Alexandria and the Canopic branch; for Dr. *Shaw* observes, that "there are few or no tokens of the Nile's inundation, to be met with from Alexandria to Rosetta, the whole tract appearing to have been, originally, either

* Pocoke's Travels, vol. I, page 13.

a continuation of the sandy coast of Lybia, or else an island."*

It is to this cause that many parts of Egypt, once rich and fertile, have already become barren and desolate, whilst the whole space contained within its limits, is fast progressing towards that state, in which its inhabitants must experience all the horrours of a perpetual famine :† for the lands are becoming more and more elevated and extended, and when no longer overflowed by the Nile, they must inevitably become as barren and unproductive, as the neighbouring deserts, which are now supplying the means of their destruction. In speaking of the elevation of the soil of Egypt, Mr. *Shaw* observes, "Thus in process of time, this whole country may be raised to such a height, that the river will not be able to overflow its banks; and Egypt, consequently, from being the most fertile, will, for want of the annual inundation, become *one of the most barren parts of the universe.*"‡

"The ancient Egyptians," says M. *Denon*, "speak of this encroachment of the sands, under the symbol of the mysterious entrance of Typhon into the bed of his sister-in-law Isis; an incest which is to *change Egypt into a desert, as frightful as those by which it is encompassed;* and this great event will happen, when the Nile finds a lower level, through some one of the sur-

* Shaw's Travels, page 339.

† See Herodotus Euterpe, Chap. 14. ‡ Do. page 441.

rounding vallies, than the bed in which it now flows, and which is constantly getting lower."*

From Mr. *Bruce*, whose veracity can scarcely be doubted, we have the following opinion: "It seems to me, that soon, the greatest part of Egypt, on the side east of the Nile, between Aichmim and Cairo, will be a desert; not from the rising of the ground by *the mud*, as is supposed, but from the *quantity of sand* from the mountains, which covers the mould, or earth, several feet deep."†

From this view, it must appear evident, that the operations of the winds on the deserts that skirt the valley of Egypt, both on the east and the west, have been the principal cause by which both the plains in the valley of Egypt and its delta have been formed and extended to their present limits. That these sources have existed, and the same process has been in operation, for nearly or quite four thousand years, we have the most unquestionable authority; and we have the same reason to believe, that they were in full operation for nearly two thousand years before.

That they still exist, and are threatening the entire expulsion of the inhabitants of this once fertile region, we have the most respectable testimony from several travellers who have visited it, and from whose writings I shall take the liberty of transcribing the following extracts, as they are written in a style forcible and ex-

* Denon's Travels, vol. I, page 370.

† Bruce's Travels, vol. I, page 105.

pressive, of the calamitous scenes that were exhibited to their views.

"From Media, or Passage," says Mr. *Bruce*, "our road lay through very dry sand, to avoid which, and seek a firmer footing, we were obliged to ride up to the bellies of our horses in the sea. If the wind blows this quantity of dust or sand into the Mediterranean, it is no wonder the mouths of the branches of the Nile are choaked up."

"*All Egypt* is like to this part of it, full of deep dust and sand, from the beginning of March till the first inundation. It is this fine powder and sand, raised and loosened by the heat of the sun, and want of dew, and not being tied fast, as it were, by any root or vegetation, which the Nile carries off with it, and buries in the sea; and which many ignorantly suppose, comes from Abyssinia, where *every river* runs in a bed of rock."*

Of the deserts on the west side of the Nile, *Sonini* observes: "Wretched is the situation of those who find themselves entangled in the vast sandy deserts with which Egypt is bordered; intrepidity is then of no avail whatever; and the most valiant armies may be thus overwhelmed with clouds of sand, which the wind drives impetuously along, may be stifled to death, and perish in despair. The atmosphere was

* Bruce's Travels, vol. i. p. 20.

on fire, and at the same time darkened by whirlwinds of dust."†

"It is well known," says Mr. *Rennell*, "that travellers differ exceedingly, in their reports of the dimensions of the great pyramid, owing to the *impossibility* of measuring the sides of its base; which are, in a great measure, covered with *heaps of sand, drifted against them by the winds.*"‡

In speaking of the changes of the delta, Mr. *Volney* observes, "these are not entirely owing to the Nile and the sea; *the wind itself* is a powerful agent, which sometimes choaks up the canals, and drives back the river, as it has done at the Canopic branch. At others, it *amasses* the sand, and buries the ruins so that their very remembrance is lost. Mr. *Niebhur* relates a remarkable instance of this. While he was at Rosetta, in 1762, he discovered, by chance, under the *sandy hillocks*, to the southward of that city, several ancient ruins, and among others, twenty fine marble columns, of Grecian workmanship, without being able to learn any tradition even of the name of the place. This appears to me to have been the case with the whole of the adjacent desert. This tract, formerly intersected by large canals, and filled with towns, presents nothing but hillocks of a *yellowish sand*, very

† Sonini's Travels, vol. iii. p. 32. Also page 24, and 224, on the same subject.

‡ Rennell's Herod. p. 360.

fine, which the wind heaps up at the foot of every obstacle, and which frequently buries the palm trees."*

In describing the obelisks at the entrance of Luxor, Mr. *Denon* observes, "the two obelisks of rose-coloured granite, are still seventy feet above the ground; and to judge by the depth to which the figures seem to be covered, we may reckon about thirty feet more concealed from the eye, making in all one hundred feet for the heighth of these monuments."†

In their march towards Keneh, he again observes: "Our progress was interrupted by those particular winds, which, notwithstanding the sky is clear and unclouded, fill the air with so much sand, that it is *neither day nor night* ‡

In describing the valley formed by Mount Kolsun, and the Arabian mountains, he says, "The mouth of this valley, towards the Nile, exhibits nothing but a dreary plain, the only cultivated part of which, is a narrow slip of land, on the bank of the river; some vestiges of villages *overwhelmed by sand,* may be discovered, and they present the *afflicting sight* of *daily devastation* produced by the *continual encroachment of the desert,* on the soil *inundated* with sand."

"Nothing is so melancholy to the feelings, as to march over these ruined villages; to tread under foot the roofs of the houses, and the tops of the minerets; and to think that these were once cultivated fields,

* Volney's Travels, p. 24.

† Denon's Travels, vol. iii. p. 188.

‡ Denon's Travels, vol. ii. p. 225.

flourishing towns, and the habitations of man. Every thing living has disappeared; silence is within and around every wall, and the deserted villages are like the dead, whose skeletons strike with horrour."*

In the description of Oxyrinchus, once a famous city of Egypt, we have the following account: "Oxyrinchus, once a metropolis surrounded by a fertile plain, two leagues off the Lybian range of hills, has *disappeared beneath the sand;* and the new town has been *obliged to retreat* from this *desolating invasion, leaving to its ravages house after house*, and the inhabitants *must at last be driven beyond the canal Jusef*, on the border of which *they will still be threatened.*"†

In the general description of the inundation of the sands from the deserts, this author gives us the following gloomy and distressing picture.

"At more than ten leagues from Cairo, we discovered the points of the pyramids piercing the horizon; soon after we saw Mount Katham, and opposite to it, the chain of hills which separates Egypt from Lybia, and forms a barrier to the banks of the Nile against the sands of the desert; but in *this eternal conflict* between *this destructive scourge*, and the beneficent river, *the inundation of sand often overwhelms the country, changes its fertility to barrenness, drives the labourer from his house, whose walls it covers up*, and leaves no other mark of vegetable life, than the tops of

* Denon, vol. i. p. 191.
† Denon, vol. i. p. 373.

a few palm trees, which adds still more to the dreary aspect of destruction."*

To this amount of evidence in favour of the operation of the winds, in forming the plains of Egypt and its delta, who, when he considers that they have been the same, perhaps, from the beginning of time, will attempt to oppose the opinion, or pretend that the alluvion only of the Nile, has been the cause of this great and wonderful change?

As well, almost, might we contend that the mouldering remains of the millions of inhabitants, whose bodies have served to fatten the soil of Egypt for ages past, have been equally accessary to its formation. For it is not even necessary, under existing circumstances, that the alluvion of the Nile should be taken into view, or that a river should flow, to produce a similar change.

If we examine the borders of the Red Sea, and their relation with the deserts of Arabia, we shall find sufficient proof of this fact.

The Arabian gulf or Red Sea, is bounded on the west, almost from one extremity to the other, by a range of mountains, from which, strange as it may appear, not a river is discharged into this sea, from the straits of Babel Mandel to the Isthmus of Suez.† On the western side of this sea, the water is in general deep

* Denon, vol. i. p. 256.

† See Bruce's Travels, vol. II. page 115.

with a rocky and uneven bottom, owing, probably, to the proximity of the mountains.

On the eastern side it is bounded nearly throughout its whole extent, by the Arabian deserts, which are as barren, and unfit for the habitation of man, as those of any other in the known world.

The shore on this side is in many places rocky, and the navigation generally difficult and dangerous, on account of the shallowness of the water and the innumerable sand banks, which prevail more or less, from Mocha to the northern extremity of this sea, throughout the whole of which distance, not a river, it is believed, is known to flow into it.*

It is supposed by many that this sea is fast retreating, becoming less, or filling up; or in other words, the land is encroaching on the sea; and under existing circumstances it is by no means to be wondered at. If we consider the immensely extended regions over which the easterly monsoons are, for nearly half the year, sweeping, and driving the sand in torrents into this sea, we shall not be disposed to doubt the fact; nor at a loss to account for the innumerable sand banks, and shallowness of the water, all along its eastern coast.

To what extent these inroads have been carried along a great part of it, I have no means of ascertaining. But that they are constantly progressing and,

* Ali Bey's Travels, vol. II. page 185.

most probably, have been ever since the sea existed, is certain.*

Mr. *Bruce* says, "On the opposite, or Arabian side, the sea coast of the Hejas, and that of the Tehama, are all moving sands; and the dry winter monsoon from the south east blows a large quantity from the deserts, which is lodged among the rocks on the Arabian side of the gulf, and confined there by the north east, or summer monsoon, which is in a contrary direction, and hinders them from coming over, or circulating towards the Egyptian side."†

From this source, and in this manner the Arabian deserts are constantly advancing into that sea.

At its northern extremity, where it is more frequented and better known by travellers, we have a more particular account of the changes that have taken place.

In speaking of the winds of the Arabian deserts, Dr. *Shaw* observes, "Of these the southerly ones are the gentlest; though those in other directions are the most frequent; and by blowing over a vast tract of this sandy desert, and bearing away the sandy surface along with them, make *continual encroachments* upon the sea, and frequent changes upon the continent.—From the same cause likewise, not only the harbour of Suez is, at present *entirely filled up;* but the channel of the sea which extendeth two or three miles further to the northward, nay once, perhaps, reached as

* See Rennell's Herodotus, p. 454 & 457.

† Bruce's Travels, second edition, vol. II. page 122.

far as Adjeroute (the Heroopolis, as it is supposed to be) is now dry at half ebb, though sometimes the sea floweth here near the heigth of a fathom."*

To these winds, he further observes may be attributed the many billows and mountains of sand which are scattered all over those deserts.

In a voyage of discoveries up the Red sea it is observed, "It is difficult to account for a narrow passage between two lines of coral rock having continued for so long a period free for vessels, without having been filled up, either by a sea constantly breaking on its mouth, after having *passed over sand banks,* or by clouds of sand, which at one season of the year are *borne towards it from the desert.*"†

Also, "It blew a gale from the east of north so that the mountains were, as usual on such occasions, *concealed from our view by clouds of sand.*"‡

It is to this cause that many places on the coast of Syria, and on the Mediterranean sea have been buried up, and every trace of them lost. Yet there are no rivers by which alluvion is deposited, to produce this change.

Mr. *Bruce* observes that "All vestiges of old Tyre are effaced;§ the ports of Sidon, Berout, (Berytus) Tripoli, and Latika, (Laodicea ad Mare) are filled up by the accretion of sand; and not many

* Shaw's Travels, page 378.

† Valentia's Travels, vol. II. p. 286. ‡ Do. vol. II. p. 315.

§ See Shaw's Travels, page 331, on the ancient port of Tyre.

days before my leaving Sidon,* M. *de Clerambaut,* consul of France, shewed me the pavements of the *old city of Sidon, seven and a half feet lower* than the ground on which the present city stands, and considerably further back in the gardens, near mount Libanus."†

It must be observed, however, that in this instance Mr. *Bruce* attributes the cause of this change to the operation of the Etesian winds on the current of the Nile, thereby causing it to flow round by the coast of Egypt and Syria, and by which "has been thrown a great quantity of *mud, gravel,* and sand, into all the ports of Syria."‡

How to account for the apparent inconsistency in the remarks and conclusions of that enlightened author on this point, I am unable to tell.

That the river Nile, the alluvion of which is a slimy mud,§ an impalpable powder,¶ should flow in a circuitous course, more than two hundred and fifty miles through *a level sea* at a rate sufficient to carry sand and gravel, and deposite them on the coast of Syria, and in such quantities as to bury cities and fill

* On the filling up of ports and harbours by the drifting of sands, see Ali Bey's Travels, vol. I. page 235. On the same subject, and the burying of towns and cities by the drifting of sands, see Capt. Riley's Narrative, pages 208, 229, 388, &c.

† Bruce's Travels, vol. I. page 85. ‡ Do. Do.

§ See Herodotus. ¶ See Shaw's Travels.

up their ancient ports, appears to me not only improbable, but unphilosophical,—nay, impossible.

Lest it should be thought that I have misunderstood this author's meaning, I shall transcribe his own words on this subject.

"This every one knows is the effect of that easterly current" (in the Mediterranean) "setting upon the coast, which as it acts perpendicularly to the course of the Nile, when discharging itself, at all, or any of its mouths, into the Mediterranean, *must hurry what it is charged with on to the coast of Syria, and hinder it settling opposite, or making those additions to the land of Egypt which Herodotus has vainly supposed.*"*

If the reader will cast his eye over this part of the map of the Mediterranean sea, he will at once be able to judge how improbable such a conclusion must be: for admitting that, during the prevalence of the Etesian winds, a current sets up the Mediterranean, it can only flow, (since there is no outlet at the eastern extremity of that sea,) round by the coast of Egypt and Phœnicia, and return again by the northern coast of the Mediterranean.

Now let us examine the probable effect of this current, on the two principal branches of the Nile.

The course of the Canopic branch is almost in a north west direction, and nearly opposed to the current of the Mediterranean. But we will suppose, that the

* Bruce's Travels, vol. II. page 85.

current of this branch of the Nile is influenced by that of the sea, and turned aside; instead of running perpendicularly to the course of the branch, it must follow, or stretch along the coast of the delta east of the branch, which is about north-east by east, until it comes to Cape Berelos or Brulos, when, instead of following the coast, it would inevitably be thrown off into the open sea, in the direction of the island of Cyprus; the same as the gulf stream is thrown off from the American coast by Cape Hatteras, and, in all probability, never unite its waters and alluvion, if it retain any, with that of the Sibennitic branch, or Damietta river. This is confirmed by the remarks of Mr *Rennell*, who says "Here it is proper to observe, that although the general current of the sea is to the east, along the coast of Egypt, yet that there is a counter current, from the Rosetta river, through the bay of Abouker, at whose point it falls into the general easterly current, *which is thrown off from the coast by the projecting form* of that point."*

I will next examine the Damietta river. Its course is in a north easterly direction, particularly, near its mouth. Now if the current of the Mediterranean flowed perpendiculy to this branch, its current must flow to the south east opposite the lake of Menzala, and so on by the coast of Syria; in which case, not a handful of sand would have been deposited on that coast, by reasons of its running parallel with it only, and not

* Rennell's Herodotus, page 489.

directly upon it. M. *Volney* observes, that "during the inundation, the Nile occasions a current along the whole coast of Syria, which extends from Gaza to Cyprus:"* but he does not pretend, or hint, that it acts on the coast of Syria, or that it deposites a particle of alluvion on its shores.

The probability is that the current of the Damietta river, was but very little affected by that of the Mediterranean, and that by reason of Cape Berelos stretching out into the sea, throws the current of the latter off more to the north east, and would therefore leave the current of the Damietta to flow in the direction of Tyre, where, if it had retained any alluvion, (which for reasons that I have advanced is highly improbable,) it might have deposited some. But if it had struck the coast of Phœnicia in this direction, it must, from thence, have flowed parallel with the coast to the northward. How then shall we account for the situation of ancient Sidon, Tripoli, and Laodicea, the latter of which is one hundred miles north of Tyre, being all, nearly alike, buried with sand? Not, certainly, by the deposition of alluvion of the Nile, since there are other sources but too well known, which have been, for more than forty centuries, almost constantly yielding their materials to bury those cities, through the medium of the winds sweeping over the deserts.

The same change is constantly progressing upon the gulf of Suez,† where no river was ever known to flow.

* Volney's Travels, page 212.

† See Pococke, page 132, and Rennell's Herodotus, page 454.

The ancient city of Kolzoun, which, in the time of the Caliphs, stood at the head of the gulf of Suez, is entirely buried with sand, and at the distance of six miles, or two leagues, from the present head of the gulf.* This distance is allowed for the retreat of the sea in seventeen centuries.

It is a prevailing opinion with several, that the gaining of the land upon this sea, is occasioned by the current of the tides and waves, which throw the sand upon the beach, where it accumulates, and the sea retires.

On this subject M. *Volney* says, "The dock at Suez is ill adapted to repair such damages; scarcely do they build a *Cayasse* in three years. Besides that, the sea, which from its flux and reflux accumulates the sand upon that coast, will at last choak up the entrance, and the same change will take place at Suez, which has already at Kolzoun and Arsinoe."†

Mr. *Rennell* is likewise disposed to attribute this change to the same cause; that is, to the operation of the tides, and strong south winds.‡

But why, let us ask, is not the same effect produced on the western coast of the Red Sea, by the sands that are borne, by the winds, almost from the Persian Gulf, across the deserts; and the waves that are beating directly upon it? No mention is here made of any thing of the kind.

* Volney's Travels, page † Do. page 137.

‡ Rennell's Herodotus, page 475.

As to this change having been produced by the operation of the tides; who, when he considers that the tide, in the middle of that sea, rises but twelve inches,* can suppose that such an increase only will cause a current of sufficient force, to take up the sand, and drive it upon the beach; when, as before, we may see, in rivulets, creeks, and rivers, the currents flowing at the rate of four or five miles an hour, yet not a particle of sand is seen to move?

Besides, admitting that a current of some force does prevail in that sea during flood tide, whence is the sand brought in a quantity sufficient to fill up the head of the gulf, and cause a retreat of the sea for six miles?† The gulf of Suez is not represented as hav-

* See Lord Valentia's Travels, vol. II, page 274, and Rennell's Herodotus, page 476.

† I have already remarked that, during, or immediately after the universal deluge, the Isthmus of Suez, in all probability, did not exist. The more this subject is examined, and the various circumstances inseparably connected with it, the less reason I find to alter or change my opinion on that head. It is well known that it is a low level plain, rising but a very little above the level of the Mediterranean and Red Sea; that it lies immediately between two deserts of great extent, over which the Etesian and Levant winds are sweeping, and bearing the sand away in torrents, directly across this isthmus, almost from one end of the year to the other.

It is also well known, that it has actually made considerable advances upon the gulf of Suez or Red Sea, within a few centuries and in the course of time, most probably a distance of many leagues; for when the French where in possession of Suez, their engineers discovered, at a little distance to the north of that place, ing a sandy bottom. On the contrary it is called the Weedy Sea,* from the quantity and variety of marine plants, that grow upon its bottom, which is, in a large proportion, composed of mud. It is particularly worthy of notice, that Lord *Valentia*, in his voyage of discoveries up the Red Sea, found almost uniformly by soundings, and at various depths, a muddy bottom, and sometimes a stiff clay.†

"It has been thought more proper therefore," says Mr. *Shaw*, "to translate *Jam Suph*, the sea of weeds, or the weedy sea, from the variety of Algae, and Fuci, that grow within its channel, and at low water particularly, are left in great quantities upon the sea shore."‡

some marshes, which extend for more than twenty-five miles, and are *actually lower than the sea*, though they are not overflowed, in consequence of a large bar of sand, which has accumulated between them. "Nothing, therefore," says Lord Valentia, "can be more probable, than that, in times so far back, as the departure of the Israelites, the sea itself extended to these marshes, and that since, the same gradual encroachments of sand from the desert, which have formed the Tehama in Lower Arabia, have *annihilated the sea in a place where it was so much narrower."—Valentia's Travels, vol. III. page* 356.

Moreover—"There is every reason to believe that the Red Sea actually extended, in former times, twenty-five miles north of Suez."—*Do. Do. vol. III. page* 359.

* It was at Suez that Lord Valentia was enabled to enlarge his collection of marine plants. "I also greatly increased my collection of sea weed, *with which the Red Sea* abounds more than any other."—*Do. Do. vol. III.* page 345.

† Valentia's Travels, vol. II.

‡ Shaw's Travels, pages 349 & 387.

If this fact be admitted, the probability is, that the influence which the waves, or the current of the tides, may have had on the bottom of a sea, or river, covered with weeds, must be similar to that of the winds passing over lands, covered with weeds or grass; very little sand would be disturbed. But whether little or much, where is the necessity of resorting to a cause so improbable and uncertain, while the operation of the winds on the surrounding sandy deserts, is so palpable and common to the view of every person, that is disposed to notice and examine their effects, and which alone are amply sufficient to produce, in time, all those changes, without the assistance of either waves or currents?

To substantiate this fact, it is not necessary to confine our views to the gulf of Suez, or the coast of Phœnicia. The same or similar changes have taken place, and are still going on upon the borders of the Caspian sea, and the sea of Aral, where there are no regular tides and but few rivers.

Professor Pallas observes that "All the countries on the northern part of the Caspian sea tend to prove that it has decreased, and probably continues to decrease in a greater proportion than the Mediterranean and other seas."*

Between the Caspian sea and that of Aral, lies an immense sandy desert, extending from south east to north west, nearly five hundred miles in length. The

* Pallas's Travels in Russia, vol. I. page 79 or 80.

northern extremity of this desert is bounded by the Caspian, for nearly two hundred miles in extent, from west to east. This part of the sea, into which no rivers are discharged, is subject to perpetual inroads from the deserts, by the sand, that is driven in torrents by the south easterly winds, and deposited on its shores.

Through, or rather across this desert, the river Oxus once directed its course, and discharged itself into a gulf, upon the eastern side of the Caspian sea, near Minkislak. It continued to pursue this course until the year 1640, when it assumed a different route, since which, its ancient bed has been filled up.

"The southern and principal branch of the Oxus," (says Mr. *Rennell*,) which ran into the south east part of the Caspian, *has deserted its bed;* and according to *Abulgazi Khan*, the tract it ran through, from the condition of fertile and well planted fields, is become a *sandy desert*."*

Whence, I would again ask, came these changes, but by the operation of the winds upon the sandy deserts? There are, I believe, no tides in the Caspian sea, to produce this effect: nor are there any rivers which are discharged into this sea at the northern extremity of this great desert, to cause its retreat. Neither are we willing to admit that this gain of the land was occasioned by the sand washed, or thrown up by the waves; since in that case, as the winds blow in all

* Rennell's Herod. p. 533.

directions, and the waves are dashed upon the shores at all points, the effect must have been uniform throughout the entire borders of the Caspian sea. But this is not the case. It is only in the neighbourhood of sandy deserts, or districts, that we witness this tendency of the sands to accumulate upon the beach, and gradually extending into the sea, thereby causing its retreat. Hence we are justified in the conclusion, that these changes are the result of the operations of the winds, upon the dry and exposed surfaces of sandy districts.

From this view, which might be extended to various other parts of the world, the inference is plain and unequivocal, that the ancient gulf, now occupied by the plains of Egypt, and the delta of the Nile, has been filled up to the present extent of the latter, by the agency of the three following causes :

1st. The alluvion of the Nile.

2dly. The direct and indirect labours of man ; and

3dly. The operations of the winds on the sandy deserts in its vicinity.

Having already taken notice of the rapid extension of the delta of the Po, since the year 1200, and that too in an increased ratio, particularly in the last two hundred years ; and also the causes, which will apply to that of the Indus, the Ganges, and almost all other deltas, I have omitted any remarks on this subject, as it relates to the delta of the Nile, presuming that every person who will give himself the trouble to examine the facts, will find, that as the same causes have been, and continue to be in operation, governed by the same principles, and regulated by similar laws, the same results will naturally follow in the one case as in the other.

It may not be amiss, however, to observe, in order to give a superficial view of the subject, that Damietta, which in the time of St. Louis, (A. D. 1243,) was a sea-port town, is now more than ten miles from the sea.

That Fooah, which a little more than three hundred years ago, was at the mouth of the Canopic branch, is now more than seven miles above it. And further, the land between Rosetta and the sea, has gained, in forty years, half a league.*

From this it appears obvious, that the extension of the lands into the sea has been, and continues to be, in an increased ratio, proportioned to the distance from, or below Thebes, Memphis, or any other fixed point, on the river Nile.

For instance, the increase of the land between Fooah and the Canopic mouth, in three hundred years, exceeds the gain of five hundred and seventy-six years, (that is, from 1243 to the present time,) in proportion as thirteen and a half miles is to ten; or nearly as nine is to seven.

The increase or gain of land, in forty years, exceeds that of three hundred, in proportion as eleven and a quarter miles is to seven. Lastly, the gain of

* Shaw's Travels, p. 340.

forty years, exceeds that of five hundred and seventy-six, in proportion as twenty-two miles is to ten; shewing that the extension of the delta of the Nile has progressed, in an increased ratio, as well as almost all other cases of a similar kind.

CHAPTER XIV.

From the grounds which have been assumed, and the manner in which the subject of alluvial formations, and the deltas of rivers have been treated, and particularly those of the Po, the Indus, the Ganges, and the Nile, it may reasonably be expected that something will be said, on the delta of the Mississippi, or at least that part of the alluvial formation through which it passes, for more than two degrees of latitude.

There are but few instances of the kind in the world that possess more interest, nor but few that afford a more extensive field for investigation, than this mighty sovereign of rivers, and the districts on its borders. At the same time, no instance occurs in which the subject appears to be involved in more profound obscurity, or is attended with greater and more numerous difficulties in acquiring a correct knowledge of facts, than the one under consideration.

That a very considerable increase and extent of soil and alluvial formations have been created at the mouth of this river, cannot for a moment be doubted. But where the original limits of the bay of Mexico were, on the north; or where the primitive shores of the continent were, or the point at which this river originally discharged its waters into the sea or gulf, no mortal can explain.

In this instance, we have no *Osiris*, nor no *Menes* from whose time we can date the gradual advances of this district; nor have we a Thebes or a Memphis, as fixed points, by which we can determine its annual increase or aggregate formation and extent. Neither have we the writings of a *Pliny*, a *Herodotus*, and a long list of other historians, to inform us of the primitive course of the river; of its varied and multiplied changes; of the gradual increase and extent of alluvial deposites; or of the successive events that have, in the course of time, occurred in its vicinity. All and every circumstance that relates to its history, have remained, during a long and fearful night of darkness; wrapt in impenetrable mystery; while through this period of ages this noble river has been left, unregistered upon the faithful records of time, to pursue, in silent majesty, its devious course through the almost interminable regions of uncultivated wilds, where until the discovery of America, as far as we know, the footsteps of civilized man had never left an impress.

Under circumstances so unfavourable to the attainment of a correct knowledge of the changes that have taken place at or near the mouth of this river, it has remained since its discovery subject to the remarks and speculations of every person who might choose to express his opinion of the subject.

Among the variety that has been advanced, but two only bear the semblance of probability, and those even are not without exceptions.

The first is, that the alluvial region or districts in the vicinity of the Misssisippi, have been formed by the influence or operations of the gulf stream, which is (it is said) constantly wafting or transporting the sand into the bay of Mexico to be deposited upon its shores.

The second is, that it has been formed by the alluvion brought down by the current of the Mississippi river and its auxiliary streams, and deposited near its borders, and at its confluence with the bay of Mexico.

These two opinions I shall proceed to examine in order, in the first place, to see how far they are entitled to credit; and in the second, to ascertain to what extent we are to admit the agency of either.

M. *de Beaujour* observes that "The alluvial zone is in general, of an equal level, rising insensibly towards the Alleghany; and it appears to have been the *work of the current of the Mexican gulf,* which bathes the American coast from Florida point as far as Cape Cod, from which it afterwards diverges to run to the east towards the banks of Newfoundland."*

On the subject of the alluvial zone, Mr. *Volney* observes, "Whereas, proceeding southward from this

* Sketch of the United States, page 45.

(Long) island, we meet with nothing but a flat of pure sand, almost level with the ocean. This sand has evidently *been left by the sea*, and is traced to a considerable distance inland.*

And further, "Between this bank" (the granite ridge) "and the sea, the surface, in a breadth of from thirty to a hundred miles, is composed of sand, *evidently deposited by the sea*, which once flowed at the foot of this bank."†

A similar inference may be drawn from the remarks of Mr. *Stoddard*, who says, "The eastern part of New Spain along the gulf, exhibits abundant proofs of similar advances; owing, perhaps, to the constant accumulation of sand by the trade winds which is driven to the shore by the perpetual action of the waves in that direction."‡

Without offering any remarks, or even asking the simple question, whence comes the incredible quantity of sand thus supposed to have been brought by the gulf stream, to produce these wonderful changes at the mouth of the Mississippi, and in the bay of Mexico; it is sufficient to observe, that enough has been said on the transportation of sand by currents, and of its specifick gravity, when compared with water, to convince any person acquainted with the first principles of hydraulicks, or the fundamental maxims of gravitation, that such extraordinary effects are physically impossi-

* Volney's View of America, page 16. † Do. page 56.

‡ Sketches of Louisiana, page 158.

ble, even under the most aggravated circumstances by which the gulf stream has ever been known to be regulated. Hence it is taken for granted that no part or portion of the great alluvial region, upon any part of the Atlantic shores, nor of the shores of the gulf of Mexico were ever brought and deposited by the sea, or gulf stream; for with as much propriety might it be said that the great alluvial region skirting the northern borders of Siberia, and constituting the southern boundaries of the Arctic sea for more than seven hundred leagues from west to east, was formed by alluvion brought from the North Pole, where not an inch of land is, at least, known to exist; for it is well known that currents are not wanting in the Arctic sea of sufficient rapidity, to produce much more extensive and surprising effects of the kind if it depended on them.*

It only remains to examine the second opinion, viz. that the alluvial lands in the neighbourhood, and at the mouth of the Mississippi river, have been formed by the alluvion brought down by that river and its auxiliary streams.

That an almost inconceivable quantity of alluvion is annually borne away by the current of that river, there cannot remain the least shadow of doubt; but that the lands to the extent that many are inclined to believe,

* For an account of which see Linschotten's Voyage to Waygat's Straits, vol. IV. page 204. and Wm. Barent's account of the voyage of the Dutch East India Company.

were formed by it, is by no means probable; therefore cannot be admitted, while there exist facts that will warrant a very different opinion.

In order to a more correct view, or a more perfect knowledge of the subject, it is a matter of no small importance that all the existing circumstances should be carefully examined, and duly weighed, that we may be enabled to judge whether, in the first place, the lands in question were all formed by the alluvion of the Mississippi river, or not; or secondly, to what extent we are to admit its agency in this extensive work.

In the examination and discussion of these questions, I am well aware of the disadvantages under which a person labours, who has never seen the smallest part or portion of the Mississippi river, or of its auxiliary branches; much less any portion of the alluvial districts upon their borders. But from the well known facts that exist, I am not disposed to shrink from the investigation, under an apprehension that popular prejudices cannot be overcome nor made to yield to the force of conviction, where truth stands pre-eminent; nor to relinquish the pursuit from fear of a difference of opinion, since it is not expected, nor intended to establish a decision from which there is no appeal.

It must appear obvious to every one that the only object in view in the present instance is the developement of truth. To this end, I shall first take notice of the tides in the gulf of Mexico, with a view to the influence which they may have on the current of the Mississippi river.

It is, I believe, pretty well known, and generally understood, that the tides in the gulf of Mexico rise but very little, except during the prevalence of violent north east or south east storms, or gales of wind.—The principal authority which we have for this, is that of Mr. *Stoddard*, which has been already quoted, page 88. On this subject he observes, "The difference between the *highest and lowest stages of water in the Balize*, is about three feet." And moreover, "The tides have but little effect on the water at New Orleans; they sometimes cause it to swell, but *never to slacken its current.*"*

Hence, when we take into view the amazing quantity of water that flows in that river, and the force and velocity of its current, which bears down almost all opposition, the conclusion is very obvious, that the alluvion which may be, at any time, suspended in its waters, must be carried and deposited at, or in the neighbourhood of its confluence with the bay of Mexico; except when its banks are no longer capable of retaining its waters, and they are free to overflow and inundate the neighbouring country. From these facts we might reasonably infer that this river would, from the earliest periods of time, have been pushing forward and depositing its alluvion farther and farther into the sea, presenting to view, at the present time an

* Sketches of Louisiana, page 164.

extensive peninsula, stretching into the sea, *far* beyond the borders of its neighbouring coasts, or the original and primitive shores of the ocean: this, however, is not altogether the case. But it may be asked, what means the long strip of land extending beyond a line drawn from Bastien Bay to Black Lake, to the head of the present delta, or where the river is divided into three branches, a distance of about thirty-five miles in a straight line; and to the extremity of the land at the South Pass, about forty-seven miles?

I am perfectly willing to admit the existence of this strip of land, and that it has been formed principally by the alluvion deposited from the waters of the Mississippi river.—But before I proceed to answer this question, it is necessary in order to come at truth in this case, to take a view of the whole ground, and the various circumstances necessarily attending it.

To the persevering industry and exertions of Mr. *Darby*, we are principally indebted for the means by which to form something like correct ideas of the subject under consideration. In his map of the Mississippi Territory, we find laid down an immense tract of alluvial lands, projecting into the gulf of Mexico, more than sixty miles beyond a right line drawn from the entrance into Mobile bay, or Pensacola river, to the mouth of the Sabine, or Mermentau river, which line corresponds very nearly with that of the coast generally; that is, east and west of the Mississippi river. This projection of land, with the little islands adjacent, as represented, form a pretty correct segment of a circle of nearly 120°. Through or across the eastern portion of this segment of land, the Mississippi river runs; but which, in its course from New Orleans to near Fort St. Philip, does not embrace one quarter of this alluvial district or projecting segment. Now with all the gain of this river by alluvial deposites, and the extension of lands which it has for ages been pushing forward into the sea, the extreme point of land at the Balize does not, it is believed, extend so far, due south, into the gulf of Mexico, as the land at the mouth of the river Lafourche, or the land opposite the east end of the island Grand Caillou.

I have admitted that the strip of land beyond the mouth of Bastien bay, to that of Black Lake has been formed by alluvial deposites from the Mississippi river. I now beg leave to ask by what means was the projection of land formed between the east end of Grand Isle, and the entrance of Atchafalaya bay?

The Mississippi river does not approach the mouth of the river Lafourche, in any direction, within almost fifty miles, and at no point below New Orleans, not within seventy miles of the land opposite the east end of Isle Grand Caillou.

It may be, and doubtless is attributed to one, or all of the following causes.

In the first place, it may be said that during the inundation of the Mississippi at some remote period, its current, from the pressure above, was urged into the channel of the river Lafourche, overflowing the country to the right and left, and depositing its alluvion in proportion as its current was checked by the waters in the bay of Mexico.

2dly. It may be alleged that the same or similar operations have been carried on upon the whole course of the Atchafalaya river; or that, without confining our view to either of those rivers, the Mississippi river by its annual inundations, which overflow all that part of the country, has in the course of time, formed this district of alluvial lands that now projects into the bay of Mexico so far beyond the general line of sea coast.

In reply to the first supposition, (viz.) that the Mississippi during the period of its annual inundations, may have assumed the channel of the river Lafourche, if the fact be even admitted, it seems highly improbable that the alluvial depositions on the borders of the river Lafourche, and at its mouth, should be so very abundant, during the period of its inundation, as almost to keep pace with that of the Mississippi, at, and near its present influx, and where these operations are unremitting for nearly or quite three fourths of the year. Nay, the circumstance seems so unlikely, and so void of support, that we ought to hesitate to admit it, even if there were no other source, or means left, by which to explain the cause of this phenomenon.

3dly. The same remarks will apply with equal force to that of the river Atchafalaya. Moreover we may add, if it be admitted that any portion of the Mississippi, flows through the channel of this river during the annual inundation, and by which the alluvial district has been formed and extended, the quantity of alluvial deposites ought to have been much greater and extended much farther into the gulf than the lands at the mouth of Lafourche; because the former is a much larger stream than the latter, and runs through a greater extent of country; but this is by no means the case; for the alluvial lands at the mouth of the Atchafalaya, where it enters the bay of that name, do not project so far into the bay of Mexico, by about twenty-five miles, as the lands at the mouth of Lafourche.

To this we may add, that if the alluvial deposites, by which these lands were formed, were acquired from this source; we might reasonably suppose that Atchafalaya bay which is more than twenty miles in length, from east to west, and about twelve miles in breadth, and in many parts, fifty feet deep, ought to have been filled up, and the river discharging itself immediately into the gulf, as does the Lafourche, and as did the Mississippi, at the head of the present delta.

From this view, the advocates for the formation of this immense section of land, or segment of a circle, which is equally as appropriate, by alluvial deposites from the overflowing or inundations of the Mississippi river, seem to derive but a very precarious support, at best, from these sources.

It may be further alleged, that the formation of the lands that project into the gulf of Mexico, and through which the Mississippi runs, has been owing in part to the following causes. It has been imagined, and is, at present believed by some, that the course of the Mississippi, was once through the river Atchafalaya into the bay of that name. By others, that the Mississippi had its course for a time through the river Lafourche.

If we examine the various turnings and windings of this river, from its entrance into the Mississippi Territory, to New Orleans, we shall be ready to admit that it may have run in any, and all directions through the country; for in that distance, the whole channel or current of the river may be said to run in every possible direction, or in that of every known point of the compass.

But there are circumstances which lead to the conclusion that its general course has never varied much from that in which it now runs, since the subsidence of the general deluge; and moreover that it has never run in the direction, nor through the channel of the Atchafalaya river, or that of Lafourche: and for the following reasons.

If the Mississippi had ever occupied the channel or bed of the Atchafalaya, for any considerable length of time, we have every reason to believe that it would have filled up Lake Chetimaches (with which and the Atchafalaya there is a communication at present, at the north end, and across which and Lake Palourde that river now runs,) with alluvion. Not only so, but we have still greater reason to believe that Atchafalaya bay, into which the Mississippi river must have discharged its waters, as the Atchafalaya now does, must have been entirely effaced by alluvial deposites, but which is not the case; on the contrary, the Atchafalaya bay is, at least, represented to be, as before, fifty feet in depth, in some parts of it.

Another circumstance of no small importance, must be taken into view in this case. If the Mississippi river had ever followed the course of the Atchafalaya river, or that of Lafourche, to which the same reasoning will apply to a certain extent, we should still be able to trace its channel in both instances, throughout its whole course; for it is next to impossible, that a river so deep, and of such uncommon magnitude as that of the Mississippi, should, by any cause whatever, assume a new channel, and relinquish entirely the old or primitive one, without leaving traces *never* to be effaced. Of this, we have ample and unquestionable proof, in a number of instances, on the Mississippi river, where, at some period of time, it has cut across a neck of land, and left its original channel, which, in all probability, will never be entirely obliterated. Instance the *Fausse Riviere*, Lake Concordia, Lake St. John, Lake St. Joseph, Lake Providence, and Grand Lake, all of which were, without doubt, the ancient channels of the river, and all within the Mississippi territory.

If these are not sufficient proof, we have only to look to the ancient bed of the Nile, which runs along at the foot of the Lybian range. This channel, although deserted for some thousand years, and subjected, if not to alluvial deposites from water, to deposites of sand, that are swept in torrents from the deserts, still exhibits traces of its ancient course, and breadth.*

Mr. *Darby* has intimated, that from the number of large rivers that flow over the inclined plane from the west, into the Mississippi river, and the comparatively few and small ones that flow into it on the east, there seems to be a tendency in the Mississippi to incline more eastwardly, and to range along the eastern bluffs.†

But it is not to be inferred, from this remark, that Mr. *Darby* is of the opinion that the Mississippi river ever has, or ever will, run in a different channel: on the contrary, he observes, "The bed of the Mississippi, like that of all other rivers, is the deepest valley in the country through which it flows. Nothing can have less foundation, on principles of sound philosophy, than the common notion of the liability of the Mississippi to desert its channel. There exists no data in the country, to substantiate this opinion."‡

Hence, the conclusion is, that the immense alluvial region, and more particularly that portion of it which extends so far into the gulf, between Barataria and Atchafalaya bays, was never formed exclusively by deposites of alluvion from the waters of the Mississippi, either directly, or indirectly: for, to what has been

* See Rennell's Herodotus.

† See Darby's Louisiana, p. 42.

‡ Darby's Louisiana, p. 136.

said on the subject of that river having followed the course of either the Atchafalaya, or Lafourche, it may be added, that if it had ever run into the channel of either of those streams, it would have borne along and deposited its alluvion, beyond the adjacent shores, forming a projection into the gulf, the same, or similar to that through which the river now runs, from Fort St. Philip to the Balize. But this is not the case.

Mr. *Stoddard*, whose opinions I have already quoted, seems to consider it as having been formed of materials deposited principally by the Mississippi, and which "have been rolled from the sources of the great rivers."*

Mr. *Darby*, however, seems to entertain a very different belief, or at least, that these alluvial regions were not formed exclusively by deposites of alluvion from the Mississippi. He, who has seen and observed, perhaps, every portion of this territory, and examined, with a discriminating eye, the various phenomena that are presented to view, has ventured, unawed by popular opinion, and unbiassed by preconceived notions of physical facts, to assert an opinion more consistent with truth, though at variance with most others that have been advanced on this subject.

From a view of the existing facts, he plainly saw it was impossible that the districts on the borders of the Mississippi could have been formed alone by that river. This conclusion, however, is drawn from the following

* Stoddard's Sketches, p. 184.

remarks: "That the revolutions that have changed the very face of nature in Lower Louisiana, have not entirely been the effect of alluvion, appears almost demonstrable, from an inspection of the banks of Red river, which are intermixed with marine shells."*

Now as Lower Louisiana is here spoken of generally, it may be said that the banks of the Red river, do not strictly come within the limits of what is considered the delta of the Mississippi.

This is admitted; but in speaking of the tendency of the Mississippi river, to range along the eastern bluffs, he again observes; "But a change of bed, could never have been the sole cause of the exemption from inundation, of places that are now *twenty or thirty feet above the highest water*, that were evidently once periodically submerged."†

Moreover, in speaking of the lands in Ouachitta, Red, Teche, and other rivers, he further observes, "We may pronounce those lands to have been, to a great depth below the present surface, the product of alluvion, and that in distant and remote time, a large bay, reaching from the eastern to the western bluffs, penetrated the continent in the direction of the Mississippi. This bay has been filled above the ordinary level of the water, by accretion of soil. The *whole delta* bears evident marks of this revolution. But the slope along the western bluffs, being raised above, not only the *common level of the sea,*

* Darby's Louisiana, p. 48.

† Darby's Louisiana, page 48.

but above the influx of the tide, and the *highest annual flood*, must have acquired an addition of matter from some other store of materials, or has *been elevated by other causes*."—*Page* 102.

The existence of these facts, and the deductions which Mr. *Darby* has drawn, and which, by the by, have been but very seldom taken notice of, are too plain and palpable, to admit of the least shadow of doubt : viz. that alluvial or other lands, being above the highest tides of the sea, and the annual or semi-annual inundations of rivers, cannot owe their formation to deposites of alluvion from either. It is a circumstance by which I have endeavoured to prove, that the great alluvial region on our Atlantic coast, was never formed by the sea or rivers, and it is an argument made use of by *Baron de Tott* to prove that cape Beleros, on the coast of Egypt, was not formed by the alluvion of the Nile, as is generally supposed : and one I trust, that will stand the test of the most scrupulous investigation, without the slightest fear of weakening its validity.

Taking this fact for granted, and knowing at least from respectable authority, that lands of this description extend a very considerable distance south of the thirtieth degree of latitude, or below New Orleans, lands, over which the Mississippi has no control, and with which it has not, and, perhaps, never had any direct communication, we may reasonably ask, to what source then are we to look for the cause, by which this extensive district has been formed ?

Mr. *Darby* believing, without doubt, that it could not, as before, have been formed by the Mississippi, has suggested the following idea, "May not this revolution have drawn its causes from a change in the earth's centre? May not the time have existed, when the Canadian lakes discharged the whole or part of their column down the Mississippi?

"How very small difference in the inclination of the plane, from lake Michigan, towards the Mexican gulf, would produce the most extraordinary changes?"* &c.

Having already introduced the subject of a change of the earth's axis, in speaking of the cause of the general deluge, or Noatick flood, it is unnecessary and inexpedient to offer any remarks or opinions, on that head, in the present instance. I shall therefore proceed to observe, that having endeavoured to prove, that the great alluvial region on our Atlantic coast, and of which a large portion of the delta of the Mississippi is unquestionably a part, has been formed by the operation of currents flowing, probably, from the Arctic sea or Noth Pole, across the continent of America, I trust I may again appeal to the same source, for the cause in part of the phenomena in question, without being suspected of too great a fondness for innovation, or an undue partiality for a favourite theory.

The numerous facts that have been adduced in favour of such a revolution, and a change in the configuration

* Darby's Louisiana, page 42.

of this continent, by this cause are sufficient, it is presumed, to warrant the conclusion, that they are founded in truth and the premises correct.

Taking these for granted, no person will pretend that the alluvial regions in Lower Louisiana, and particularly on the Mississippi river, below the thirtieth degree of latitude, were exempt from the operations of this general current; on the contrary, no one, it is believed, will hesitate to admit, that this part or portion of the country, and also the whole valley of the Mississippi must have been, not only the principal theatre of its action, but most liable to the full force of its operations.

I have observed that as the waters of the deluge overran the continent, being at first confined between the great chains of mountains, the soil and earth were torn up, and transported to the borders of the sea, and deposited; that in this manner the whole alluvial region was formed. Now, if it be admitted, that any part or portion of this region was formed in this way and by this cause, it follows of course that, whether an extensive estuary once existed at the mouth of the Mississippi or not, the whole of the alluvial region from Natches,* *to the line of coast* extending direct from Pensacola bay, to the mouth of the Colorado river, must have been formed in *the same way, at the same time, and by the same means.* There is no other source

* See Mr. M'Clure's Geological chart, or Beaujours' map of America, in his Sketches of the United States.

to which we can look for the probable cause of the formation, and extension of an alluvial region so vast, and so very far above the highest tides of the sea, or the overflowings or inundations of any river.

On the strength of this supposition, I may venture to explain the manner in which, during the same revolution, the alluvion was urged forward into the gulf or bay of Mexico, thereby forming the extensive segment of a circle, lying between the meridian of Cat Island, and Grand Pass into Vermillion bay, as laid down in Mr. *Darby's* map, which, it is believed, is the most accurate of any before published.

It may be presumed, on an examination of the Mississippi river, and its numerous tributary streams, that whether the general deluge was occasioned by an incessant fall of rain for forty days, and forty nights, or from some other cause, the Mississippi river, from the commencement, must have been pre-eminently conspicuous in its operations, in forming the alluvial region on its borders, and at its confluence with the bay of Mexico, at least within the line of coast already defined. Not only so, but from the increasing strength of its current, and the amazing quantity of alluvion, suspended in, and borne away by its waters, before the continent, generally, was overrun by currents, its alluvial deposites, during this period, must have been in advance of the adjacent coast. If these facts be admitted as being possible, or probable, what may we not conclude, if the actual source of the current was that of the North Pole? In this case, as I have already remarked, the Arctic sea, defying all bounds, overran its ancient limits, and uniting its waters with those of Hudson's bay, lakes Superior, Huron, and Michigan, urged their united forces into this immense valley, the *actual channel* of which is the Mississippi river.

In such a state of things, which is, by no means, improbable, who, that is endowed even with the most transcendant energies of the human mind, can form any adequate conceptions of a scene so awfully sublime, and so tremendous in its operations? Or who, that has witnessed the effects of an incessant and copious fall of rain for twenty-four hours, will not admit that the alluvion, with which the waters were doubtless saturated, must have been propelled by such a force, beyond the limits of the adjacent coast, so as to form a projection similar to the one under consideration? But, it will be said perhaps that as the floods rose, so as to overflow the ordinary mountains, the currents of all rivers were merged in that of one vast sea, which, during its prevalence, must have deposited its alluvion on the sea coast and adjacent shores of rivers, as well as at their mouths; thereby making, with some local exceptions, one uniform line of coast.

It will readily be admitted, that there is some degree of plausibility in this remark. But it must be recollected, that the same operations that were going on in the great vallies, in the channels and at the mouths of rivers, from the commencement of the universal deluge, to the period at which continents were nearly submerged and overrun by a general current, were resumed, or, in other words, continued, *after* the waters of the flood had so far subsided, that the continents were but partially inundated, and the waters confined to great and extensive vallies, through which rivers run; and these too, by the continued draining of the lands, which had been long saturated with water; instances of which may be witnessed, on the subsidence of every spring and autumnal flood of our rivers: and also, to the disruption of the sides of deep and extensive reservoirs, formed by nature, upon elevated lands, and upon the tops of mountains, through which the waters that were collected during the flood, and left on its subsidence, rushed with overwhelming force, bearing away every moveable thing, and particularly the soil, to add to the currents of rivers already turbid with alluvion.

It is to this source that we may reasonably look for the cause by which this immense district has, at least in part, been formed and projected into the bay of Mexico, so far beyond the adjacent coasts.

In order to establish this point, it is necessary that all the existing facts and circumstances, relating to the geology and topography of this region, should be examined and brought into view. These it is difficult, nay, impossible, to have access to, being, in part, beneath the surface; and the remainder but superficially known, or if examined at all, it has not been with a view to the subject in question.

Now the difficulties under which a person must labour, who is endeavouring to elucidate a point that is involved in doubt and obscurity, without these advantages, must appear obvious to every intelligent mind. But, when the motives and the object are kept in view, it is hoped that a suitable indulgence will not be withheld.

Notwithstanding the disadvantages which have been stated, there are two facts on which, from their actual existence, and unequivocal character, I shall risk the final decision.

The first is, that lands which are higher than the overflowing or inundation of the river, or the tides of the sea, could not, as before, have been formed by either. Of such, the district in question abounds. This conclusion, however, is drawn from the remarks of Mr. *Darby*, who observes, "The following line includes all the territorial surface upon which the *sugar cane has as yet been attempted*, in the state of Louisiana. Beginning at the Rigolets, and running through Lakes Ponchartrain and Maurepas, and up the Amite and Iberville rivers to the Mississippi; thence up the latter stream, including the settlements at Point Coupee, and Fausse Riviere; thence west to Opelousas; and thence including the *Teche and Atchafalaya to their mouths; thence along the coast of the gulf of Mexico, to the place of beginning.*"

Now if the lands included within the above limits, (the superficies of which amount to more than two-thirds of the district under consideration,) are susceptible of the cultivation of the sugar cane, and particularly that portion which lies "along the coast of the gulf of Mexico," we have reason to believe, that they are above the overflowing of the tides of the sea, or the inundations of the river; consequently, they could not have been formed and elevated to their present height, exclusively by either, although much may have been done in this work, by the latter.

A circumstance that has had considerable influence in establishing a belief that the delta of the Mississippi, so called, has been formed by that river, is, that its banks, and those of almost all the subordinate streams and bayous, are highest next to the rivers, where the greatest quantity of alluvion was deposited, and thence gradually descending, as they recede from them. That the banks are higher immediately upon the river, than at a distance, is unquestionably true: But that they were formed and elevated by deposites of alluvion from the currents alone, is doubtless an errour; for we find, upon almost all rivers running through alluvial districts, or having alluvial banks, however high they may be elevated above the water, or the highest inundations, that they have always a greater or less descent from the river. This may be seen on the banks of many rivers, and which, being thirty or forty feet above low water, were never known to have been overflowed.

In order to comprehend the subject more fully, it may not be amiss to examine the process by which they are formed.

It is believed, that when a river passes beyond the limits of the coast, and discharges itself into an open bay, or sea, it becomes diffused with the general mass. As the volume or current of the river is urged forward, the waters at the two sides leave the main body of the current, and their force is slackened or checked by the resistance of the surrounding medium, and the grosser parts of the alluvion, which, till then, were held suspended, are let fall; while the finer, or alluminous parts, are still suspended and conveyed further on. By the frequent repetition, or long continuance of this process, lateral banks are elevated and extended beyond their ancient limits, until they are raised nearly to the highest point at which the tides, or water of the river ever rise.

On the subsidence of an annual inundation, or the tides, these banks are left above the water, while the grounds, at a few rods distant, where there is, perhaps, a lagoon or pond, is ten feet lower. On the succeeding annual or semi-annual inundation, the water in the river rises to the height of twelve inches above the new forming bank; flows into the adjacent pond, or lagoon, and fills it up. Now, admitting that the waters in the river were charged with alluvion, what kind of result ought we to expect, on the subsidence of the water? The answer appears obvious, that if there be ten feet of water in the pond, or lagoon, or on the grounds adjacent to the river, and only one foot on the newly formed bank, and the waters of the river alike saturated with alluvion, we ought, for every deposite of one inch on the bank, to find ten inches in the lagoon, or adjacent grounds; consequently, by a repetition of this process, for a series of years, the grounds adjacent to a river would be brought up to a perfect level with the banks, by the time that they cease to be overflowed. But is this the case? I answer no; not, perhaps, in a solitary instance. On the contrary, the banks continue to increase in height until they are elevated so far above the highest inundation as seldom, if ever to be overflowed, while the lands adjacent continue low, and are, perhaps, annually inundated.

This state of things will be found to exist on many of the rivers in America, on all the deltas of which I have taken notice, and particularly that of Egypt; of which Dr. *Shaw* has said, "For whereas the soil of other plain countries is usually of the same depth, here we find it vary in proportion to the distance from the river, being sometimes near the bank more than thirty feet high, whilst at the utmost extremity of the inundation, (viz.) at the skirts of the valley, and next to the hills, it is not the quarter part of so many inches."*

Whatever may have been the opinion of Dr. *Shaw*, respecting the fact above quoted, it may be remarked, that it is not peculiar to the banks of the Nile, nor the valley of Egypt; on the contrary, it is almost universal in all alluvial districts, on the borders of rivers, and the cause of which may be accounted for, or explained in the following very easy and rational manner, viz: by the operations of the winds, sometimes

* Shaw's Travels, page 439, for remarks on this passage, see pages 304 and 305.

assisted by the growth of vegetables: the former of which if carefully observed and particularly examined, together with the operations of currents, it may be asserted with safety, that there is not a spit, sand-bar, sand-bank, flat, or alluvial island, the formation, modification, or changes of which may not be accounted for, by the operation of one or the other of these agents, either separately or combined. This, however improbable and unimportant it may appear, is of the utmost consequence in all hydraulic researches, and particularly in military architecture, where it becomes necessary to erect fortifications on the borders of alluvial districts, or in situations liable to changes.

The process by which alluvial banks are more and more elevated by vegetation, and more especially by winds, is nearly as follows—

When a newly formed bank or banks, are elevated by successive deposites of alluvion, to the height at which the annual inundations of the waters rise, they are, on the subsidence of the waters, left exposed to the operations of the winds, which, however small the elevation may be above the water, will soon produce some change; for the wind in passing over an uniform surface, as that of a river, lake, &c. and meeting with an obstruction, is elevated in the same manner as the current of water in a rivulet, where it meets with an obstruction in its course. If the wind be so strong as to raise the sand, when it first meets the obstruction, or strikes this sand bank, it is carried over and at a little distance beyond the summit of the bank, before it is let fall, on the opposite side; because the wind in its course, not conforming to the inequality, or course of the bank, or other obstructing medium, forms, on the leeward side, a kind of eddy, into which the sand, being much heavier than air, is immediately deposited.

If the winds change in an opposite direction, the same operation is continued, until the sand is at last heaped up in a ridge of a pyramidal shape, on the top and sides of which, vegetation at length springs up, and serves to increase the obstruction, and detain the sand. Subsequently, other successive strata of alluvion are annually deposited, at the base of the bank. This is, in the same manner, afterwards hurried by the winds towards the summit, where it is, in part, detained by the growth of vegetables. Thus it continues to be elevated, while the neighbouring low grounds experience the trifling augmentation of an annual deposite of alluvion, from the waters that overflow them.

At length the violence of the current of the river, or the beating of the waves against the bank, breaks down a portion, and forms a somewhat inclined or perpendicular front, against which the winds are more directly apposed. Should they prevail with more than ordinary force or strength, or should they blow either obliquely, or at right angles across the river loaded with dust, or should they even, by their force against this upright bank, raise a torrent of dust, it is elevated into the air, and deposited more immediately on the margin of the bank next the river.

This operation is carried on upon all broken and sandy banks, from the lowest to the highest; but it may be seen and observed, to the best advantage, upon high perpendicular banks, such as prevail higher upon the Mississippi and other rivers, in the Mississippi territory.

Here the wind, in crossing the river, either obliquely or at right angles, strikes forcibly against the bank, and is immediately elevated with its dust and sand into the air; in passing over the bank, it forms an arch of about one hundred and twenty degrees of a circle, before it is brought into the general current of air, so as to sweep along the surface of the ground again. Beneath this arch, or current of air, is a kind of eddy, into which the sand and dust, that is suspended and floating over the banks, is let fall, in the same manner, as alluvion is deposited by a current, that falls into an eddy.

It is in this way and by this process, that the alluvial banks of almost all rivers, have been raised and *kept higher* than the land at a distance from the river; and it is, doubtless, to this source that we may look for the cause, in part, of the elevation of the banks of the alluvial region under consideration.

Should any doubts exist of the correctness of this view, a more satisfactory and a more beautiful illustration of the fact may be witnessed, almost every winter, by the drifting of snow; in which all the phenomena are regulated by the same laws, and governed by the same principles.

In this instance, so familiar to every person, it is well known that every object which is opposed to the winds, so as to obstruct its current, causes it to be elevated; so that in passing over the obstruction, to mingle again in the general current, this arch is formed, proportioned, as in all cases, to the velocity of the wind, the height of the opposing object, and the angle which it forms with the horizon.

Through, and beneath this arch, the snow, being specifically much heavier than air, is deposited and forms a drift. As soon as this drift or bank has risen sufficiently high to oppose the winds, a perpendicular front is soon formed, against which the wind is forcibly hurried, and being elevated into the air is swept over the drift, depositing beneath the arch, or in the eddy, and on the top of the drift, the snow that is elevated by it. In this way the drift is raised in front, and gradually descending to the level of the surrounding mass.

Waiving for the present, any further remarks on this particular part of the subject, which, though interesting in itself, may be considered a kind of digression, I shall proceed to an examination of the second fact.

Among the proofs of the operations of currents, that have overran this continent, and probably every other, the existence of fossil organick remains, at a great depth in the earth, and particularly of wood, has already been frequently mentioned in this work. It becomes necessary, however, in the present instance to bring it again into view, and in a particular manner to invite attention to it, as constituting one of the criteria, by which we are enabled to form correct notions of the changes that have taken place in almost all alluvial regions, and particularly the one under consideration.

Independently of the many places that have been pointed out, where fossil remains of wood are formed; it is mentioned by Mr. *Bartram* and Mr. *Stoddard*,* as being abundant in several places on the Mississippi river, at, and below low water, and at a great depth below the surface of the lands. These remains may be traced in many places, and to a great distance in the Mississippi valley; but in no instance, that I know of, are they to be seen *between* the lower deposite or stratum, and the surface of the earth; at least, at any place above New Orleans.

To what extent towards the mouth of the Mississippi river this stratum of fossil wood is to be found, I am unable to say; but if respectable verbal testimony may be relied on, it may be traced to a great distance below New Orleans. But whether this be true or not, it is mentioned that in a canal lately dug by the Baron *de Carondolet*, between Lake Ponchartrain and the Mississippi, "a *substratum* of black earth was discovered, mixed with the remains of trees."†

The existence of a stratum of fossil wood, in this and many other places, below low water, and in situa-

* See Bartram's Travels, and Stoddard's Sketches.

† Volney's View, page 61.

tions where, without doubt, the sea or ocean once prevailed, and where living forest trees could never have existed, leads us at once to the conclusion, that in the onset of some great revolution, these trees were torn up, and hurried beyond the ancient boundaries of the ocean, and deposited upon or near its bottom. And that, moreover, during the same revolution and by the same cause, the immense districts of alluvial grounds, that have been formed over them, and in which, no organick remains of the kind are to be seen, were also deposited.

That to whatever point or distance we find this substratum of fossil wood to extend, below New Orleans, so far, it is presumed, this district was formed and extended, by the same cause, and at the same time that the great alluvial region was formed below Natchez, extending from Long Island to the Colorado river.

These conclusions are grounded on the following facts. In the first place, there exists an almost perfect correspondence in the situation and depth of this substratum of fossil wood, wherever it has been found, throughout the alluvial region on the coast of America, as well as in other parts of the world; which is a strong proof that, in general, it was deposited at the same time.

2dly. Between the surface of the ground and this substratum of fossil wood, and within the limits just mentioned, no intermediate layer or deposite of wood, has been found, with the exception of, perhaps, a solitary limb or piece of wood. Such is the case throughout the alluvial zone, and, it is believed, a great portion of that part of the delta of the Mississippi, which projects into the gulf of Mexico.

3dly. In almost all situations, upon the borders and at the mouths of rivers, where alluvial districts are forming by annual deposites of alluvion from such river, and in which great quantities of drift wood is annually or semi-annually floated down its current, we find the deposites of organick remains, whether of trees, shrubs, or other vegetable substances, corresponding with the annual deposites of alluvion, in regular succession.

Hence the plain and only inference is, that to whatever distance below New Orleans, or south of a line drawn from Mobile bay, to the mouth of Mermentau river, this substratum of organick remains may be found to exist with a superincumbent mass of alluvion, in which there are no fossil remains of wood, and over which neither the inundations of the river nor the tides of the sea ever flow, so far it is believed this district could never have been formed by the alluvion of the Mississippi, or that of any other river.

It may have been, and doubtless, will be said that these conclusions are drawn from false premises—that the facts stated, though they exist, are by no means uniform, or general.—That fossil remains of wood are or may be found in numerous places, far above New Orleans, and in many parts of the delta, at any depth below the surface.—That during the period of the inundation, a large portion of this region is overflowed, and constantly becoming more elevated by annual deposites of alluvion, &c.

That fossil wood may be found in many places in this district, and at various depths below the surface, is by no means improbable. In speaking of deposites of fossil wood, in the early part of this work, it has been admitted that remains of wood are sometimes found in marshes, or low sunken places, at the depth of several feet below the surface: but this does not invalidate the assertion that an uniform, general, and extensive deposite of fossil wood may exist at a still greater depth, throughout the district, and, at the same time, be the result of a very different cause.

It will likewise be admitted that at certain seasons of the year, a very large proportion of this part of the country is actually inundated, and by which there is an annual increase of soil by alluvial deposites. Neither does this prove that the very districts thus annually inundated, and which are becoming more and more elevated by deposites of alluvion, may not have been formed by the operations of a current, flowing from the Arctic sea, or Hudson's bay, through the valley of the Mississippi: for it does not follow, that because they are in this age annually overflowed, they have always been thus deluged. On the contrary, it may be safely alleged, that the time has been, and that too, probably, long since the Christian Æra, when the same lands that are now annually inundated, were elevated above the overflowings of the Mississippi, and other rivers; when they were left dry, and covered with a luxuriant growth of herbage, and forest trees waving high in air. When the inhabitants, who erected the Tumuli and mounds, discovered by Mr. Darby on the Teche river, were free to roam, at large, unawed and unrestrained by the floods, that now annually flow at their bases.*

To attempt to establish these facts would necessarily lead to the discussion of points, foreign to the intentions and plan of this work; and in which no motives could induce a participation, save the wish to promote the cause of truth, and the comfort and happiness of that part of the human family, whose destiny it may be to inhabit, and improve this portion of the country, which holds out such flattering prospects, of the easy acquirement of rapid fortunes, by the rich and almost spontaneous products of its luxuriant soil.

These, it is hoped, will be a sufficient excuse for offering some reasons, for the opinions which I have advanced, more especially since in this subject, the welfare of, not only, the present, but future generations may be deeply involved.

Whether the lands that are, at this period of time, annually inundated by the overflowing of the Mississippi, were formed by deposites of alluvion from its waters, or not, is not the question in the present instance. It is whether the lands that are *now* inun-

* See Darby's Louisiana, page 117.

dated, were, at any period of time, *less so* than at present.

To determine this point, it is necessary to inquire into, and examine what was the ancient state and condition of the Mississippi river, as it respects its confluence with the bay of Mexico, and what it now is.

It is pretty well known, and generally admitted, that the ancient southern boundaries of the continent, on the Mississippi river, did not extend far below Natches. That by some revolution in the economy of the earth, a very great increase of territory has been formed, and added to the continent, extending from Natches to a line, having a bearing south westerly, and intersecting the thirtieth degree of latitude at New-Orleans, and, perhaps, much farther.

This fact being admitted, we are left to conclude that the ancient mouth of the Mississippi was at or near Natches.* That in consequence of the addition of territory, the Mississippi had to pass through an extent of country more than two degrees beyond its ancient point of discharge into the sea. Consequently through a district, having but little descent, as must appear evident from a view of the land on its borders—therefore its current must necessarily have been retarded in proportion to the diminution of slope in the in-

* In order to comprehend this fact, it is necessary to consult the map of the United States, in which the alluvial zone and other formations are clearly laid down.

clined plane, and distance which it had to run, and also the resistance of the tides in the gulf of Mexico.

These were, doubtless, considerable; but when we consider that the Mississippi river was then confined within high banks, and propelled by the same irresistible force into the ocean, and over a distance much less than at present; need we hesitate to say, that the lands on the western borders of what is called the delta of the Mississippi were not only previously formed, but seldom overflowed, and that not until the inundations of the river had arrived to its greatest height? I presume not. If, however, it is contended that the waters in the Mississippi have probably been always the same in quantity, and that, consequently, it has always risen to the same height, attended by the same results, as respects the inundation of the neighbouring districts; let us examine a little farther, and compare the present state of things with the past, in order to see whether this opinion will bear the test of a plain and impartial investigation.

Let us suppose that the Misissippi river, instead of discharging its waters at a point corresponding with the general line of sea coast, as at New Orleans, was by the formation and extension of alluvial grounds, conveyed so far beyond its ancient limits as to discharge itself at some indefinite point, on a line from Black Lake to Bastien bay, which is distant from New Orleans forty miles, in a direct line.

Now as there is not the least possible doubt, that the sea once flowed at New Orleans, and that the Mississippi once discharged itself at that point, it follows, since it is sufficiently evident that the sea has not diminished in height, that the Mississippi must, in every inch of that distance have urged its way through or in opposition to the ocean or bay of Mexico, through which distance, being upon the level with the waters in the gulf, there is not the least possible descent. This is not all: the tides it is well known, do actually rise so as to check the current in the Atchafalaya river, as far up as the great raft* which lies west of, and is on the same parrallel of latitude, as New Orleans. It is equally well known that the tides likewise rise in Lake Borgne, Lake Ponchartrain, and even in the river Iberville, all of which are on the east, *and north* of New Orleans.†

This being the case, will any one pretend that the tides, but for the current of the Mississippi, would not rise above New Orleans? I presume not. Consequently, in addition to the diminished slope in the inclined plane, or want of descent, the resistance of the waters of the bay of Mexico in their natural state and elevation, and against which this river has to force its way; is also the resistance of the tides through an extent of more than ninety miles.

It will, doubtless, be said that the force of the current of the Mississippi is such, that the tides do not exercise any power or influence over it, so far at least, as to occasion any difference in its velocity; and this,

* Darby's Louisiana, page 73. † Do. Do. page 131.

perhaps, because Mr. *Stoddard* has said, "The tides have little effect on the water at New-Orleans; they sometimes *cause it to swell*, but never to slacken its current."*

But does it follow that the current is not checked at the distance of twenty, or even ten miles below, because it does not appear to be slackened at New-Orleans? I must reply, by no means. It is, at times, and under certain circumstances, materially slackened at the distance of twenty miles below that city, and doubtless from the causes which I have mentioned; and if checked at that distance, it must necessarily be proportionately so at New-Orleans. That this is the fact, is obviously implied by the remark, which I have just quoted, viz: "They (the tides) sometimes cause it to swell."

If then the tides cause the river or current to swell at New-Orleans, can a proof more positive be required, that it is at the same time slackened? I answer no. If nevertheless it be still doubted, what shall we say to the following, "Heavy winds," says Mr. *Stoddard*, "roll in the water from the gulf, and cause sudden rises of the river, in some instances, *equal to a spring freshet*."†

In this instance, can it be supposed, that the water of the bay of Mexico is actually driven by the winds up to New-Orleans, so as to occasion the elevation of the current of the Misssissippi? No one, it is presumed, will answer in the affirmative.

* Stoddard's Sketches, page 164. † Do. page 164.

The fact is, the long continued or high southern or south eastern winds, cause the tides to rise so high, as to impede the discharge of the waters of the Mississippi into the gulf, consequently a reflux, which is "in some instances equal to a spring freshet." Will any one hesitate to admit, that, in this instance, the current of this river was checked, retarded, or slackened? and if in this instance, does it not follow, that it is proportionately slackened in the common tides, that cause the river at New-Orleans, to swell? I answer, yes.

From this view it appears, in the first place, evident, that when the Mississippi river discharged its waters at the original or primitive point, where there was a natural slope, and no obstruction to its current, the lands in its neighbourhood were but slightly and seldom overflowed. Thus, when the lands on its borders and its banks, through which it runs, were, by some cause, projected into the gulf, to the distance of forty miles south of New-Orleans, the resistance which I have mentioned was such as to cause a reflux, particularly, during the spring freshets; and such as to occasion an inundation of the lands adjacent.

If then the prolongation of the Mississippi into the gulf of Mexico, to the distance of forty miles, will produce this change, what may we not expect, when we find it extended into the gulf to the distance of fifty miles farther, or about ninety miles, in a right line, from New-Orleans to the extremity of the land at the south pass? Need we be surprised that, under certain circumstances, the winds should "roll in the water from the gulf, and cause sudden rises of the river, in some instances, equal to a spring freshet." Need we, or can we hesitate to admit, that the lands adjacent to the Mississippi which, at some remote period of time, were exempt from the overflowings of that river, should, under present circumstances, be annually inundated? Let us extend our views of the subject, and for a moment contemplate the scene, which must occasionally be extended over nearly the entire surface of this immense district.

I have hitherto only taken into consideration, the probable results arising or growing out of the changes in the Mississippi. It becomes necessary to bring into view, some of the subordinate streams, that have a material bearing and influence in this business, and which flow through this part of the country.

The Lafourche, Atchafalaya, and Teche rivers, have each experienced, from some cause, a considerable extension or prolongation into the gulf, as well as the Mississippi; and each of them from their sluggish movements, together with the Sabine, Calcasa, Mermentau, and Vermillion rivers, are subject, from the operations of strong southerly gales, to a re-flux proportionate to that of the Mississippi.

When the currents of all these rivers experience this check, and that of the Mississippi, from the same cause, and at the same time, is thrown back, so as to equal a spring freshet, what can we expect but an inundation of the country to a great distance? And, moreover, if this should occur at the time of the annual inundation, or spring freshets, need we wonder that great and important changes should be going on,* in many parts of this territory, by the annual operations of conflicting currents? That lands, which at some distant and unknown period of time, were, probably, inhabited, and on which mounds or tumuli have been erected, should experience such a change, that "Not even a village of savages could have existed throughout the year, within several miles of this place."

"The spot where they (the tumuli) are situated, is more dreary *and sunken* than any part of the swamp."†

Need we hesitate to admit that, under such circumstances, alluvial deposites should be yearly accumulating upon lands, previously formed and once, probably, exempt even from partial inundations by water; and where the stately oak and lofty cypress were at liberty to shoot up, and arrive at maturity, undisturbed and uninjured by the inroads of that element; but whose naked trunks are now standing leafless and dead, surrounded by water in the midst of lagoons?‡

It appears that in this case no one can long remain in suspense, or, for a moment, cherish a single doubt.

It is this view of the subject that led to the remark, that in it the welfare and happiness of, not only the present, but future generations are deeply involved.

A few observations illustrative of this fact, although not strictly connected with the general views of this

* Darby's Louisiana. † Do. p. 118. ‡ Do. p. 31.

work, will not, it is hoped, be considered unseasonable or inexpedient.

In attempting this, it is not intended to bring into view all the circumstances, that are connected with the subject, as it would unavoidably increase the number of pages, which has already exceeded the limits prescribed.

From what has been said, it must appear obvious, that the Mississippi river, has, at different epochs, discharged its waters into the gulf of Mexico, at different points in its course, as at New-Orleans, &c. but principally, and more probably, not far from the head of Black Lake, or about fifty miles above the efflux of that river at the Balize. From this point, at least, to its present termination, it may be said to flow through a self-created channel.

The consequences resulting from this extension of the banks into the gulf, have already been taken notice of; but as these results do not depend, exclusively upon the prolongation of the river, and its banks, it is necessary to examine another circumstance, intimately connected with the subject, and by no means of the least importance.

I have observed, that as the banks of a river are extended into a bay or gulf, beyond its *original* point of discharge, either by artificial means, or by deposites of alluvion, its current is checked or retarded in proportion to the distance, which it has to pass beyond tide water, or the level of the bay or gulf, *and the alluvion which was suspended by the current, is deposited at* *the bottom.* By this process, the bed or channel of the river becomes more and more elevated, until there is no longer any descent, and the capacity of the channel is insufficient to retain its waters. Hence, in common tides, a considerable reflux: but in violent storms, or gales of wind, a reflux that overflows the surrounding country, causing disruptions of its banks at some point or points, that will afford a descent of its waters into the sea.

This has been, and will continue to be universally the case with all rivers, whose point of discharge has been extended into a bay, or gulf, beyond that of their original or primitive efflux.

This has been one of the principal agents in the formation and extension of the deltas of the Po, the Indus, the Ganges, and the Nile; and also in the frequent disruptions of their banks, thereby forming low sunken places, or lagoons of stagnant waters, the never-failing sources of pestilence and disease, among the innocent and unsuspecting inhabitants who may be situated within reach of their poisonous exhalations.

It was by this cause that the bed of the Nile was elevated so far above the adjacent vallies, that it became necessary to attend with the greatest diligence, to preserve the banks in repair, lest, by the force of the waters, a breach should be made, and the whole country be inundated.* And it is this which may be said to be in full operation, at this time, on the Mississippi, at

* See remarks on the delta of the Po, Indus, and Nile, chap. 13.

least from Fort St. Philip to the Balize, above which it has already laid the foundation for, and actually formed the first delta that, in all probability, ever divided the current of that river.

When it is considered that all the lands on the border of the Mississippi, below Baton Rouge, are called the delta, this assertion may be viewed as a strange dereliction from truth, and in direct opposition to the general opinion of, what is considered, an established fact.

A careful examination, it is believed, will, nevertheless, convince any one, that however strange it may appear, it is not without some foundation; and for the following reasons:

Agreeable to Mr. *Darby's* map, there is not a point from New Orleans to Fort St. Philip, where there are manifest indications of an actual delta, formed by a separation or division of the current of the river. On the contrary, there are a number of places by which it can be proved, that such a thing never could take place without producing a state of things very different from the present.

But these I shall not, at this time, attempt to discuss; but content myself with a view of the distance from Fort St. Philip to the head of the present delta.

From this Fort to the point of the delta, the distance is about twenty-five miles, in a right line. Through this extent, the whole current of the Mississippi river passes between two banks of land, the mean breadth of which, inclusive, is only six miles. This being the case, can any person suppose that if the current of the river had ever been divided, so as to form a delta, at any point between New-Orleans and Fort St. Philip, that branches of it would not now exist at Plaquemine bend, or Fort St. Philip, through Bayou Madrigas on the east, and Bayou Liard on the west? Can any person believe, that if the river had ever been divided at this point, or at any other between it and the efflux of the river, that it would not have produced the same or similar effects, that it has at the different branches that are now formed; where, instead of a strip of land twenty-five miles in length, with a mean breadth of only six, the extreme points of land at the east and west branches, which form the base of a triangle, the apex of which is the point of the delta, are distant forty-two miles?—I can scarce believe an answer necessary.

Hence, when we find that the currents of the rivers Po, the Indus, the Ganges, and particularly the Nile, may be said to have disputed every foot of ground with the deltas, and in which they have been driven before them, as with the Nile, where the delta has retreated from Memphis to the distance of many leagues below; the conclusion is, that the present is the first and only delta formed by the Mississippi river.

This opinion, however novel and highly improbable it may seem, will appear much less doubtful, when we examine some of the prominent features peculiar to this river, and on which many of the existing phenomena of that region materially depend.

The most important and only one, that I shall bring into view in the present instance, is that of its current.

It is well known, or at least generally believed, that in point of magnitude, in all respects, the river Mississippi has not its equal upon this globe. That in no one, (the St. Lawrence excepted,) is there an equal quantity of water discharged into the ocean, in the same given time.

Hence, from the amazing torrent that is, in ceaseless motion, poured into the gulf, and this urged on or propelled by an almost equal volume of water, that is, descending an inclined plane of three thousand miles in extent, and accelerated too by numerous auxiliary branches, some of which are nearly of an equal length, it has for ages literally forced its way in defiance of the waters of the gulf and the tides of the sea, to the head of the present delta, without having experienced a check sufficient to cause the depositing of its alluvion, and the elevation of the bed of the river to a height sufficiently great, to occasion the overflowing of the river and lateral branches.

Here, as if jealous of her rights, the parent ocean opposed its bold career, and turned aside its force. The consequences have been the formation of deltas, that are annually increasing and extending, and which will, one day, prove a source of evils more to be feared by the inhabitants of these fertile regions, than those which may flow from any other earthly source.

Few, perhaps, are disposed to view the subject in this light. It has, nevertheless, excited the well-grounded apprehensions of many—and to it the attention of the community at large, at least, in that portion of the country, has been called by the observations and remarks of Mr. *Darby*. But whether his judicious opinions and well-meaning efforts, will have the effect, of exciting the spirit, and calling into action the exertions of the people of that country, to avert the evils with which they may be threatened—or whether the plan which he has suggested is the most eligible, or most likely to prove effectual, (for pretty certain it is, that the thing is practicable, and the means extremely obvious ;) or even, whether it is the duty exclusively incumbent upon them, without any aid or assistance from the General Government, who must have, see, and feel, an interest in the *security*, welfare and prosperity of that country, or not, would betray an inexcusable presumption in me to declare.

This much, however, I may venture to assert, without infringing, I trust, the least important rules of propriety ; that if the subject be not seasonably and effectually attended to by either one or the other ; the inhabitants of the districts on the borders of the Mississippi, will, if not in the present, at least in future generations, experience the visitations of an enemy more fearful in its consequences, and more to be dreaded, than the sanguinary hordes of a Packenham—An enemy that, in the midst of plenty, cheerfulness and comfort, will lay waste both towns and cities, and spread desolation through the land ; and which the united forces of the country, aided by the hardy veterans of Tennessee, with the victorious Hero of Orleans at their head, can never repel or subdue.

AGENDA.

As facts are essentially important in all researches instituted for the promotion of science; the following AGENDA, OR SELECTION OF QUERIES, is respectfully recommended to the attention of Geologists, Mineralogists, and other persons of correct observation, as being intimately connected with the subjects contained in this work, and calculated to aid and assist in all future researches of a similar kind.

OF MOUNTAINS.

1st. What is their mean height, and what their course or direction?

2d. Is one side of a range of mountains, or hills, more abrupt, steep, and broken, than the other? If so, which side is it, "and to what point of the compass is it opposed?"*

* Question by the London Geological Society.

3d. If a steep and craggy appearance present itself on one side of a mountain, does it face an extensive valley through which runs a river, large or small? If so, what is the direction of its current, and the greatest height to which such river has been known to rise, from rains, melting of snows, &c.?

4th. If such river exist, is its *general* course through the middle of the valley, or does it run any distance near the foot of the mountain?

5th. If a river pass either obliquely or at right angles through the mountain, where rocks are presented to view, to any considerable height above the water, are there any appearances of the operations of currents upon the rocks, above the greatest height that such river has been known to rise? If so, what appears to have been the direction of such currents? This may be easily determined by the following remarks;

1st. The parts, or points of rocks, against which the currents were opposed, will present a smoother surface and more worn than the side which looks down the stream, or against which the current was not opposed.

2dly. Pot-like holes, formed in the rocks by the operation of currents, are often observable in situations far above the present level of any streams in their vicinity. A careful examination of these, will enable the observer to determine the course of the current by which they were formed—and by the following marks:—The side over which the current flows into the hole, is generally shelving under, on the up-stream side. This is occasioned in the following manner: When the current is propelled into the pot-like hole, the pebbles which are already within it, are driven with considerable force against the up-stream side. If they occasionally fall into the current, when it strikes against the lower or down-stream side, they are forcibly thrown back again, and thus kept playing against the upper side, by which means the hole becomes shelving under. Lastly, the sand and pebbles that are occasionally driven out, produce, by abrasion upon the down-stream side, an ewer-like process or gutter, which is very perceptible in many of them.

6th. If there are any appearances of a part or portion of the side of a mountain having slidden down to its base, what appears to have been the most probable cause of its removal? and what its *original* height above the mountain's base?—And moreover, is there any narrow, but extensive valley or channel through subordinate hills, and through which a current may have run, directed against a point where such portion of earth, or rocks, have slidden off? If so, what is its breadth, extent, and direction, in relation to the ridge, or range of the mountain?

7th. Are there any vallies, or gaps, that intersect a range of mountains, either strait or circuitous? and what is the greatest probable height of the highest point in such valley or gap, above the mountain's base?

8th. Are there any appearances of the operations of currents in such vallies, either in the earth or upon the rocks that may be exposed; and above the height at which the streams that at present flow in them? If so, at what height above the bottom of the vallies do they run, and what appears to have been the direction of such current?

9th. Are there any considerable quantities of alluvial grounds, where the waters of such vallies are discharged into the vallies adjacent to the mountains? and have they increased materially within the memory of man? If so, what is their extent, and probable increase, annually?

10th. Are there to be found on the tops or sides of mountains, composed principally of granite, or primitive limestone, detached masses of transition, or secondary rocks, out of place? If so, on which side of the mountain are they found, and at what height above its base ? And also, of what size, description, or character, are such masses; at what distance are such rocks found in place, and in what direction from the masses so found?

The same remarks are applicable to mountains, the rocks of which are of a different order, (viz.)

11th. Are there to be found on transition mountains, masses of secondary rocks? on which side, and at what height? At what distance, and in what direction, are rocks of the same kind found in place?

12th. On a range of mountains of secondary formation, are there to be found masses of primitive rocks such as granite, or those of transition? &c. &c.

OF EXTENSIVE, BROAD, OR NARROW VALLIES, OR INTERVALS.

1st. Are they *generally* level, or broken and interrupted? If of the former kind, do they appear to be composed in any degree of alluvion? This may be determined by several means. 1st. By the nature of the soil, being either of sand, or gravel, and differing materially from that at the bases, and on the sides of adjacent mountains. 2dly. By ditching, canaling, sinking wells and other works, by which the structure and character of the earth beneath the surface is exposed to view. If composed of alternate layers of sand, clay, and pebbles, in horizontal, inclined, or undulating strata, with occasional deposites of fossil wood, or organick remains, it may reasonably be considered as alluvial. If on the contrary, it is of an uniform texture, and presenting none of the above marks, it may be considered as not having been disturbed, and as original.

2d. If the earth, thus exposed, appears stratafied and horizontal, what is the order in which they occur, and to what depth has this appearance been known to extend?

3d. If the strata are inclined and undulating, or wave-like, what is the dip or inclination of such strata, and what the *general* direction of their dip?

4th. If pebbles occur in such strata, are they in nids, or nests like, or uniformly distributed to any considerable extent? Are they rolled, or rounded, and of what size?

5th. Are they uniformly of one kind in substance, or different; and what are the kinds?

6th. Are there rocks of a similar substance, in place, at any distance from them, and what is the distance and direction?

7th. If the vallies are broken and interrupted, is it by spurs of mountains, ridges of rocks, or isolated hills, composed in a greater or less degree of pebbles?

8th. If of spurs of mountains extending to any distance into the valley, are there any appearances on either side, of the operations of currents which may have been opposed to, or set against them? If so, what are the appearances, and on which side of the spurs in relation to the compass, are they?

9th. If interrupted by ridges of rocks, of what kind are they, and in what direction do they run in relation to the valley, and do they discover any marks of abrasion by the operation of running water, &c.?

10th. If interrupted by isolated hills, composed mostly, or in part, of rolled pebbles, what is their character, and are there rocks of the same substance in place, in any direction from such collection of pebbles? If so, what is the direction from such hills, and at what distance?

11th. If such accumulation of pebbles are to be found in a valley, are there any deep and extensive ravines, vallies, or gaps, in the neighbouring mountains, or hills, through which a violent current may have ran, and by which such pebbles may have been transported to some distance in the low grounds, where they are found? If so, in what direction are the vallies from the pebbles thus collected, and at what distance?

11th. If it is reasonable to suppose that the pebbles so collected, may have been transported from the mountains by a current, or currents, *and they are thrown up into hills,* or small eminences; it is a fair conclusion, that the currents by which they were transported, were checked or opposed in their course, by opposite or lateral currents from other directions. To determine this, it is necessary to examine whether there are any deep vallies or gaps, through the mountains or hills, on the opposite side of the valley, where such pebbles are found, and through which currents may have flowed in a direction opposite to the first.

This fact may be often observed in the high and sudden rise of waters, by heavy rains, melting of snows, &c. In order, however, to obtain an accurate view, and correct information on this point, it is necessary to examine the subject from an elevated situation; as on the side or top of a mountain, from which the eye can take in at one view, all the narrowings and widenings of the great valley; the sinuosities of the mountains; and the cross cuts or gaps of the mountains, that open into the great valley or vallies.

12th. If from such a view, there should be found vallies, or gaps, through the opposite range of mountains, what is their breadth, extent, course, and direction, in relation to the accumulated masses of pebbles, or other substances differing from the common earth?

13th. If transverse vallies occur (so called by *Saussure,* in contradistinction to longitudinal vallies, which are such as have an extensive range between two parallel ridges or mountains,) are there any appearances of the operations of currents from the lateral vallies; such as hillocks of sand, pebbles, boulders, or rocks, at or near the junction of the transverse with the longitudinal valley? If so, in what direction do the transverse vallies run, and on which hand do the deposites appear; whether on the right or left?

14th. "If the lateral valleys, which terminate at a principal valley, as the branches of a tree at its trunk, correspond or not; or, in other words, whether the branches of that trunk are opposite or alternate?"—*Saussure.*

"The answers to these two questions are very important, for the solution of this question: whether the valleys have been excavated by currents of the sea?" —*Saussure.*

15th. If a valley, on one side of a range of mountains, appears to be underlayed with rocks, primitive or secondary; stratified or unstratified; horizontal or inclined, are the rocks, if any, in the valley on the opposite side of the mountain or range, of the same kind, and arranged in the same order, so as to afford any reason to believe that they underlay the mountain? This is a question of no small importance to the geologist.

16th. If a valley occurs, of great or small extent, surrounded by hills or mountains, is there reason to believe that it was ever a lake? If so, what are the reasons?

17th. If it is supposed that in such a situation, a lake ever existed, what are the most probable means by which it was filled up?

18th. Is there one, or more, natural openings through the surrounding hills or mountains, at a small elevation above the present level of the valley? If so, of what description are those openings, and in what direction in relation to such valley?

19th. If there are no openings of the above description, are there any appearances of a disruption of the hills or mountains, that surround such valley? If so, what are the appearances, and on which side, or sides of the valley are they?

20th. If there are appearances of a disruption of the hills &c. by water, (which must be supposed, if the lake was filled up with alluvion,) what is the most probable cause of its having been put in operation?

21st. Are there any appearances of a neighbouring valley, which may have, likewise, been a lake, and at a higher elevation than the first? If so, what are the appearances?

22d. In this valley, where a lake is supposed to have existed, are there any detached masses of rocks, either rounded or angular, buried in the earth, mixed with the soil, or distributed over the surface of the ground? If so, of what description are they, and in *what direction*, and at *what distance*, are rocks of the same kind found in place?

23d. In digging into the earth in such a situation, are there to be found organick remains of vegetables; or those of animals, either land or æquatick?

24th. If of vegetables, or fossil wood, of what description are they?

25th. If of land animals, are they of a species that are indigenous, foreign, or of such as are extinct?

26th. If of æquatick, are there analogous to be found living? If so, where are they to be found, and of what kinds are they?

27th. Are such remains found only at a certain depth? or are they distributed generally through the alluvial mass? If the former, at what depth are they found?

28th. In a situation where it is supposed, a lake once existed, is the surface of the valley generally level? or is there a gradual descent from one side, or end, to the other? If the latter, in what direction is the descent?

29th. What is the probable height of such a valley, or valleys, above the level of the ocean?

OF RIVERS.

1st. "What is the extent of their course, and their inclination from their sources to their mouth."—(*Saussure.*) Do they discharge their waters immediately into the sea, or bay; or into a gulf, or arm of a bay?

2d. Is the country through which they run, generally mountainous or hilly? or is it low and flat?

3d. What is the mean rate at which the current generally flows?

4th. What is the highest rate at which the current of a river flows, in any part of its course, for any considerable distance, during, or at nearly low water?

5th. Is the water of a river or rivers, clear and transparent to any considerable depth, during the winter and summer months?

6th. If the current of a river is rapid, for any distance, in those seasons, does there appear to be any alluvion mixed with the water; or sand moving upon the bottom?

7th. If the course of a river is between two ranges of mountains, with extensive meadows, or intervales on its borders, are they rocky or alluvial?

8th. If alluvial, what is the mean height of the banks?

9th. Are they steep and broken, or gradually descending towards the water?

10th. If high and broken, what are the appearances which they present?

11th. Are there any appearances of fossil wood, or other organick remains to be seen in the banks, and of what kind are they?

12th. If in such banks organick remains are to be seen, are they *at, or below low water mark,* or gradually distributed in the earth from the water to the top of the banks?

On many large rivers, and, in some instances, on smaller ones, there are two and sometimes three alluvial banks on each side, except where the river passes through a mountainous district. On this important subject, it may not be amiss to offer a few remarks previous to proposing any interrogatories.

The lands immediately bordering upon a river, and which form the first bank on each side, are generally considered as the intervales or meadows, and, if alluvial, have generally a gradual descent from the river for a half a mile, and from that to two miles or more, where there commences another bank or range of hills, likewise of alluvion, from twenty to sixty feet or more in height. This second tract of country or land, generally extends to the foot of the mountains, and varies in breadth from one to several miles.

These two, and sometimes three banks or tiers of alluvial land, have been distinctly mentioned by several travellers, as occurring on many rivers; but no particular description has hitherto been given of them, that I can find, neither have any remarks been offered that are calculated to make us acquainted with their history, or the cause of their formation. In a geological point of view, they are extremely interesting and important; so much so that, on a careful examination of the order of their arrangement, in relation to the river on which they lie, and the adjacent mountains or hills, and their internal structure, no one will hesitate to admit, that they distinctly point to *two important epochs* or events, that have taken place upon this globe, and by which they were probably formed. It is from this view, that I am induced to invite the attention of the naturalist more particularly to them, and to propose the following questions for his observance.

13th. Whenever two or three alluvial banks, of the above description occur, what is the course of the river through the entire extent of such district?

I mention "such district," because in some cases, a spur of a mountain, or ridge of rocks, crosses a valley, breaks off at a river, and interrupts the extension of those alluvial banks, and also occasions a bend or difference in the course of the river, below which the alluvial banks occur again, &c.

14th. What is the mean breadth of the first intervales, or alluvial banks next to the river, and what their height?

15th. What is the mean height and breadth of the second alluvial banks, on each side of the river?

16th. Do they ascend or descend towards the mountains or hills?

17th. Of what do those districts appear to be composed, at a small depth below the surface, and to the greatest depth to which they have been explored?

18th. Of the component parts, which is the most predominant; sand or clay, &c.?

19th. Do springs of water occur, at the foot of the second alluvial banks *generally?*

20th. Have mineral springs been known to occur in those districts, and what are their properties?

21st. Are they resorted to as such, and are they perpetual?

22d. In digging for wells, and other purposes, in the second alluvial plain, has an instance occurred in which it has been carried *below the level* of the lower, or first intervale on the river? If so, what were the appearances?

23d. Were there any appearances of fossil wood, or other organick remains to be seen, *particularly* on a level with the first bank or alluvial district?

24th. Are there to be found in the earth upon the second plain, irregular masses or boulders of rocks, out of place?

25th. If so, are they exclusively confined to the upper plain, or are they alike distributed in the earth, both in the first as well as second bank?

26th. Of what description are they, and in what direction, and at what distance are rocks of the same kind found *in place?*

27th. Have beds of salt or fresh water shells, or shell-marle, been found in either of those banks? If so, which bank is it, and of which kind of shells, and at what depth are they found?

28th. Are there rocks, shells, &c. to be found in the alluvial banks on both sides of a river, or only on one side? If the latter, which side is it?

29th. Are the alluvial banks or intervales on one side of a river, generally *of a greater breadth than those on the opposite side?* If so, on which side do those of the greatest breadth lie, and what is the difference from those on the opposite side?

30th. If a river has a southerly course, from any point, between north west and north east, and after running through a mountainous or rocky district, enters upon a district entirely alluvial, are there to be found in the latter district, masses of rocks and rolled pebbles of the same description as those through which the river passes above? If so, how far do they extend in the ålluvial soil?

31st. Are the pebbles uniformly distributed through the soil, on both sides of a river, or are they more abundant on one side than the other?

32d. If, as before, a small river has a southerly course, through a rocky district of country, and in its descent, receives an auxiliary branch from an easterly direction, are not rolled pebbles more abundant, in the south and west bank of the principal stream, in the direction of the auxiliary branch?

33d. Wherever rolled pebbles prevail on the borders of rivers, creeks, &c.; are they not found in greater quantities on the banks on the south side, than in those on the north?

34th. Wherever pebbles are found, as above, do they not diminish in size, as we recede from the river or creek?

35th. Where auxiliary branches pass through a rocky district, and discharge their waters into a river on the east, or north and east side, are rolled pebbles found at their mouths in greater quantities than elsewhere? If so, are there like quantities found at the mouths of auxiliary branches, running through similar districts, and discharging themselves on the west, or north west side of a river?

36th. If a river has a southerly course, and an auxiliary branch falls into it on the west side, on which side of the branch are the alluvial banks the highest? and *in particular*, where there are two alluvial banks.

37th. If a river discharges itself into the sea, how high does the tide of the latter rise at that place?

38th. At what rate does the tide, at half flood, flow up the river, and to what extent does it check the current of the river?

39th. If there are deltas at the mouths of rivers, what are their lengths, breadths, and heights, above the level of the sea?

40th. Are they ever generally or partially overflown by the tides of the sea, or freshes of the rivers?

41st. What are the appearances of their banks?

42d. To what extent have they been known to increase, within the longest known period?

43d. Are they covered with forest trees? If so, of what kind and size are they, and how near do they approach the sea?

44th. Are there any sandy districts or deserts in the vicinity of such deltas? If so, how are they situated, and what are their lengths, breadths, &c.?

OF ALLUVIAL DISTRICTS AND PLAINS, WHETHER INCLINED, ON THE MARGIN OF LAKES, OR ON THE BORDERS OF THE OCEAN.

1st. "What their shape and extent, with the nature, height, and general appearance of the hills or mountains, by which they may be bounded." (*London Geological Society.*

2d. "The degree and direction of the inclination or slope?" (*Ibid.*)

3d. If plains, or alluvial districts, occur on the margin of a lake or lakes, on which side are they, and are their corresponding plains or districts on the opposite side, or in any other direction on the borders of the lake?

4th. If wells, canals, or other excavations, have been made in such districts, to what depth have they been carried, and what are the appearances that are presented to view?

5th. Are fossil trees found in digging in such districts?

6th. If so, at what depth below the surface do they occur, and are they found only at a certain depth, or occasionally distributed from the surface to the bottom of a well, canal, &c.?

7th. If trees are thus found in the earth, do they appear to be thrown together promiscuously; or do the tops appear to lie in one direction, as is the case at Yule, in Yorkshire, England?

8th. Are organick remains of animals found in such situations? If so, at what depth, and of what kind are they?

9th. Are there found, beneath the surface, in such districts, rolled or angular masses of rocks? If so, in what direction, and at what distance, does the same kind occur in place?

10th. Is it reasonable to suppose, that such districts could have been formed by the operations of any river that at present flows, or may have flown, in the vicinity of such districts? If so, what must have been its course?

THE END.

388

Storage