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EARTHQUAKES AND THEIR CAUSES.

BY JOHN J. LAKE.

THE origin of earthquakes has been assigned to many causes, as the falling in of caverns, steam, the combustion of gases, volcanic and electric action. Their most prominent and peculiar features are the following:

1. Great subterranean noises and reports resembling thunder. These occur more or less during all earthquakes. Father Kircher describes them as "a horrid sound resembling that of an infinite number of chariots driven fiercely forward, the wheels rattling, and the thongs of the whips cracking;" Sir Hans Sloane, in Jamaica, as "a hollow rumbling noise almost like that of thunder." At Colares, near Lisbon, in 1755, during the great earthquake, the sound is said to have been "like that of chariots, which increased till it equaled that of the roar of cannon ;" and at Lisbon, "a rattling as of coaches in the street, with a frightful noise underground resembling the rumbling of distant thunder." At Madeira the same earthquake was preceded "by rumbling noises in the air like that of empty carriages, which died away like a peal of distant thunder," **On the 16th of September, 1849, there was an earthquake at Burra-Burra, in South Australia, where the noise is said to have resembled the rolling of heavy carriages. The shock was followed by a flash of lightning that illumined the whole atmosphere.**

2. Another feature of these phenomena is the upheaval of the ground observed during the prevalence of most earthquakes, which is one cause of the sea retiring, another being the suction of the approaching wave when the centre of the convulsion has been removed from the shore. During the great earthquake at Lisbon the bar at the mouth of the Tagus was laid bare by the upheaval, and the master of a vessel, lying in that river at the time, stated that his large anchor was thrown up from the bottom, and seemed to swim on the surface of the water. Other results of the upward movement during this catastrophe were observed elsewhere. The water in a pond at Dunstal, in Suftblk, was jerked up into the form of a pyramid. At some places the water was tossed out of the wells. At Loch Lomond a large stone was forced out of the water. Rocks were raised into the air from the bottom of the Atlantic, and on board a vessel, about forty leagues from the island of St. Vincent in the West Indies, the anchors, which were lashed,

bounced up, and the sailors thrown a foot and a half perpendicular from the deck, the ship sinking into the water immediately afterward as low as the main-chains. At Riobamba, in South America, on the 5th of January, 1797, the bodies of many of the inhabitants were thrown, by this vertical action, upon the hill of La Cullca, which is several hundred feet high, and on the opposite side of the river. During some of these convulsions in Italy, paving-stones have been tossed into the air and found with their lower sides uppermost ; and, at the time of a late convulsion in South America, the rising of the ground caused the sea to retire, which returned like a wall in appearance, carrying before it inland vessels that had only a few minutes before been left dry, towns and people being overwhelmed by the resistless recoil.

3. Another peculiarity to be noticed in these convulsions is the frequent horizontal and circular motion of the soil. These effects are often very curious, and, in countries much subject to such catastrophes in their severest forms, have often given rise to lawsuits. Walls that had served to divide fields have been completely changed in direction, but without having been shattered or overthrown. Straight and parallel rows of trees have been inflected, and fields and portions of fields have changed places. Houses have also exchanged situations with each other.

4. It has been observed that clouds have become fixed or suspended over particular spots affected, or about to be affected, by earthquake, as in London, in 1749, in Calabria, in 1783 ; and it is more than probable that the fog that enveloped Euphemia, in Sicily, in 1638, Millitello in 1693, and other places when they were destroyed, arose from the operation of one cause.

5. Explosions of great violence frequently attend these convulsions, often with disastrous results. When Millitello was destroyed, there was a great explosion heard in the fog that enveloped it ; traces were noticed afterward as of the presence of fire on the rocks in the neighborhood, and the vines in the country surrounding it appeared as though they had been seared by fire. A similar explosion was heard in 1783 at Castel Nuovo, in Calabria, when that place was overwhelmed.

6. A further peculiarity is the exemption of certain spots, although the shocks were felt in all the surrounding neighborhood. Thus, at Manchester, in 1777, St. Paul's Church and the Dissenting Chapel escaped. Both of these were low buildings without steeples, and the church situated over a common sewer ; but other more lofty buildings, especially those with metal pipes attached, felt the shocks severely. At Blockley the shocks were experienced strongly at the church, but very slightly at the chapel about 300 yards distant, and the latter was constructed without water-pipes.

7. Earthquakes are very frequently attended by thunder and lightning. At Munster, in 1612, thunder and lightning were heavy during an earthquake ; and in Sicily, in 1693, it caused very great mischief. This conjunction of lightning with earthquake was noticed by Luke Howard, and constitutes what he designates " spurious earthquake." One of the cases he mentions occurred in Radnorshire: "At Knill Court the oscillation of the house was plainly perceptible, and felt by all the family, and that, too, in several apartments, and was accompanied by a peculiar rumbling noise. At Harpton, a severe storm of thunder and lightning was experienced the same night and

at the same time."

8. Peculiar rushing noises have also at times been perceived, as in Staffordshire in 1692, and London in 1749.

9. These convulsions are attended by the disturbance of the magnetic needle, and compasses on board ship are frequently for a time useless. On the 19th of January, 1845, on the Thames steamer, during an earthquake in the West Indies, they revolved on their pivots with great rapidity ; and on the 29th of October, 1867, during a hurricane, there were shocks of earthquake at St. Thomas', and the electrical disturbance was so great as temporarily to render the compasses unavailable.

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Such being some of the more prominent peculiarities attending earthquakes, let us now apply them to the theories above referred to, and endeavor to ascertain the causes of these disturbances or the agencies employed in producing them.

They do not support the theory of the foiling in of caverns being the cause of these phenomena ; for they are invariably attended by an upheaval of the ground, and often with a horizontal or a circular motion. This theory, therefore, cannot be maintained, and more especially as it does not explain the electric and magnetic accompaniments.

The hypothesis that they are caused by steam or the explosion of confined gases has scarcely a better foundation. These agents might produce vertical motion and subterranean noises, but it is difficult to conceive how they could bring about circular motion at the surface ; and it is quite impossible that the explosion of gases or the escape of steam could, immediately preceding a shock, attract the clouds floating in the atmosphere, so that they should remain fixed over particular spots. Other characteristics also cannot be explained on this theory, as the lightning and disturbance of the compass.

The volcanic and igneous theory is not so easily to be disposed of; for it appears very clear that volcanic eruptions do produce earthquake. A remarkable instance is that of Santorini in 1650. Earthquake is also very common where volcanic action is extensively developed, as in South America and the neighborhood of Etna and Vesuvius.

Volcanoes produce these disturbances in two ways: 1. By their own direct motion ; 2. By disturbing the electric equilibrium in their neighborhood. This electric disturbance was noticed by Pliny, who records that an officer, one of the Decuriones Municipales of Pompeii, was struck by lightning in 79, although the sky was perfectly unclouded ; and these indications have been put to practical use. The presence of lightning is also a prominent feature during volcanic eruptions. When Kattleguia, in Iceland, now extinct, was last in a state of eruption, lightning proceeded from it and killed a farmer and his servant, together with some horses and cows. We cannot, therefore, exclude the consideration of volcanoes as producers of earthquake, sometimes by direct action, at others through the medium of electric disturbance.

But by far the most prominent agent seems to be electricity, and the Italians, who suffer so much from these calamities, consider it to be the only cause. The evidences of the activity of the electric fluid in this respect are so palpable that they cannot be controverted. As some may be

skeptical on this point, it will not be amiss to examine a few cases in which the operation of this agent is quite apparent.

When considering this part of the subject, we must not omit to notice the frequency with which the greatest weight of these calami-

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ties falls upon towns and the neighborhoods of mountains. This is to be accounted for on the electric theory, from these places offering points for the escape of the fluid which naturally flies there to seek a thoroughfare, so to speak. From this cause we have St. Elmo's fire on the masts and yards of ships at sea, and De Saussure's experiences of the escape of the fluid from an Alpine peak. Hence we may infer that towns and mountains create centres of force in these convulsions.

At Munster, in Germany, an earthquake began on December 8, 1612, and lasted for several days. During the shocks, Billenelt Castle, near Munster, built on a rock, "sunk more than the depth of two men's height," a breach being made in the rock itself. The destruction by earthquake and lightning seems to have been great. "If any," says a chronicler of the catastrophe, "have so much heart left as to lift up his hands to heaven, he is presently struck down by thunder and lightning;" "fiery clouds and a direful comet" alarmed the superstitious. The state of the atmosphere must have been very peculiar, even allowing for exaggeration, since the writer referred to states that the appearance of the stars was "changed into prodigious, dreadful, fiery meteors." During this calamity, earthquake, thunder, and lightning, occurred twice every day, but not at the same time.

The earthquake of 1638 disturbed both Etna and Stromboli, causing them to send forth flame and smoke, as though the sources of the convulsion descended deeper than their roots. Father Kircher describes the disappearance of the city of Eujjhemia, which he was endeavoring to reach at this time, and was in sight of. After a violent shock, on rising from the ground and looking toward the city, he saw only a frightful dark cloud, which surprised him and his companions, as the sky was otherwise very serene. Waiting until the cloud had passed away, they found Euphemia had totally disappeared, and its place a putrid lake.

The earthquakes of 1692, in Jamaica, and 1693, in Sicily, present very strong evidences of general electric disturbance in the globe at those times. One evening in February, 1692, at Alari, in Sicily, the village seemed to the country-people to be in flames. The fire, as they imagined, began by little and increased for about a quarter of an hour, when all the houses in the place appeared to be enveloped in one flame which lasted about six minutes and then began to decay, as from want of more fuel. Many who ran to render assistance observed this increase as they passed along the road, but on entering the village found all to be a delusion. Such appearances of fire and light occur in other localities subject to earthquake, e. g., at Cowrie, Perthshire, one morning before daybreak, in 1842, the light is stated to have been so brilliant that birds were distinguished on the trees. Again, in Sicily, about the 15th of May, following the incident at Alari, two hours before sunset, the atmosphere being very clear, the heavens appeared on a sudden all on fire, without any flashes of lightning or the

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least noise of thunder. This history, at Syracuse, about a quarter of an hour, when there appeared in the air over the city two bows, the colors extremely bright, after the usual manner, and a third with the extremities inverted, and, as not a single cloud was visible in any part of the

sky, the abnormal state of the atmosphere is clear. It was also during this summer that the unusually severe thunder-storm occurred at Geneva that so materially affected the future career of the celebrated Robert Boyle. The earthquakes at Jamaica began on the 17th of June, and their greatest violence seems to have been spent in the mountains. Terrific noises were heard among them at Port Royal during the last shock, and they were so torn and rent as to present a very shattered appearance and quite new forms. In this month Etna emitted extraordinarily loud noises for three days together. A singular circumstance, during this catastrophe at Jamaica, was the derangement of the wind. The land-breeze often failed, and the sea-breeze blew all night, whereas the land-breeze should blow all night and the sea-breeze all day. There was an earthquake on September 8, 1692, in Europe, but I have not yet been able to find out the locality.

Space will not admit of more than noticing some special phenomena of the Sicilian earthquakes, 1693. On the 10th of January the castle of Augusta was blown up by the lightning firing the powder-magazine. At Minco, on the 11th, the shock was attended by "a mighty storm of lightning, thunder, and hail, that lasted six hours." The archbishop's palace at Monreal was set on fire by the lightning. Etna emitted great noises, flames, and ashes, during the shocks that overthrew Catania, but there does not appear to have been eruption. Furla, situated among limestone-quarries, disappeared, and at several parts of the hill the rocks, which were previously almost as white as Geneva marble, had changed, and in the clefts made by the earthquake had become of a burnt color, as if fire and powder had been employed to rend them asunder. Millitello seems to have been destroyed before the 11th of January, for the country-people, who dwelt on the neighboring ridge of mountains, affirmed that it was not to be seen on the morning of that day, to which time, from twelve o'clock on the 8th, it had been concealed in a thick fog. During the interval the mountain that lay on the north side of the town had been split asunder one portion overwhelming Millitello, so that not an inhabitant escaped. Francofonte, built chiefly of wood, escaped with little damage from the shocks, but was fired by lightning; the spire of the church wood covered with lead burnt down, and the nunnery of the Carmelites entirely destroyed so suddenly, that five of the nuns were stifled in their beds. The largest part of the inhabitants of Luochela escaped by flying from the town on the sudden disappearance of the castle, situated on a rising ground. Ragusa experienced shocks on the 8th, with violent thunder and lightning. At Specufurno, on the 10th,.

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❖❖❖ "from morning till night, there was never heard so violent a storm of thunder and lightning, as if heaven and earth had been mixing together;" the town-house and several other houses were destroyed by it. The peasants on the neighboring hills observed that this lightning had burnt the vines so that no crop could be expected for the season.

The earthquake of London, 1749, also exhibited strong symptoms of electric action. The year abounded with thunder and lightning, coruscations frequently appeared in the air, and the aurora removed to the south, showing upon two occasions unusual colors. Dr. Stephen Hales heard a rushing in his house which ended in an explosion in the air as from a small cannon, and attributed it to the escape of the fluid by the steeple of the church of St. Martin's-in-the-Fields, adjoining. The Rev. J. H. Murray refers to the electrical disturbances on the east coast of South America, contemporaneous with the great earthquakes on the west coast in 1868, and considers them related. He describes one storm, just at the time of the earthquake, as giving

"an idea of what the bombardment of Sevastopol must have been like."

The phenomena of seaquake are of a similar character. We have ourselves seen electric clouds thrown into auroral forms contemporaneously with the disturbance of the sea at another locality. Examples might be extensively multiplied, but the above would seem sufficient to show that a leading cause of earthquake is electric action, and that volcanoes sometimes produce the same by direct convulsion, and at others by disturbing the electric equilibrium of a locality.—*English Mechanic*.