ADDITIONS to the Article, Of Earthquakes and Volcano's, vol. i. p. 382.

I.

Of Earthquakes.

EARTHQUAKES are produced by two cauſes: The firſt is the ſudden ſinking of cavities in the bowels of the earth; and the ſecond, which is ſtill more frequent and more violent than the firſt, is the action of ſubterraneous fires.

When a cavern ſinks in the middle of a continent, it produces a commotion which extends to a greater or ſmaller diſtance, in proportion to the quantity of motion excited by the fall of this maſs of earth; and, if this maſs is inconſiderable, or falls from no great height, it will not produce a ſuccuſſion ſo violent as to be perceived at a great diſtance; the effect is limited to the neighbourhood of the ſunk cavern; and if the movement is propagated to greater diſtances, it is only by ſlight tremblings or vibrations.

As

As moſt of the primitive mountains reſt upon caverns, becauſe, at the moment of their conſolidation, theſe eminences were blown up by the action of the internal fire, ſinkings in the mountains have happened, and ſtill happen, whenever the vaults of the caverns are undermined by water, or ſhaken by any convulſion. An entire portion of a mountain ſometimes ſinks perpendicularly, but oftener inclines, and not unfrequently reverſes. Of this we have ſtriking examples in ſeveral of the Pyrennees, where the ſtrata, formerly horizontal, are often inclined more than forty-five degrees; which ſhows, that the entire maſs of each portion of the mountain, whoſe ſtrata were parallel to each other, has inclined by the lump, and, in the moment of its ſinking, reſted upon a baſe inclined to the horizon forty-five degrees. This is the moſt general cauſe of the inclination of ſtrata in mountains. For the ſame reaſon, we often find, between the adjacent eminences, ſtrata which deſcend from the firſt and riſe to the ſecond, after having traverſed the valley. Theſe ſtrata are horizontal, and are bedded at the ſame height in the two oppoſite hills, between which the cavern had fallen in. The earth ſinks down, and the valley is formed, without producing any other derangement than a greater or ſmaller inclination of the ſtrata, according to the depth of the valley, or the declivity of the two oppoſite hills.

This

This is the only ſenſible effect of the ſinking of caverns in mountains and other parts of continents. But, whenever this effect happens in the bottom of the ſea, where ſinkings muſt be more frequent than on the land, becauſe the water perpetually undermines the vaults in every place where they ſupport the bottom of the ocean, theſe ſinkings not only derange and incline the ſtrata, but ſenſibly lower the level of the ſea. From the firſt occupation of the waters, their level has been depreſſed two thouſand fathoms by theſe ſinkings; and, as all the ſubmarine caverns have not yet fallen in, it is more than probable, that the baſin of the ſea, by growing more and more deep, will leſſen its ſurface, and, of courſe, that the extent of all the continents will always continue to augment by the retreat and ſinking of the waters.

A ſecond and more powerful cauſe than the firſt concurs in producing the ſame effect. This cauſe is the rupture and ſinking of caverns by the action of ſubmarine fires. It is certain, that no motion or ſinking in the bottom of the ſea can happen without diminiſhing its ſurface: And, if we conſider the general effects of ſubterraneous fires, we will perceive that, as long as there is fire, the commotions of the earth will not be confined to ſimple tremblings; for the efforts of fire raiſe and open the ſea and the land by violent and reiterated ſuccuſſions, which not only

only overturn and deſtroy the adjacent lands, but ſhake thoſe that are diſtant, and ravage or derange every thing in the route of their direction.

The earthquakes occaſioned by ſubterraneous fires generally precede eruptions of volcano's, and ſometimes ceaſe the moment the fire opens a paſſage through the earth, and carries its flames into the air. Theſe dreadful earthquakes ſometimes continue during the whole time of eruptions. Theſe two effects are intimately connected. There is never a great eruption of a volcano without being preceded, or at leaſt accompanied, with an earthquake. But we often feel very violent ſuccuſſions of the earth without any eruption of fire. Thoſe movements in which fire has no part, proceed not only from the firſt cauſe, the falling in of caverns, but likewiſe from the action of ſubterraneous winds and ſtorms. There are many examples of lands raiſed or ſunk by the force of theſe internal winds. Sir William Hamilton, a man as reſpectable for his private character, as admirable for the extent of his knowledge and reſearches on this ſubject, told me that he had ſeen between Trente and Verona, near the village of Roveredo, ſeveral little hills compoſed of large maſſes of calcarious ſtones, which had evidently been raiſed by different exploſions of ſubterraneous winds. There is no indication of the action of fire upon any of theſe

rocks

indication of the action of fire upon any of these rocks or their fragments. The whole country, on both sides of the highway, for an extent of near a league, has, from place to place, been overturned by the prodigious efforts of subterraneous winds: The inhabitants say that it happened suddenly, and was the effect of an earthquake.

But the force of the wind, however violent, appears not to be a cause sufficient to produce such great effects; and, though there be no marks of fire in these little hills raised by the commotion of the earth, I am persuaded that they have been elevated by electrical explosions of subterraneous thunder, and that the internal winds have contributed to this effect solely by producing electrical storms in the cavities of the earth. Hence all convulsive movements of the earth may be referred to three causes: The first and most simple is the sinking of caverns; the second, storms and subterraneous thunder; and the third, the action of fire kindled in the interior parts of the globe. It is easy to ascribe to one or other of these three causes all the phænomena which accompany or succeed earthquakes.

Commotions of the earth sometimes give rise to eminences; but they more frequently produce gulfs. On the 15th day of October 1773, a gulf opened in the territory of Induno, in the

State of Modena, the cavity of which was more than four hundred fathoms wide by two hundred deep *. In 1726, a mountain of a considerable height, situated in the northern part of Iceland, was sunk in one night by an earthquake, and a very deep lake assumed its place. The same night, about a league and a half distant, an ancient lake, the depth of which was unknown, was entirely dried up, and its bottom raised in such a manner as to form a pretty high hill, which still exists †. In the seas in the neighbourhood of New Britain, M. Bougainville remarks, earthquakes have terrible effects on navigation. On the 17th of June, the 12th and 27th of July 1768, there were three earthquakes at Boero, and on the 22d of the same month, one at New Brittany. These earthquakes sometimes annihilate islands and known sandbanks, and sometimes create them ‡.

There are earthquakes which extend to great distances; but they are always longer than broad. One of the most considerable was that felt in Canada in the year 1663. It extended more than two hundred leagues in length and one hundred in breadth, *i. e.* more than twenty thousand superficial leagues. The effects of the

* Journ. Hist. et Politique, Dec. 10, 1773, *art. Milan.*
† Melanges interassans, tom. i. p. 159.
‡ Voyage autour du Monde, tom. ii. p. 278.

last

laſt earthquake in Portugal, which happened in our own time, were felt ſtill farther. M. le Chevalier de Saint-Sauveur, King's commandant at Merucis, informed M. de Genſanne, that, when walking on the left margin of Jouante in Languedoc, the ſky ſuddenly became very dark, and that, in a moment after, he perceived, at the foot of the hill, which is ſituated to the right of that river, a terrible bright globe of fire: Immediately there aroſe from the bowels of the earth a conſiderable maſs of rocks, and the whole chain of mountains ſplit from Merucis to Florac, an extent of near ſix leagues. This rent, in ſome places, is more than two feet wide, and has partly fallen in*. There are other earthquakes which produce little or no commotion. Kolbe relates, that, on the 24th of September 1707, from eight to ten o'clock before noon, the ſea roſe upon the land at the Cape of Good Hope, and deſcended ſeven times ſucceſſively, and with ſuch rapidity, that, from one moment to another, the place was alternately covered and left by the waters †.

With regard to the effects of earthquakes, the falling of mountains, and the ſinking of caverns, I ſhall ſubjoin a few facts, which are

* Hiſt. Nat. de Languedoc, par M. de Genſanne, tom. i. p. 231.

† Deſcript. du Cap de Bonne-Eſperance, tom. ii. p. 237.

laſt

both recent and well atteſted. In Norway, a whole promontory called *Hammersfields* ſuddenly fell *. A very high mountain, near that of Chimboraço, one of the higheſt of the Cordeliers in the province of Quito, tumbled down in a moment. This fact, with all its circumſtances, is related in the memoirs of M. de la Condamine and Bouguer. Similar fallings and ſinkings often happen in the ſouthern iſlands of India. At Gamma-canore, where the Dutch have a ſettlement, a high mountain fell ſuddenly in the year 1673, when the weather was fine: It was followed by an earthquake, which overturned the neighbouring villages, and deſtroyed ſeveral thouſands of perſons †. On the 11th of Auguſt 1772, in the iſland of Java and province of Cheribou, one of the richeſt ſettlements of the Dutch, a mountain, of about three leagues in circumference, ſuddenly ſunk, and roſe and ſunk alternately like waves in a ſtormy ocean: It at the ſame time threw out many globes of fire, which were ſeen at a great diſtance, and gave a light as brilliant as that of day: All the plantations, together with about two thouſand one hundred and forty inhabitants, without reckoning ſtrangers, were entirely ſwallowed up ‡. We might recite many other examples of the ſinking of

* Hiſt. Nat. de Norwége, par Pontoppidan; *Journal Etranger, Août* 1755.

† Hiſt. Gen. des Voyages, tom. xvii. p. 54.

‡ See Gazette de France, 21 Mai 1773, *art. de la Haie.*

lands and ſwallowing of mountains by the rupture of caverns, and the ſuccuſſions occaſioned by earthquakes and the action of volcano's: But we have ſaid enough to eſtabliſh the general concluſions we have drawn from the facts already related.

II.

Of Volcano's.

THE ancients have left us ſome notices concerning the volcano's which were known to them, and particularly thoſe of Ætna and Veſuvius. Several learned and curious obſervers have in our days examined more minutely the form and effects of theſe volcano's. On comparing their deſcriptions, the firſt obſervation that preſents itſelf, is the folly of tranſmitting to poſterity the exact topography of theſe burning mountains. Their form may be ſaid to change daily; their ſurface riſes or ſinks in various places; every eruption produces new gulfs or new eminences: To attempt to deſcribe all theſe changes, is to follow and paint the ſucceſſive ruins of a burning edifice. The Veſuvius of Pliny, and the Ætna of Empedocles, preſent very different aſpects from thoſe which have been ſo ably delineated by Sir William Hamilton and Mr. Brydone; and, in a few ages,

ages, theſe recent deſcriptions will no longer reſemble their objects. Next to the ſurface of the ocean, nothing on this globe is ſo fluctuating and inconſtant as the ſurface of volcanic mountains: But even from this inconſtancy, and from the variation of form and movements, ſome general concluſions may be drawn, by bringing particular obſervations under one point of view.

III.

Of the Changes which have happened in Volcano's.

THE baſe of Ætna is about ſixty leagues in circumference, and its perpendicular height about two thouſand fathoms above the level of the Mediterranean ſea. We may, therefore, regard this enormous mountain as an obtuſe cone, the ſuperficies of which are not leſs than three hundred ſquare leagues. This conical ſurface is divided into four zones, ſituated concentrically above each other. The firſt is the largeſt, and, by a gradual aſcent, extends above ſix leagues from the moſt diſtant point at the foot of the mountain. This zone of ſix leagues broad is almoſt totally peopled and cultivated. The city of Catania and ſeveral villages are ſituated in this firſt zone, the ſurface of which