

LITERARY.

Dr. Hays' Lecture.

Given before the Franklin Lecture, in Brooklyn, N. Y., and published by request of the Society.

Mr. President, Ladies and Gentlemen:

If I should be so fortunate, in the remarks which I shall make this evening, as to persuade even a single individual among you to turn his attention to the study and investigation of natural history, or the operations of nature as displayed in her works, which surround us at every step we take upon the earth, I shall feel myself well repaid for the small amount of time and labor required in the preparation of this address.

I am, myself, well persuaded that the study of nature is calculated both to make us better and happier—to draw away the mind from the difficulties which are incident to life—from our own evil passions and the bickerings and strife of those among whom we live—in short, from the artificial to the natural.

The most splendid conceptions of the human mind, when carried out by the most consummate art in the construction of any kind of fabric whatever, fall so immeasurably short of the amazing perfection of all the works of the Creator, from the greatest of which men have any knowledge, to the meanest, the ultimate point of animal existence, that those who closely compare them are astonished at the imperfections of all the works of men—and equally astonished at the perfect arrangement and beauty of the works of nature, and are irresistibly led to contemplate more or less, the great source and power from whence springs this perfection.

All nature, both animate and inanimate, is worthy of your study and investigation—which you find in a stone or pebble upon which you tread in your daily walks, which has not an interesting history, a history which the mineralogist and geologist are able to read. Not a plant or flower but has a secret history known only to the botanist—each beast, bird, fish, and insect, has also its history, which is read only by the zoologist, ornithologist, &c. Much of this knowledge is within the reach of all of you who are young, and have sufficient energy and industry to occupy that portion of your time in study, which is usually wasted in idleness, or thrown away in pursuits wholly unprofitable.

I do not wish, by any means, to be understood as saying that your whole studies should be directed to the investigation of nature's operations, but that much of your time may be thus profitably employed, and that any amount of knowledge thus obtained, is calculated in a great degree to refine our feelings and cultivate a chastity of thought scarcely attainable by other means.

I have never seen a lady with even a single pet of flowers, without having a better opinion of her; and I always associate with the love of flowers purity of thought, deep rooted affections and upright conduct.

Our associations are apt to give tone to our character and actions—and as there is perfection and beauty in all nature's works, that mind which is the most constantly active in their investigation, can scarcely be devoid of those great principles which adorn human nature.

I shall confine myself in the remainder of the remarks which I propose to make this evening, to the study of VOLCANOS and VOLCANIC AGENCIES—THEIR CAUSES AND EFFECTS.

It will at once be obvious, that a subject of such vast magnitude and intricacy as this, would require a much greater period of time, for a thorough and minute examination, than has been allotted to me upon this occasion. Volcanoes would be required to describe all the causes, effects, and changes which have been produced in and upon the Earth by igneous agency during the long period which has elapsed since its creation; I shall therefore attempt to do nothing more, than give a mere outline of the causes of these phenomena, and a history of some of their effects upon the physical condition of the globe.

That we may the more clearly understand the subject, it will be necessary to make some inquiry into the past and present conditions of the Earth. It is now almost universally admitted by learned and scientific men, who have made the subject of geology the principal study of their lives, that at some former period, the whole of our globe was a liquid mass in a state of fusion, except that part of it which now constitutes water, and the various gasses. The evidence that the metallic mass of the globe was in a perfect state of fluidity, from intense heat at some former period, and since its diurnal revolutions were performed in the same period that they now are, are very numerous. The want of time, however, will prevent me from entering into a detail of these evidences at the present time. I will therefore only state a few facts in the great chain of evidence, which have entirely convinced my mind, and thousands of others, of the correctness of this theory. The form of the Earth (being an oblate spheroid) is exactly that which it would assume, if, while in a fluid state, it commenced to revolve upon its axis with its present velocity. The Earth, you are aware, is flattened at the poles, and presents something the figure of a grain of wheat, (to use a homely comparison) though much thicker in its polar diameter. Its motion upon its axis is also similar to that of a swiftly revolving grindstone with a double cutting surface or rounded face, making its equatorial or vertical diameter greater than the horizontal. Many of you have observed, I have no doubt, that, when a certain degree of velocity has been given to a revolving wheel or cone, you may pour water upon it, which, instead of running off laterally upon the two inclined planes, rushes up to the centre ridge, and is there thrown off, mostly towards the Earth, by the combined action of centrifugal power and gravity. This would not be the case if the wheel, like the Earth, were placed in a situation where the attraction upon all sides was equal.

The fluid globe, when it commenced its revolutions, had all the advantages of attraction within itself, which was nearly sufficient to counteract the centrifugal force and prevent solution of its substance. Hence, the cause of its oblate form is obvious. Another evidence of the truth of the Plutonian theory, as it is called, is the fact that the "heat increases one degree for every 45 feet that we descend into the earth, and not one exception to this increase of internal temperature has ever occurred, where the experiment has been made in deep excavations."

At this rate of increase, a heat sufficient to boil water would be reached at a depth of 3602 feet, which is a little more than a mile: a heat of 7000 degrees, sufficient to melt all known rocks, would be reached at 45 miles—and at the

centre of the earth, it would amount to 577,000 deg.

A further evidence of the original fluidity of the Earth, is the fact, that all the primary rocks have a crystalline structure, which they never would have taken unless they had been melted, or been entirely dissolved in water; and it seems to me that the latter hypothesis is entirely out of the question, for the solid matter of the globe is 50,000 times heavier than the water—and much greater, than the amount of water which is now, or ever has been upon the globe, could hold in solution.

These few reasons alone, say nothing of Volcanic action, of which I shall speak directly, seem sufficient to establish pretty clearly the theory of Terrestrial heat. If, then, we admit this matter as proven, it will be easy to account for the formation of the solid crust of the earth, by the gradual cooling of the surface, from the radiation of heat into the surrounding celestial space. This cooling process prior to the formation of a crust must have proceeded very rapidly, for the temperature of the space surrounding the globe is ascertained to be at least 58 deg. below zero, and possibly may be more. So soon as a crust completely surrounding the globe was formed, the process of cooling became extremely slow, as we may infer, for the crust which soon forms upon molten lava, is a good non-conductor of heat. This is clearly proven by the fact that the matter ejected by an eruption of Jorullo in Mexico about 100 years ago, has not yet become cool.

We may also refer to the lava thrown out of Etna in 1819, "which was in motion at the rate of a yard in a day 9 months after the eruption;" and it is stated that lava from the same mountain, at a previous eruption, was in motion after the lapse of 10 years.

The first solid crust must have formed similar to ice upon a bosterosa sea or lake, gradually increasing until the whole surface was covered with a rough scoriaceous mass, which soon became cool enough to retain the water which was formed from the vapors floating mingled with the atmosphere around its surface.

Soon after this period the magnificent phenomena of earthquakes and volcanic eruptions must have appeared, to add additional grandeur to a scene which was witnessed alone by him from whose almighty will it sprang into being.

As the thickness of the crust increased, the presumption is that it acquired strength sufficient to sustain its own weight, until the liquid mass below, shrinking from the loss of caloric, space was left between it and the crust, the latter of which, from its own weight, and the superincumbent waters, which must still have increased as the surface cooled, finally gave way and was precipitated upon the liquid fire, accompanied by the water, which of necessity was instantaneously converted into steam, and forced, with irresistible power, along the surface of the fiery globe, in great waves, upheaving the solid earth, and causing it to shake and tremble as the aspen leaf, until some place less resisting than the rest was found, through which the pent up fire and steam rushes forth, the perfect "embodiment" of a VOLCANO.

As defined in the books, "A volcano is an opening in the earth from whence matter has been ejected by heat, in the form of lava, scoria, or ashes. Usually the opening called the crater is an inverted cone; and around it, there rises a mountain in the form of a cone, with its apex truncated, produced by the elevation of the Earth's crust and the ejection of lava." Volcanic cones vary in height from 600 feet, to the height of Stromboli, to 17,730 feet, the height of Cotopaxi.

When nothing but aqueous and igneous vapors have been emitted from a volcanic elevation for centuries, such elevation is termed a Solfatara—when they exist beneath the sea, they are called Submarine; when upon the land, Subaerial.

Volcanos act as safety valves or vents, through which steam and gasses are thrown off, when formed by the contact of water with the subterranean heat—and through which lava is forced in consequence of the subsidence of the crust upon the liquid substance below.

"As a general fact, volcanic vents are not insulated mountains, but are arranged in zones, often reaching half around the globe."

The most remarkable line of these vents is the long chain of islands, commencing with Alaska, on the coast of Russia, America, passing over the Aleutian Isles, Kamtschatka, the Kurilian, Japanese, Philippine, and Molucca Isles, and then turning, includes Sumbawa, Java, and Sumatra, and terminates at Barron Island, in the Bay of Bengal. Another almost equally extensive line, commences at the southern extremity of South America, and following the chain of the Andes, passes along the Cordillera of Mexico, thence into California, and thence northward, beyond the Columbia river, which it crosses between the Pacific Ocean and the Rocky Mountains.

A region 10 degrees of latitude in breadth, and 1000 miles long, extending from the Azores to the Capitan Sea, abounds in volcanos, though very much scattered. All are aware that the region around the Mediterranean, is particularly fruitful in volcanos.

Volcanos not arranged in lines or zones are called central volcanos, and are more or less insulated. For example, those of Iceland, the Sandwich Islands, Society Islands, Island of Bourbon, Jorullo in Mexico, and those of a region in Central Asia, 2500 square geographical miles in extent—800 to 1200 miles from the Ocean.

The number of active volcanos upon the globe is estimated at 303, by Girardin, and the number of eruptions about 20 in a year, or 2000 in a century.

Of these 303 active volcanos, 109 are situated upon Continents, and 194 upon Islands—almost 2 to 1 upon the latter—hence it may be very rationally inferred that water acts a very important part in volcanic phenomena—indeed it is generally admitted that the immediate causes of an eruption is the expansive force of steam and gasses.

There are but few volcanos which are constantly active; in most cases their operation is paroxysmal, and is succeeded by longer or shorter intervals of repose, varying from a few months to 17 centuries.

Hence some of the volcanos, considered as extinct, may yet break forth, and show themselves to belong to the active class; for example, Chimborazo in Quito, Tacora in Peru, &c.

"A volcanic eruption is commonly preceded by earthquakes in the vicinity; stillness of the air, and a sense of oppression, noises in the mountain, and the drying up of fountains. The eruption commences with a sudden explosion, followed by vast clouds of smoke and vapor, with flashes of lightning and showers of ashes and stones, and finally by red hot lava, which flows over the rim of the crater and spreads over the surrounding country."

One of the most remarkable and tremendous eruptions of modern times took place in 1815, on the Island of Sumbawa, one of the Molucca

group. It commenced on the 5th of April, and did not cease until July. The explosions were heard in Sumatra, 970 miles distant in one direction, and at Ternate in the opposite direction, 720. So heavy was the fall of ashes 40 miles distant, that houses were crushed beneath them.

Towards Celebes, they were carried to the distance of 217 miles; and towards Java 300 miles, in such quantities as to occasion a darkness, greater than that of the darkest night—a darkness in every respect equal to the celebrated Egyptian darkness.

Out of a population of 12,000 upon this Island only 26 persons escaped with life.

During the eruption of a volcano in Guatemala on the Pacific coast, in 1835, ashes fell upon the island of Jamaica, 800 miles eastward—and upon the deck of a vessel 1200 miles westward.

Most of you are familiar with the fact, that an eruption of Vesuvius, which occurred in the 79th year of the Christian era, buried three cities, Herculaneum, Pompeii, and Stabiae. Of these cities, Herculaneum and Pompeii have been discovered, and a large part of the latter has been uncovered, and the houses found standing, and their contents in a most perfect state of preservation—inscriptions, manuscripts, grain, fruit, bread, pickles, and even a few pills, and a roll upon which the Dea was engaged in making more, were found upon his counter—when the great calamity put a stop to his labors. This eruption happened more than 1700 years ago.

Sometimes during an eruption the whole mountain is blown to pieces, or falls into the gulf beneath; and its place is afterwards occupied by a lake. In 1773 the Papandayang, a large volcano in the island of Java, after a short and severe eruption, fell in and disappeared over an extent 15 miles long, and 6 broad, burying 40 villages, and near 3000 people. In 1638 a volcano in the island of Timor, so high as to be visible 300 miles, disappeared, and its place is now occupied by a lake. Many lakes in the south of Italy are supposed to have been thus formed; and the Dead Sea, in Palestine, probably had its origin in this cause.

The Earth's crust is estimated to be somewhere between 48 and 100 miles in thickness, we may therefore form some very faint conception of the power exerted by volcanic agency by the amount of lava protruded during an eruption, from this immense depth, and the distance to which masses of rock have been thrown.

From the facts which I have given in relation to volcanic eruptions, I think it will be perfectly obvious to you all, that the power which produces them must be deeply seated beneath the earth's crust, and independent of the mountain, for they often throw out more matter at a single eruption, than the whole mountain, if melted down, could supply.

Among the most prominent effects of igneous agency, we may mention earthquakes; of which it will be necessary to say something before closing this paper.

Dr. Buckland, in his Bridgewater Treatise, remarks, that "In the state of tranquil equilibrium which our planet has attained in the region we inhabit, [this remark will apply equally well to most of N. America,] we are apt to regard the foundation of the solid earth, as an emblem of duration and stability. Very different are the feelings of those whose lot is cast near the fact of volcanic eruptions; to them the earth affords no stable resting place, but during the paroxysms of volcanic activity, feels to and fro, and vibrates beneath their feet; overthrowing cities, yawning with dreadful chasms, converting seas into dry lands, and dry lands into seas."

To the inhabitants of such districts, we speak a language which they fully comprehend, when we describe the crust of the globe as floating on an internal nucleus of molten elements; they have seen these molten elements burst forth in liquid streams of lava—they have felt the earth beneath them quivering and rolling; as if upon the billows of a subterranean sea—they have seen mountains raised and valleys depressed, almost in an instant of time—they can only appreciate from sensible experience, the force of the terms in which geologists describe the tremulous throes, and convulsive agitations of the bottom of the seas, in which they received their origin, to the plains and mountains in which they find their present place of rest."

Earthquakes are said to be preceded in volcanic districts, by discharges from the earth of electric matter—inflammable gasses, fire, and sulphuric vapors—noises like the trundling of carriages, and the discharge of artillery, are heard beneath the ground—something like sea sickness is frequently experienced by the inhabitants, and the domestic animals shake and tremble, possessing, it seems, a perfect consciousness of their approach.

The number of changes which have been produced upon the face of the globe from earthquakes is unknown; thousands have been made since the historic period, but the tens of thousands which they have produced in the vista of ages which have gone forth antedated to that date, must forever remain a secret, unless revealed by that Almighty power who created the earth, and by whose laws all matter is governed.

The cases of cities, towns, mountains, &c., that have been partially or entirely destroyed, thrown down, submerged, elevated and depressed, are very numerous. In the year 876, Mount Etna is said to have fallen into the sea; in 541 Pompeii was half swallowed up; in 1512 a part of Caracas. About the same time numerous earthquakes agitated the valley of the Mississippi. They extended, if I remember rightly, over the whole valley—but were much more terrible from the mouth of the Ohio to the St. Francis: where numerous tracts were sunk and raised, lakes and islands were formed, and the bed of the Mississippi was exceedingly altered. In many of the lakes formed at that time, the forests are said to be standing as when they were first depressed, deep below the surface of the water; and when the water is clear and the air tranquil, great numbers of fish may be distinctly seen swimming about in the cane brakes and forests.

In 1519 the bed of the Indus, at its mouth, was sunk 18 feet, and the village and part of Sindree submerged. At the same time a tract of the delta of the Indus, 50 miles long and 16 broad, was elevated about 10 feet.

In 1783, a large part of Calabria was terribly convulsed by earthquakes, over an area of 500 square miles. These shocks lasted for 30 days in 1783; they were 949—and in 1784, 151. The most extensive elevation of land in modern times took place in 1823, on the western coast of South America. The shock felt 1200 miles along the coast; and for more than 100 miles, the coast was elevated from 3 to 4 feet; and it is estimated that an area of 100,000 square miles was thus raised up. A very curious instance of slow but steady elevation of a vast extent of country, is now going on in the region north of the Baltic sea, comprising Norway, Sweden, Finland, &c.—the ancient Scandinavia.

All these countries appear to have been raised from 100 to 200 feet; and are now rising at an average rate of four feet in a century.

Dr. Clark, as quoted by Mr. Lyell, in describing an eruption of Vesuvius, which occurred in 1793, says, "at the point where the lava issued from an arched chasm in the side of the mountain, the vivid torrent rushed with the velocity of a flood. It was in perfect fusion, attended with any scoriae on its surface, or any gasses materials not in a state of complete solution."

It flowed with the transparency of honey, in regular channels, cut finer than art can imitate, and glowing with all the splendor of the Sun. Stones of from 5 to 20 pounds in weight, thrown upon it, made no impression, but were carried off floating upon its surface." This lava, it will be seen, was in a state of perfect fusion, and therefore an exception to the general rule, that a few volcanos have been constantly active ever since their discovery. They always contain boiling lava; and vapor and gasses are constantly escaping. Stromboli is an example of this kind—and for the last 2000 years it has been unceasingly active. There are others of the kind, of which we may mention Popocatepetl, in Mexico, which is nearly 18,000 feet high. Ever since the conquest of Mexico, it has been pouring forth smoke.

But the most remarkable volcano upon the Globe is said to be Kilaua, on the island of Hawaii, one of the Sandwich group. It is situated upon a plain 8 or 10,000 feet above the level of the ocean, at the foot of Mount Roa. In approaching the crater it is necessary to descend two steep terraces, each from 100 to 200 feet high, and extending entirely around the volcano. The outer one is 20, and the inner one 15 miles in circumference. Arrived at the margin of the present crater, the observer has before him a crescent shaped gulf, 1500 feet deep; at whose bottom, which is from 5 to 7 miles in circumference, the top being 8 or 10, is a vast lake of lava, in some parts molten, in others covered with a crust; while in numerous places, (some have noticed as many as 50) are small cones, with smoke and lava issuing out of them from time to time. Sometimes, and especially at night, such masses of lava are forced up, that a lake of liquid fire, not less than 2 miles in circumference, is seen dishing up its angry billows, and forming one of the most magnificent and thrilling objects ever witnessed by man.

A powerful eruption of this volcano took place in May and June 1840. For several years the great gulf had been gradually filling up, until it was not more than 900 feet deep. At length the lava found a subterranean passage, and flowed 8 miles underground, when it reached the surface, and then advanced 32 miles farther, and for three weeks continued to pour into the sea a stream of red hot lava, with the most frightful hissing and detonations.

From the facts which I have given in relation to volcanic eruptions, I think it will be perfectly obvious to you all, that the power which produces them must be deeply seated beneath the earth's crust, and independent of the mountain, for they often throw out more matter at a single eruption, than the whole mountain, if melted down, could supply.

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To the inhabitants of such districts, we speak a language which they fully comprehend, when we describe the crust of the globe as floating on an internal nucleus of molten elements; they have seen these molten elements burst forth in liquid streams of lava—they have felt the earth beneath them quivering and rolling; as if upon the billows of a subterranean sea—they have seen mountains raised and valleys depressed, almost in an instant of time—they can only appreciate from sensible experience, the force of the terms in which geologists describe the tremulous throes, and convulsive agitations of the bottom of the seas, in which they received their origin, to the plains and mountains in which they find their present place of rest."

Earthquakes are said to be preceded in volcanic districts, by discharges from the earth of electric matter—inflammable gasses, fire, and sulphuric vapors—noises like the trundling of carriages, and the discharge of artillery, are heard beneath the ground—something like sea sickness is frequently experienced by the inhabitants, and the domestic animals shake and tremble, possessing, it seems, a perfect consciousness of their approach.

The number of changes which have been produced upon the face of the globe from earthquakes is unknown; thousands have been made since the historic period, but the tens of thousands which they have produced in the vista of ages which have gone forth antedated to that date, must forever remain a secret, unless revealed by that Almighty power who created the earth, and by whose laws all matter is governed.

The cases of cities, towns, mountains, &c., that have been partially or entirely destroyed, thrown down, submerged, elevated and depressed, are very numerous. In the year 876, Mount Etna is said to have fallen into the sea; in 541 Pompeii was half swallowed up; in 1512 a part of Caracas. About the same time numerous earthquakes agitated the valley of the Mississippi. They extended, if I remember rightly, over the whole valley—but were much more terrible from the mouth of the Ohio to the St. Francis: where numerous tracts were sunk and raised, lakes and islands were formed, and the bed of the Mississippi was exceedingly altered. In many of the lakes formed at that time, the forests are said to be standing as when they were first depressed, deep below the surface of the water; and when the water is clear and the air tranquil, great numbers of fish may be distinctly seen swimming about in the cane brakes and forests.

In 1519 the bed of the Indus, at its mouth, was sunk 18 feet, and the village and part of Sindree submerged. At the same time a tract of the delta of the Indus, 50 miles long and 16 broad, was elevated about 10 feet.

In 1783, a large part of Calabria was terribly convulsed by earthquakes, over an area of 500 square miles. These shocks lasted for 30 days in 1783; they were 949—and in 1784, 151. The most extensive elevation of land in modern times took place in 1823, on the western coast of South America. The shock felt 1200 miles along the coast; and for more than 100 miles, the coast was elevated from 3 to 4 feet; and it is estimated that an area of 100,000 square miles was thus raised up. A very curious instance of slow but steady elevation of a vast extent of country, is now going on in the region north of the Baltic sea, comprising Norway, Sweden, Finland, &c.—the ancient Scandinavia.

Mr. Darwin, the naturalist, who was in the neighborhood of Concepcion, on the 20th day of February, 1835, when that city was almost wholly destroyed by an earthquake, says in his journal, "A bad earthquake, at once destroys our oldest associations; the Earth, the very emblem of solidity, has moved beneath our feet like a thin crust over a fluid; one second of time has created in the mind a strange idea of insecurity, which hours of reflection would not have produced."

During the earthquake, in a description of which, Mr. Darwin makes the remarks I have quoted, part of the Chilean coast was elevated from 4 to 10 feet. In this great catastrophe, most of the inhabitants escaped by fleeing from their houses the instant the first tremulous motion of the earth was felt—this is the custom of all people living in districts subject to great earthquakes. Mr. Kendall tells us that the people of the city of Mexico, during an earthquake which happened whilst he was there, ran into the streets crying, "misericordia!" and falling upon their knees in supplication to the saints to preserve them. He tells us also that he was very desirous of feeling the shock of an earthquake, but when it came, it was so alarming and terrible, that he is likely to be satisfied with this single experiment for the rest of his life. Dr. Tschudi, in his journal of travels in Peru, has described this long after earthquake shocks, and the fearful sensations they produce, in a manner still stronger than Mr. Kendall: I have not the space, however, to quote his language.

During the shock which destroyed Concepcion, the whole ocean in the harbor and neighborhood was in a state of agitation similar to boiling water; and to complete more thoroughly the destruction of the doomed city—a great wave was seen at the distance of 2 or 3 miles approaching, having an altitude of 23 feet, which broke upon