CHAPTER XXV.

Earthquakes of the eighteenth century, *continued*—Java, 1772—Truncation of a lofty cone—Caucasus, 1772—Java, 1771—Colombia, 1766—Chili, 1760—Azores, 1757—Lisbon, 1755—Sinking down of the quay to the depth of six hundred feet—Shocks felt throughout Europe, Northern Africa, and the West Indies—Great wave—Shocks felt at sea—St. Domingo, 1751—Conception Bay, 1750—Permanent elevation of the bed of the sea to the height of twenty-four feet—Peru, 1746—Kamtschatka, 1737—Martinique, 1727—Iceland, 1725—Teneriffe, 1706—Java, 1699—Landslips obstruct the Batavian and Tangaran rivers—Quito, 1698—Sicily, 1693—Subsidence of land—Moluccas, 1693—Jamaica, 1692—Large tracts engulphed—Portion of Port Royal sunk from twenty to fifty feet under water—The Blue Mountains shattered—Reflections on the amount of change in the last one hundred and forty years—Proofs of elevation and subsidence of land on the coast of the Bay of Baiæ—Evidence of the same afforded by the present state of the Temple of Serapis.

In the preceding chapters we have considered a small part of those earthquakes only which have occurred during the last fifty years, of which accurate and authentic descriptions happen to have been recorded. We shall next proceed to examine some of earlier date, respecting which information of geological interest has been obtained.

Java, 1772.—In the year 1772, Papandayang, formerly one of the loftiest volcanos in the island of Java, was in eruption. Before all the inhabitants on the declivities of the mountain could save themselves by flight, the ground began to give way, and a great part of the volcano fell in and disappeared. It is estimated that an extent of ground of the mountain itself and its immediate environs fifteen miles long and full six broad, was by this commotion swallowed up in the bowels of the earth. Forty villages were destroyed, some being engulphed and some covered by the substances thrown out on this occasion, and two thousand nine hundred and fifty-seven of the inhabitants perished. A proportionate number of cattle were also killed,

and most of the plantations of cotton, indigo, and coffee in the adjacent districts were buried under the volcanic matter. This catastrophe appears to have resembled, although on a grander scale, that of the ancient Vesuvius in the year 79. The cone was reduced in height from nine thousand to about five thousand feet, and, as vapours still escape from the crater on its summit, a new cone may one day rise out of the ruins of the ancient mountain, as the modern Vesuvius has risen from the remains of Somma*.

Caucasus, 1772.—About the year 1772, an earthquake convulsed the ground in the province of Beshtau, in the Caucasus, so that part of the hill Metshuka sunk into an abyss†.

Java, 1771.—By an earthquake in the year 1771, several tracts of ground were upraised in Java, and a new bank made its appearance opposite the mouth of the river of Batavia‡.

Colombia, 1766.—On the 21st of October, 1766, the ground was agitated at once at Cumana, at Caraccas, at Maracaybo, and on the banks of the rivers Casanare, the Meta, the Orinoco, and the Ventuario. These districts were much fissured, and great fallings in of the earth took place in the mountain Paurari; Trinidad was violently shaken. A small island in the Orinoco, near the rock Aravacoto, sunk down and disappeared§. At the same time the ground was raised in the sea near Cariaco, where the Point Del Gardo was enlarged. A rock also rose up in the river Guarapica, near the village of Maturin‖. The shocks continued in Colombia hourly for fourteen months.

Chili, 1760.—In 1760, the volcano Peteroa, in Chili, was in eruption, and formed a new crater. A fissure, several miles in

* Dr. Horsfield, Batav. Trans., vol. viii., p. 26. Dr. H. informs me that he has seen this truncated mountain, and though he did not ascend it, he has conversed with those who have examined it. Raffles's account (History of Java, vol. i.) is derived from Horsfield.

† Pallas's Travels in Southern Russia.

‡ Raffles's History of Java, vol. ii., p. 232.

§ Humboldt's Personal Narrative, vol. iv., p. 45, and Saggio di Storia Americana, vol. ii., p. 6.

‖ Humboldt, Voy. Relat. Hist., part i., p. 307, and part ii., p. 23.

length, opened in a neighbouring hill, and a great landslip obstructed the river Lontue for ten days, giving rise to a considerable lake.

Azores, 1757.—In the year 1757, the island of St. George was struck by an earthquake, and eighteen small islets rose at the distance of about two hundred yards from the shore. These may possibly have been produced by a submarine eruption.

Lisbon, 1755.—In no part of the volcanic region of southern Europe has so tremendous an earthquake occurred in modern times as that which began on the 1st of November, 1755, at Lisbon. A sound of thunder was heard under ground, and immediately afterwards a violent shock threw down the greater part of that city. In the course of about six minutes, sixty thousand persons perished. The sea first retired and laid the bar dry; it then rolled in, rising fifty feet or more above its ordinary level. The mountains of Arrabida, Estrella, Julio, Marvan, and Cintra, being some of the largest in Portugal, were impetuously shaken, as it were, from their very foundations; and most of them opened at their summits, which were split and rent in a wonderful manner, huge masses of them being thrown down into the subjacent valleys*. Flames are related to have issued from these mountains, which are supposed to have been electric; they are also said to have smoked; but vast clouds of dust seem to have given rise to this appearance. The most extraordinary incident which occurred at Lisbon during the catastrophe was the subsidence of a new quay, built entirely of marble, at an immense expense. A great concourse of people had collected there for safety, as a spot where they might be beyond the reach of falling ruins; but, suddenly, the quay sank down with all the people on it, and not one of the dead bodies ever floated to the surface. A great number of boats and small vessels anchored near it, all full of people, were swallowed up, as in a whirlpool†. No fragments of these

* Hist. and Philos. of Earthquakes, p. 317.

† Rev. C. Davy's Letters, vol. ii., Letter ii., p. 12, who was at Lisbon at the time, and ascertained that the boats and vessels said to have been swallowed were missing.

wrecks ever rose again to the surface, and the water in the place where the quay had stood is stated, in many accounts, to be unfathomable; but, Whitehurst * says, he ascertained it to be one hundred fathoms.

In this case, we must either suppose that a certain tract sank down into a subterranean hollow which would cause a "fault" in the strata to the depth of six hundred feet, or we may infer, as some have done, from the entire disappearance of the substances engulphed, that a chasm opened and closed again. Yet, in adopting this latter hypothesis, we must suppose that the upper part of the chasm, to the depth of one hundred fathoms, remained open.

The great area over which this Lisbon earthquake extended is very remarkable. The movement was most violent in Spain, Portugal, and the north of Africa; but nearly the whole of Europe, and even the West Indies, felt the shock on the same day. A sea-port, called St. Eubals, about twenty miles south of Lisbon, was engulphed. At Algiers and Fez, in Africa, the agitation of the earth was equally violent, and at the distance of eight leagues from Morocco, a village, with the inhabitants to the number of about eight or ten thousand persons, together with all their cattle, were swallowed up. Soon after the earth closed again over them. A great wave swept over the coast of Spain, and is said to have been sixty feet high at Cadiz. At Tangier, in Africa, it rose and fell eighteen times on the coast. At Funchal, in Madeira, it rose full fifteen feet perpendicular above high-water mark, although the tide which ebbs and flows there seven feet was then at half ebb. Besides entering that city, and committing great havoc, it overflowed other sea-ports in the island. At Kinsale, in Ireland, a body of water rushed into the harbour, whirled round several vessels, and poured into the market place.

The shock was felt at sea, on the deck of a ship to the west of Lisbon, and produced very much the same sensation as on dry land. Off St. Lucar, the captain of the Nancy frigate felt his ship so violently shaken that he thought he had struck the ground; but, on heaving the lead, found he was in a great depth of water. Captain Clark from Denia, in north latitude

* On the Formation of the Earth, p. 55.

36° 24′, between nine and ten in the morning, had his ship shaken and strained as if she had struck upon a rock, so that the seams of the deck opened, and the compass was overturned in the binnacle. Another ship forty leagues west of St. Vincent experienced so violent a concussion, that the men were thrown a foot and a half perpendicularly up from the deck. In Antigua and Barbadoes, as also in Norway, Sweden, Germany, Holland, Corsica, Switzerland, and Italy, tremors and slight oscillations of the ground were felt.

The agitation of lakes, rivers, and springs, in Great Britain was remarkable. At Loch Lomond in Scotland, for example, the water, without the least apparent cause, rose against its banks, and then subsided below its usual level. The greatest perpendicular height of this swell was two feet four inches. It is said that the movement of this earthquake was undulatory, and that it travelled at the rate of twenty miles a minute, its velocity being calculated by the intervals between the time when the first shock was felt at Lisbon, and its time of occurrence at other distant places *.

St. Domingo, 1751.—On the 15th of September, 1751, a shock began to be experienced in several of the West India Islands, and on the 21st of November, a violent one destroyed the capital of St. Domingo, Port au Prince. Part of the coast twenty leagues in length sank down and has ever since formed a bay of the sea †.

Conception, 1750.—On the 24th of May 1750, the ancient town of Conception, otherwise called Penco, in Chili, was totally destroyed by an earthquake and the sea rolled over it. The ancient port was rendered entirely useless, and the inhabitants built another town ten miles from the sea-coast, in order to be beyond the reach of similar inundations. During a late survey of Conception Bay, Captains Beechey and Belcher discovered that the ancient harbour, which formerly admitted all large merchant vessels which went round the Cape, is now occupied by a reef of sandstone, certain points of which pro-

* Michell on the Cause and Phenomena of Earthquakes, Phil. Trans., vol. li. p. 566. 1760.

† Hist. de l'Acad. des Sciences. 1752. Paris.

ject above the sea at low-water, the greater part being very shallow. A tract of a mile and a half in length, where, according to the report of the inhabitants, the water was formerly four or five fathoms deep, is now a shoal. The correctness of this statement of the original depth may be concluded from the circumstance, that the large trading vessels which formerly frequented the port could not have anchored in less than four fathoms water. Our hydrographers found the reef to consist of hard sandstone, so that it cannot be supposed to have been formed by recent deposits of the river Biobio, an arm of which carries down loose micaceous sand into the same side of the bay. Besides it is a well known fact, that ever since the shock of 1750, no vessels have been able to approach within a mile and a half of the ancient port of Penco. That shock, therefore, uplifted the bed of the sea to the height of twenty-four feet at the least, and most probably the adjoining coast shared in the elevation, for an enormous bed of shells of the same species as those now living in the bay, are seen raised above high-water mark along the beach, filled with micaceous sand like that which the Biobio now conveys to the bay. These shells, as well as others which cover the adjoining hills of mica-schist to the height of from one thousand to one thousand five hundred feet, have lately been examined by experienced conchologists in London, and identified with those taken at the same time in a living state from the Bay and its neighbourhood *.

Ulloa, therefore, was perfectly correct in his statement, that at various heights above the sea between Talcaguana and Conception, "mines were found of various sorts of shells used for lime of the very same kinds as those found in the adjoining sea." Among them, he mentions the great mussel called Choros, and two others which he describes. Some of these, he says, are entire, and others broken; they occur at the bottom of the sea, in four, six, ten, or twelve fathom water, where they adhere to a sea-plant called Cochayuyo. They are taken in dredges, and have no resemblance to those found on the shore or in shallow water, yet beds of them occur at various heights on the hills. "I was the more pleased with the sight," he adds, "as it

* Captain Belcher has shewn me these shells, and the collection has been examined by Mr. Broderip.

appeared to me a convincing proof of the universality of the deluge, although I am not ignorant that some have attributed their position to other causes; but an unanswerable confutation of their subterfuge is, that the various sorts of shells which compose these strata, both in the plains and mountains, are the very same with those found in the bay *." Perhaps the diluvian theory of this distinguished navigator, the companion of Condamine, may account for his never having recorded even reports of changes in the relative level of land and sea on the shores of South America. He could not, however, have given us a relation of the rise of the reef above alluded to, for the destruction of Penco happened a few years after the publication of his Voyages. If we duly consider these facts so recently brought to light, as well as the elevation before mentioned of the coast at Valparaiso in 1822, we shall be less sceptical than Raspe, in regard to an event for which Hooke had cited Purchas's Travels. In that passage it was stated, "that a certain sea-coast in a province of South America called Chili, was, during a violent earthquake, propelled upwards with such force and velocity, that some ships on the sea were grounded in it, and the sea receded to a distance." Raspe, being himself of opinion that all the continents had been upraised gradually by earthquakes from the sea, admitted that the circumstance was not impossible, but he complains that Purchas had interpolated the account of the earthquake (which happened probably at the close of the seventeenth century) into Da Costa's History of the West Indies †.

Peru, 1746.—Peru was visited on the 28th of October, 1746, by an earthquake, which is declared to have been more tremendous and extensive than even that of Lisbon in 1755. In the first twenty-four hours, two hundred shocks were experienced. The ocean twice retired and returned impetuously upon the land: Lima was destroyed, and part of the coast near Callao was converted into a bay; four other harbours, among which were Cavalla and Guanape, shared the same fate. There were twenty-three ships and vessels great and small in the

* Ulloa's Voyage to South America, vol. ii., Book 8, chap. 6.
† De Novis Insulis, p. 120. 1753.

harbour of Callao, of which nineteen were sunk, and the other four, among which was a frigate called St. Fermin, were carried by the force of the waves to a great distance up the country. The number of the inhabitants in this city amounted to four thousand. Two hundred only escaped, twenty-two of whom were saved on a small fragment of the fort of Vera Cruz, which remained as the only memorial of the site of the town after this dreadful inundation.

A volcano in Lucanas burst forth the same night, and such quantities of water descended from the cone, that the whole country was overflowed; and in the mountain near Patao, called Conversiones de Caxamarquilla, three other volcanos burst out, and frightful torrents of water swept down their sides *.

Kamtschatka, 1737.—The eastern side of the peninsula of Kamtschatka, at Awatchka bay, was shaken by an earthquake on October the 6th, 1737. The sea was violently agitated, and overflowed the land to an immense height, and then withdrew so far as to lay bare its bottom between the first and second of the Kurile Isles. The shape of the ground was greatly changed. Several plains were uplifted and formed hills, and on the other hand many subsidences occasioned inland lakes and new bays on the coast †.

Martinique, 1727.—In the year 1727, a hill sunk down in Martinique during an earthquake ‡.

Iceland, 1725.—In Iceland during the eruption of the volcano Leirhnukur, in 1725-6, a tract of high land sunk down, and formed a lake, and half a mile from the same place a hill rose in a lake and converted it into dry land §.

Teneriffe, 1706.—May 5th, 1706, a lateral eruption of Teneriffe took place south of the harbour of Garachico, which was overwhelmed with lava. Many springs disappeared, and

* Ulloa's Voyage, vol. ii., Book 7, chap. 7.
† Kracheninikon by Chappe d'Auteroche, p. 337.
‡ Geog. of America, Schlözer, Part II., p. 554.
§ Dureau de la Malle, Géog., de la Mer Noire, p. 203.

there were such changes of level as to alter the whole face of the country, hills having risen up where there were plains before *.

Java, 1699.—On the 5th of January, 1699, a terrible earthquake visited Java, and no less than two hundred and eight considerable shocks were reckoned. Many houses in Batavia were overturned, and the flame and noise of a volcanic eruption were seen and heard at that city, which were afterwards found to proceed from Mount Salak †, a volcano six days' journey distant. Next morning the Batavian river, which has its rise from that mountain, became very high and muddy, and brought down abundance of bushes and trees, half burnt. The channel of the river being stopped up, the water overflowed the country round, the gardens about the town, and some of the streets, so that fishes lay dead in them. All the fish in the river, except the carps, were killed by the mud and turbid water. A great number of drowned buffaloes, tigers, rhinoceroses, deer, apes, and other wild beasts were brought down by the current, and "notwithstanding," observes one of the writers, "that a crocodile is amphibious, several of them were found dead among the rest ‡." It is stated, that seven hills bounding the river sank down, by which is merely meant, as by similar expressions in the description of the Calabrian earthquakes, seven great landslips. These hills, descending some from one side of the valley and some from the other, filled the channel, and the waters then finding their way under the mass, flowed out thick and muddy. The Tangaran river was also dammed up by nine hills, and in its channel were large quantities of drift trees. Seven of its tributaries also are said to have been "covered up with earth." A high tract of forest land, between the two great rivers before mentioned, is described as having been changed into an open country, destitute of trees, the surface being spread over with a fine red clay. This part of the account may, perhaps, merely refer to the sliding down of woody tracts into the valleys, as happened to so many extensive vineyards and olive-grounds in Calabria,

* Humboldt and Bonpland, Voy. Relat. Hist., Part I., p. 177.

† Misspelt Sales in Hooke's account.

‡ Hooke's Posthumous Works, p. 437, 1705.

in 1783. The close packing of large trees in the Batavian river is represented as very remarkable, and it attests in a striking manner the destruction of soil bordering the valleys which had been caused by floods and landslips*.

Quito, 1698.—In Quito, on the 19th of July, 1698, during an earthquake, a great part of the crater and summit of the volcano Carguairazo fell in, and a stream of water and mud issued from the broken sides of the hill †.

Sicily, 1693.—Shocks of earthquakes spread over all Sicily in 1693, and on the 11th of January the city of Catania and forty nine other places were levelled to the ground, and about one hundred thousand people killed. The bottom of the sea, says Vicentino Bonajutus, sank down considerably both in ports, inclosed bays, and open parts of the coast, and water bubbled up along the shores. Numerous long fissures of various breadths were caused, which threw out sulphureous water, and one of them, in the plain of Catania (the delta of the Simeto), at the distance of four miles from the sea, sent forth water as salt as the sea. The stone buildings of a street in the city of Noto, for the length of half a mile, sank into the ground, and remained hanging on one side. In another street, an opening large enough to swallow a man and horse appeared ‡.

Moluccas, 1693.—The small isle of Sorea, which consists of one great volcano, was in eruption in the year 1693. Different parts of the cone fell one after the other into a deep crater, until almost half the space of the island was converted into a fiery lake. Most of the inhabitants fled to Banda, but great pieces of the mountain continued to fall down, so that the lake became wider, and finally the whole population was compelled to emigrate. It is stated, that in proportion as the lake of lava increased in size, the earthquakes were less vehement §.

Jamaica, 1692.—In the year 1692 the island of Jamaica was visited by a violent earthquake, the ground swelled and

* Phil. Trans., 1700. † Humboldt, Atl. Pit., p. 106.
‡ Phil. Trans., 1693—4. § Ibid. 1693.

heaved like a rolling sea, and was traversed by numerous cracks, two or three hundred of which were often seen at a time opening and then closing rapidly again. Many people were swallowed up in these rents; some the earth caught by the middle and squeezed to death; the heads of others only appeared above ground, and some were first engulphed and then cast up again with great quantities of water. Such was the devastation, that even at Port Royal, then the capital, where more houses are said to have been left standing than in the whole island beside, three quarters of the buildings, together with the ground they stood on, sank down with their inhabitants entirely under water. The large store-houses on the harbour side subsided, so as to be twenty-four, thirty-six, and forty-eight feet under water; yet many of them appeared to have remained standing, for it is stated that, after the earthquake, the mast-heads of several ships wrecked in the harbour, together with the chimney-tops of houses, were seen just projecting above the waves. A tract of land round the town, about a thousand acres in extent, sank down in less than one minute, during the first shock, and the sea immediately rolled in. The Swan frigate, which was repairing in the wharf, was driven over the tops of many buildings, and then thrown upon one of the roofs, through which it broke. The breadth of one of the streets is said to have been doubled by the earthquake. At several thousand places in Jamaica the earth is related to have opened. On the north of the island several plantations, with their inhabitants, were swallowed up, and a lake appeared in their place, covering above a thousand acres, which afterwards dried up, leaving nothing but sand and gravel, without the least sign that there had ever been a house or tree there. Several tenements at Yallowes were buried under landslips; and one plantation was removed half a mile from its place, the crops continuing to grow upon it uninjured. Between Spanish town and Sixteen-mile-walk the high and perpendicular cliffs bounding the river fell in, stopped the passage of the river, and flooded the latter place for nine days, so that the people "concluded it had been sunk as Port Royal was." But the flood at length subsided, for the river had found some new passage at a great distance.

The Blue and other of the highest mountains are declared

to have been strangely torn and rent. They appeared shattered and half-naked, no longer affording a fine green prospect, as before, but stripped of their woods and natural verdure. The rivers on these mountains first ceased to flow for about twenty-four hours, and then brought down into the sea at Port Royal and other places, several hundred thousand tons of timber which looked like floating islands on the ocean. The trees were in general barked, most of their branches having been torn off in the descent. It is particularly remarked in this, as in the narratives of so many earthquakes, that fish were taken in great numbers on the coast during the shocks. The correspondents of Sir Hans Sloane, who collected with care the accounts of eye-witnesses of the catastrophe, refer constantly to *subsidences*, and some supposed the whole of Jamaica to have sunk down*.

We have now only enumerated the earthquakes of the last hundred and forty years, respecting which, facts illustrative of geological inquiries are on record. Even if our limits permitted, it would be a tedious and unprofitable task to examine all the obscure and ambiguous narratives of similar events of earlier epochs, although, if the localities were now examined by geologists well practised in the art of interpreting the monuments of physical changes, many events which have happened within the historical era might still be determined with precision. The reader must not imagine, that in our sketch of the occurrences in the short period above alluded to, we have given an account of all, or even the greater part of the mutations which the earth has undergone, by the agency of subterranean movements. Thus, for example, the earthquake of Aleppo, in the present century, and of Syria in the middle of the eighteenth, would doubtless have afforded numerous phenomena of great geological importance, had those catastrophes been described by scientific observers. The shocks in Syria in 1759, were protracted for three months, throughout a space of ten thousand square leagues, an area compared to which that of the Calabrian earthquake, of 1783, was insignificant. Accon, Saphat, Balbeck, Damascus, Sidon, Tripoli, and many other places, were almost entirely levelled to the ground. Many thousands of the inhabitants perished in each, and in the valley

* Phil. Trans., 1694.

of Balbeck alone twenty thousand men are said to have been victims to the convulsion. It would be as irrelevant to our present purpose to enter into a detailed account of such calamities, as to follow the track of an invading army, to enumerate the cities burnt or rased to the ground, and reckon the number of individuals who perished by famine or the sword. If such then be the amount of ascertained changes in the last one hundred and forty years, notwithstanding the extreme deficiency of our records during that brief period, how important must we presume the physical revolutions to have been in the course of thirty or forty centuries, during which, some countries habitually convulsed by earthquakes have been peopled by civilized nations! Towns engulphed during one earthquake may, by repeated shocks, have sunk to enormous depths beneath the surface, while their ruins remain as imperishable as the hardest rocks in which they are inclosed. Buildings and cities submerged for a time beneath seas or lakes, and covered with sedimentary deposits, must, in some places, have been re-elevated to considerable heights above the level of the ocean. The signs of these events have probably been rendered visible by subsequent mutations, as by the encroachments of the sea upon the coast, by deep excavations made by torrents and rivers, by the opening of new ravines and chasms, and other effects of natural agents, so active in districts agitated by subterranean movements. If it be asked why if such wonderful monuments exist, so few have hitherto been brought to light—we reply—because they have not been searched for. In order to rescue from oblivion the memorials of former occurrences, we must know what we may reasonably expect to discover; and under what peculiar local circumstances. The inquirer, moreover, must be acquainted with the action and effects of physical causes, in order to recognise, explain, and describe, correctly, the phenomena when they present themselves.

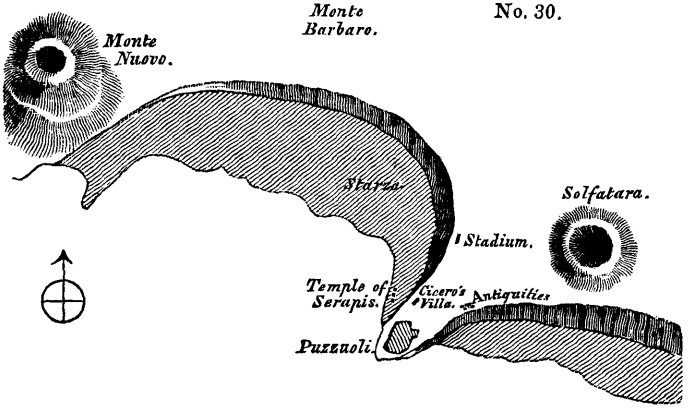
The best known of the great volcanic regions of which we sketched the boundaries, in the eighteenth chapter, is that which includes Southern Europe, Northern Africa, and Central Asia, yet nearly the whole even of this region must be laid down in a geological map as "Terra Incognita." Even Calabria may be regarded as unexplored, as also Spain, Portugal,

the Barbary states, the Ionian Isles, the Morea, Asia Minor, Cyprus, Syria, and the countries between the Caspian and Black Seas. We are, in truth, beginning to obtain some insight into one small spot of that great zone of volcanic disturbance, the district around Naples, a tract by no means remarkable for the violence of the earthquakes which have convulsed it.

If, in this part of Campania, we are enabled to establish, that considerable changes in the relative level of land and sea have taken place since the Christian era, it is all that we could have expected, and it is to recent antiquarian and geological research, not to history, that we are principally indebted for the information. We shall proceed to lay before the reader some of the results of modern investigations in the Bay of Baiæ and the adjoining coast.

Temple of Jupiter Serapis.—This celebrated monument of antiquity affords, in itself alone, unequivocal evidence, that the relative level of land and sea has changed twice at Puzzuoli, since the Christian era, and each movement both of elevation and subsidence has exceeded twenty feet. Before examining these proofs we may observe, that a geological examination of the coast of the Bay of Baiæ, both on the north and south of Puzzuoli, establishes in the most satisfactory manner an elevation at no remote period, of more than twenty feet, and the evidence of this change would have been complete even if the temple had to this day remained undiscovered. If we coast along the shore from Naples to Puzzuoli we find, on approaching the latter place, that the lofty and precipitous cliffs of indurated tuff, resembling that of which Naples is built, retire slightly from the sea, and that a low level tract of fertile land, of a very different aspect, intervenes between the present sea-beach, and what was evidently the ancient line of coast. The inland cliff is in many parts eighty feet high near Puzzuoli, and as perpendicular as if it was still undermined by the waves. At its base, the new deposit attains a height of about twenty feet above the sea, and as it consists of regular sedimentary deposits, containing marine shells, its position proves that since its formation there has been a change of more than twenty feet in the relative level of land and sea.

No. 30.



Ground plan of the coast of the Bay of Baiæ in the environs of Puzzuoli.

The sea encroaches on these new incoherent strata, and as the soil is valuable, a wall has been built for its protection; but when I visited the spot in 1828, the waves had swept away part of this rampart, and exposed to view a regular series of strata of tuff, more or less argillaceous, alternating with beds

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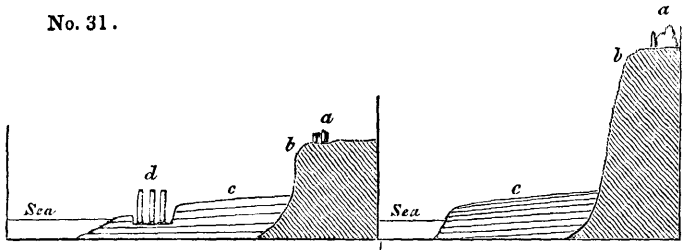

a. Remains of Cicero's villa, N. side of Puzzuoli*.
b. Ancient cliff now inland.
c. Terrace composed of recent submarine deposit.
d. Temple of Serapis.

a. Antiquities on hill S.E. of Puzzuoli.
b. Ancient cliff now inland.
c. Terrace composed of recent submarine deposit.

of pumice and lapilli, and containing great abundance of marine shells, of species now common on this coast, and amongst them Cardium rusticum, Ostrea edulis, Donax trunculus (Lam.) and

* The spot here indicated on the summit of the cliff, is that from which Hamilton's view, plate 26, Campi Phlegræi is taken, and on which he observes Cicero's villa called the Academia anciently stood.

others. The strata vary from about a foot to a foot and half in thickness, and one of them contains abundantly remains of works of art, tiles, squares of mosaic pavement of different colours, and small sculptured ornaments, perfectly uninjured. Intermixed with these I collected some teeth of the pig and ox. These fragments of building occur below as well as above strata containing marine shells.

If we then pass to the north of Puzzuoli and examine the coast between that town and Monte Nuovo, we find a repetition of analogous phenomena. The sloping sides of Monte Barbaro slant down within a short distance of the coast, and terminate in an inland cliff of moderate elevation, to which the geologist perceives at once, that the sea must, at some former period, have extended. Between this cliff and the sea is a low plain or terrace, called La Starza, corresponding to that before described on the south-east of the town; and, as the sea encroaches rapidly, fresh sections of the strata may readily be obtained, of which the annexed is an example.

Section on the shore north of the town of Puzzuoli.

	Ft.	*In.*
1. Vegetable soil	1	0
2. Horizontal beds of pumice and scoriæ, with broken fragments of unrolled bricks, bones of animals, and marine shells	1	6
3. Beds of lapilli, containing abundance of marine shells, principally Cardium rusticum, Donax trunculus Lam., Ostrea edulis, Triton cutaceum, Lam. and Buccinum serratum, Brocchi, the beds varying in thickness from one to eighteen inches	10	0
4. Argillaceous tuff containing bricks and fragments of buildings not rounded by attrition	1	6

The thickness of many of these beds varies greatly as we trace them along the shore, and sometimes the whole group rises to a greater height than at the point above described. The surface of the tract which they compose appears to slope gently upwards towards the base of the old cliffs. Puzzuoli itself stands chiefly on a promontory of the older tufaceous formation, which cuts off the new deposit, although I detected a small patch of the latter in a garden under the town.

Now if these appearances presented themselves on the eastern or southern coast of England, a geologist would naturally endeavour to seek an explanation in some local depression of high water-mark, in consequence of a change in the set of the tides

and currents: for towns have been built, like ancient Brighton, on sandy tracts intervening between the old cliff and the sea, and in some cases they have been finally swept away by the return of the ocean. On the other hand, the inland cliff at Lowestoff, in Suffolk, remains, as we stated in the fifteenth chapter, at some distance from the shore, and the low green tract called the Ness may be compared to the low flat called La Starza, near Puzzuoli. But there are no tides in the Mediterranean; and to suppose that sea to have sunk generally from twenty to twenty-five feet since the shores of Campania were covered with sumptuous buildings, is an hypothesis obviously untenable. The observations, indeed, made during modern surveys on the moles and cothons (docks) constructed by the ancients in various ports of the Mediterranean, have proved that there has been no sensible variation of level in that sea during the last two thousand years. A very slight change would have been perceptible; and had any been ascertained to have taken place, and had it amounted only to a difference of a few feet, it would not have appeared very extraordinary, since the equilibrium of the Mediterranean is only restored by a powerful current from the Atlantic*.

Thus we arrive, without the aid of the celebrated temple, at the conclusion that the recent marine deposit at Puzzuoli was upraised in modern times above the level of the sea, and that not only this change of position, but the accumulation of the modern strata, was posterior to the destruction of many edifices, of which they contain the imbedded remains. If we now examine the evidence afforded by the temple itself, it appears, from the most authentic accounts, that the three pillars now standing erect, continued, down to the middle of the last century, half buried in the new marine strata before described. The upper part of the columns, being concealed by bushes, had not attracted the notice of antiquaries; but, when the soil was removed in 1750, they were seen to form part of the remains of a splendid edifice, the pavement of which was still preserved, and upon it lay a number of columns of African breccia and of granite. The original plan of the building

* Captain W. H. Smyth, R.N. obtained, during his survey, numerous proofs of the permanency of the level of the Mediterranean from a remote historical period.

could be traced distinctly; it was of a quandrangular form, seventy feet in diameter, and the roof had been supported by forty-six noble columns, twenty-four of granite, and the rest of marble. The large court was surrounded by apartments, supposed to have been used as bathing-rooms; for a thermal spring, still used for medicinal purposes, issues now just behind the building, and the water, it is said, of this spring, was conveyed by marble ducts into the chambers. Many antiquaries have entered into elaborate discussions as to the deity to which this edifice was consecrated; but Signor Carelli, who has written the last able treatise on the subject *, endeavours to show that all the religious edifices of Greece were of a form essentially different—that the building, therefore, could never have been a temple—that it corresponded to the public bathing-rooms at many of our watering-places, and, lastly, that if it had been a temple, it could not have been dedicated to Serapis,—the worship of the Egyptian god being strictly prohibited at the time when this edifice was in use, by the senate of Rome.

It is not for the geologist to offer an opinion on these topics, and we shall, therefore, designate this valuable relic of antiquity by its generally received name, and proceed to consider the memorials of physical changes, inscribed on the three standing columns in most legible characters by the hand of nature. (See Frontispiece †.) The pillars are forty-two feet in height; their surface is smooth and uninjured to the height of about twelve feet above their pedestals. Above this, is a zone, twelve feet in height, where the marble has been pierced by a species of marine perforating bivalve—Lithodomus, Cuv. ‡ The holes of these animals are pear-shaped, the external opening being minute, and gradually increasing downwards. At the bottom of the cavities, many shells are still found, notwithstanding the great numbers that have been taken out by visitors. The perforations are so considerable in depth and size, that they manifest a long continued abode of the Lithodomi in the

* Dissertazione esergetica sulla sagra Architettura degli Antichi.

† The representation of the present state of the temple in the frontispiece has been carefully reduced from that given by the Canonico Andrea de Jorio, Ricerche sul Tempio di Serapide, in Puzzuoli. Napoli, 1820.

‡ Modiola lithophaga, Lam. Mytilus lithophagus, Linn.

columns; for, as the inhabitant grows older and increases in size, it bores a larger cavity, to correspond with the increasing magnitude of its shell. We must, consequently, infer a long continued immersion of the pillars in sea-water, at a time when the lower part was covered up and protected by strata of tuff and the rubbish of buildings, the highest part at the same time projecting above the waters, and being consequently weathered, but not materially injured. On the pavement of the temple, lie some columns of marble, which are perforated in the same manner in certain parts, one, for example, to the length of eight feet, while, for the length of four feet, it is uninjured. Several of these broken columns are eaten into, not only on the exterior, but on the cross fracture, and, on some of them, other marine animals have fixed themselves *. All the granite pillars are untouched by Lithodomi. The platform of the Temple is at present about one foot below high-water mark, (for there are small tides in the Bay of Naples,) and the sea, which is only one hundred feet distant, soaks through the intervening soil. The upper part of the perforations then are at least twenty-three feet above high-water mark, and it is clear, that the columns must have continued for a long time in an erect position, immersed in salt-water. After remaining for many years submerged, they must have been upraised to the height of about twenty-three feet above the level of the sea.

So far the information derived from the Temple corroborates that before obtained from the new strata in the plain of La Starza, and proves nothing more. But as the temple could not have been built originally at the bottom of the sea, it must have first sunk down below the waves, and afterwards have been elevated. Of such subsidences there are numerous independent proofs in the Bay of Baiæ. Not far from the shore, to the north-west of the Temple of Serapis, are the ruins of a Temple of Neptune, and a Temple of the Nymphs, now under water. These buildings probably participated in the movement which raised the Starza, but, either they were deeper under water than the Temple of Serapis, or they were not raised up again to so great a height. There are also two Roman roads under water in the

* Serpula contortuplicata, Linn., and Vermilia triquetra, Lam. These species, as well as the Lithodomus, are now inhabitants of the neighbouring sea.

Bay, one reaching from Puzzuoli towards the Lucrine Lake, which may still be seen, and the other near the Castle of Baiæ. The ancient mole too, which exists at the Port of Puzzuoli, and which is commonly called that of Caligula, has the water up to a considerable height of the arches; whereas Brieslak * justly observes, it is next to certain, that the piers must formerly have reached the surface before the springing of the arches. A modern writer also reminds us, that these effects are not so local as some would have us believe; for on the opposite side of the Bay of Naples, on the Sorrentine coast, which, as well as Puzzuoli, is subject to earthquakes, a road, with some fragments of Roman buildings, is covered to some depth by the sea. In the island of Capri, also, which is situated some way at sea, in the opening of the Bay of Naples, one of the palaces of Tiberius is now covered with water †. They who have attentively considered the effects of earthquakes before enumerated by us during the last one hundred and forty years, will not feel astonished at these signs of alternate elevation and depression of the bed of the sea and the adjoining coast during the course of eighteen centuries, but, on the contrary, they will be very much astonished if future researches fail to bring to light similar indications of change in all regions of volcanic disturbances. That buildings should have been submerged, and afterwards upheaved, without being entirely reduced to a heap of ruins, will appear no anomaly, when we recollect that in the year 1819, when the delta of the Indus sank down, the houses within the fort of Sindree subsided beneath the waves without being overthrown. In like manner, in the year 1692, the buildings around the harbour of Port Royal, in Jamaica, descended suddenly to the depth of between thirty and fifty feet under the sea without falling. Even on small portions of land, transported to a distance of a mile, down a declivity, tenements like those near Mileto, in Calabria, were carried entire. At Valparaiso, buildings were left standing when their foundations, together with a long tract of the Chilian coast, were permanently upraised to the height of several feet in 1822. It is true that, in the year 1750, when the bottom of the sea

* Voy. dans la Campanie, tome ii., p. 162.

† Mr. Forbes, Physical Notices of the Bay of Naples. Ed. Journ. of Sci., No. 2, new series, p. 280. October, 1829.

in the harbour of Penco was suddenly uplifted to the extraordinary elevation of twenty-four feet above its former level, the buildings of that town were thrown down; but we might still suppose that a great portion of them would have escaped, had the walls been supported on the exterior and interior with a deposit, like that which surrounded and filled to the height of ten or twelve feet the Temple of Serapis at Puzzuoli.

The next subject of inquiry, is the era when these remarkable changes took place in the Bay of Baiæ. It appears, that in the Atrium of the Temple of Serapis, inscriptions were found in which Septimus Severus and Marcus Aurelius record their labours in adorning it with precious marbles *. We may, therefore, conclude, that it existed at least down to the third century of our era in its original position. On the other hand, we have evidence that the marine deposit forming the flat land called La Starza was still covered by the sea in the year 1530, or just eight years anterior to the tremendous explosion of Monte Nuovo. Mr. Forbes † has lately pointed out the distinct testimony of an old Italian writer Loffredo, in confirmation of this important point. Writing in 1580, Loffredo declares that fifty years previously, the sea washed the base of the hills which rise from the flat land before alluded to, and at that time he expressly tells us that a person *might have fished* from the site of those ruins which are now called the Stadium. (See wood cut, No. 30.) Hence it follows, that the subsidence of the ground on which the Temple stood, happened at some period between the third century and the beginning of the sixteenth century. Now in this interval the only two events which are recorded in the imperfect annals of the dark ages, are the eruption of the Solfatara in 1198, and an earthquake in 1488 by which Puzzuoli was ruined. It is at least highly probable, that earthquakes, which preceded the eruption of the Solfatara, which is very near the Temple, (see wood cut, No. 30) caused a subsidence, and the pumice and other matters ejected from that volcano might have fallen in heavy showers into the sea, and would thus immediately have covered up the lower part of the columns. The action of the waves might afterwards have thrown down many pillars, and formed strata of broken fragments of the

* Brieslak, Voy. dans la Campanie, tom. ii., p. 167.

† Ed. Journ. of Science, new series, No. II., p. 281.

building intermixed with volcanic ejections, before the Lithodomi had time to perforate the lower part of the columns. In like manner, the sea acting on other submerged buildings, would naturally have caused a similar stratum, containing works of art and shells for several miles along the coast.

Now it is perfectly evident from Loffredo's statement, that the re-elevation of the low tract called La Starza took place after the year 1530, and long before the year 1580; and from this alone we might confidently conclude that the change happened in the year 1538 when Monte Nuovo was formed. But fortunately we are not left in the slightest doubt that such was the date of this remarkable event. Sir William Hamilton * has given us two original letters describing the eruption of 1538, the first of which by Falconi, dated 1538, contains the following passages. "It is now two years since there have been frequent earthquakes at Puzzuoli, Naples, and the neighbouring parts. On the day and in the night before the eruption (of Monte Nuovo), above twenty shocks great and small were felt.—The next morning (after the formation of Monte Nuovo) the poor inhabitants of Puzzuoli quitted their habitations, &c., some with their children in their arms, some with sacks full of their goods, others carrying quantities of birds of various sorts that had fallen dead at the beginning of the eruption, others again with fish which they had found, and which were to be met with in plenty on the shore, the sea having *left them dry for a considerable time*.—I accompanied Signor Moramaldo to behold the wonderful effects of the eruption. The sea had retired on the side of Baiæ, *abandoning a considerable tract*, and the shore appeared almost entirely dry from the quantity of ashes and broken pumice-stones thrown up by the eruption. I saw two springs *in the newly discovered ruins*, one before the house that was the Queen's, of hot and salt-water, &c." So far Falconi—the other account is by Pietro Giacomo di Toledo, which begins thus: "It is now two years since this province of Campagna has been afflicted with earthquakes, the country about Puzzuoli much more so than any other parts: but the 27th and the 28th of the month of September last, the earthquakes did not cease day or night in the town of Puzzuoli;

* Campi Phlegræi, p. 70.

that plain which lies between lake Avernus, the Monte Barbaro and the sea was *raised a little*, and many cracks were made in it, from some of which issued water; at the same time the sea immediately adjoining the plain *dried up about two hundred paces*, so that the fish were left on the sand a prey to the inhabitants of Puzzuoli. At last, on the 29th of the same month, about two o'clock in the night, the earth opened, &c." Now both these accounts, written immediately after the birth of Monte Nuovo, agree in expressly stating, that the sea retired, and one mentions that its bottom was upraised. To this elevation we have already seen that Hooke, writing at the close of the seventeenth century, alludes as to a well known fact*. The preposterous theories, therefore, that have been advanced in order to dispense with the elevation of the land, in the face of all this historical and physical evidence, are not entitled to a serious refutation. The flat land, when first upraised, must have been more extensive than now, for the sea encroaches somewhat rapidly, both to the north and south-east of Puzzuoli. The coast has of late years given way more than a foot in a twelvemonth, and I was assured by fishermen in the bay, that it has lost ground near Puzzuoli, to the extent of thirty feet, within their memory. It is, probably, this gradual encroachment which has led many authors to imagine that the level of the sea is slowly rising in the Bay of Baiæ, an opinion by no means warranted by such circumstances. In the course of time the whole of the low land will, perhaps, be carried away, unless some earthquake shall remodify the surface of the country, before the waves reach the ancient coast-line; but the removal of this narrow tract will by no means restore the country to its former state, for the old tufaceous hills and the interstratified current of trachytic lava which has flowed from the Solfatara, must have participated in the movement of 1538; and these will remain upraised even though the sea may regain its ancient limits.

In 1828 excavations were made below the marble pavement of the Temple of Serapis, and another costly pavement of mosaic was found, at the depth of five feet or more below the other. The existence of these two pavements at different levels seems clearly to imply some subsidence previously to all the

* Ante, p. 34.

changes already alluded to, which had rendered it necessary to construct a new floor at a higher level. But to these and other circumstances bearing on the history of the Temple antecedently to the revolutions already explained, we shall not refer at present, trusting that future investigations will set them in a clearer light.

In concluding this subject, we may observe, that the interminable controversies to which the phenomena of the Bay of Baiæ gave rise, have sprung from an extreme reluctance to admit that the land rather than the sea is subject alternately to rise and fall. Had it been assumed that the level of the ocean was invariable, on the ground that no fluctuations have as yet been clearly established, and that, on the other hand, the continents are inconstant in their level, as has been demonstrated by the most unequivocal proofs again and again, from the time of Strabo to our own times, the appearances of the temple at Puzzuoli could never have been regarded as enigmatical. Even if contemporary accounts had not distinctly attested the upraising of the coast, this explanation should have been proposed in the first instance as the most natural, instead of being now adopted unwillingly when all others have failed. To the strong prejudices still existing in regard to the mobility of the land, we may attribute the rarity of such discoveries as have been recently brought to light in the Bay of Baiæ and the Bay of Conception. A false theory it is well known may render us blind to facts, which are opposed to our prepossessions, or may conceal from us their true import when we behold them. But it is time that the geologist should in some degree overcome those first and natural impressions which induced the poets of old to select the rock as the emblem of firmness—the sea as the image of inconstancy. Our modern poet, in a more philosophical spirit, saw in the latter "The image of Eternity," and has finely contrasted the fleeting existence of the successive empires which have flourished and fallen, on the borders of the ocean, with its own unchanged stability.

——— Their decay
Has dried up realms to deserts:—not so thou,
Unchangeable, save to thy wild waves' play:
Time writes no wrinkle on thine azure brow;
Such as creation's dawn beheld, thou rollest now.

CHILDE HAROLD, Canto iv.