

P R I N C I P L E S

OF

GEOLOGY;

OR,

THE MODERN CHANGES OF THE EARTH AND
ITS INHABITANTS

CONSIDERED AS ILLUSTRATIVE OF GEOLOGY.

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ETC. ETC.

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is of rock added to the continent of America by the movement, or, in other words, the mass previously below the level of the sea, and raised by the shocks permanently above it, must have contained fifty-five cubic miles in bulk; which would be sufficient to form a conical mountain two miles high (or about as high as Etna), with a circumference at the base of nearly thirty-three miles. We may take the mean specific gravity of the rock at 2.655,—a fair average, and a convenient one in such computations, because at such a rate a cubic yard weighs two tons. Then, assuming the great pyramid of Egypt, if solid, to weigh, in accordance with an estimate before given, six million tons, we may state the rock added to the continent by the Chilian earthquake to have more than equalled 1,000 pyramids.

But it must always be borne in mind that the weight of rock here added constituted but an insignificant part of the whole amount which the volcanic forces had to overcome. The whole thickness of the crust between the surface of Chili and the subterranean foci of volcanic action may be many miles or leagues deep. Say that the thickness was only two miles, even then the mass which changed its position and rose three feet being 200,000 cubic miles in volume, must have exceeded in weight 363 million pyramids.

It may be instructive to consider these results in connection with the results already obtained from a different source, and to compare the effect of two antagonist forces—the levelling power of running water, and the expansive energy of subterranean heat. How long, it may be asked, would the Ganges require, according to data before obtained, to transport to the sea a quantity of solid matter equal to that which may have been added to the land by the Chilian earthquake? The discharge of mud in one year by the Ganges equalled the weight of sixty pyramids. In that case it would require seventeen centuries and a half before the river could bear down from the continent into the sea a mass equal to that gained by the Chilian earthquake. In about half that number of centuries, perhaps, the united efforts of the Ganges and Burrampooter might accomplish the same operation.

Cutch, 1819.—A violent earthquake occurred at Cutch, in the delta of the Indus, on the 16th of June, 1819. (See Map, plate 10.) The principal town, Bhooj, was converted into a heap of ruins, and the stone buildings were thrown down. The shock extended to Ahmedabad, where it was very destructive; and at Poonah, four hundred miles farther, it was feebly felt. At the former city, the great mosque erected by Sultan Ahmed nearly 450 years before, fell to the ground, attesting how long a period had elapsed since a shock of similar violence had visited that point. At Anjar, the fort, with its towers and guns, were hurled to the ground in one common mass of ruin. The shocks continued some days until the 20th; when, thirty miles north-west from Bhooj, the volcano called Denodur is said to have burst out in eruption, and the convulsions ceased.

Subsidence in the delta of the Indus.—Although the ruin of towns

was great, the face of nature in the inland country, says Captain Macmurdo, was not visibly altered. In the hills some large masses only of rock and soil were detached from the precipices; but the eastern and almost deserted channel of the Indus, which bounds the province of Cutch, was greatly changed. This estuary, or inlet of the sea, was, before the earthquake, fordable at Luckput, being only about a foot deep when the tide was at ebb, and at flood tide never more than six feet; but it was deepened at the fort of Luckput, after the shock, to more than *eighteen feet at low water*.* On sounding other parts of the channel, it was found, that where previously the depth of the water at flood never exceeded one or two feet, it had become from four to ten feet deep. By these and other remarkable changes of level, a part of the inland navigation of that country, which had been closed for centuries, became again practicable.

Fort and village submerged.† — The fort and village of Sindree, on the eastern arm of the Indus, above Luckput, are stated by the same writer to have been overflowed; and, after the shock, the tops of the houses and wall were alone to be seen above the water, for the houses, although submerged, were not cast down. Had they been situated, therefore, in the interior, where so many forts were levelled to the ground, their site would, perhaps, have been regarded as having remained comparatively unmoved. Hence we may suspect that great permanent upheavings and depressions of soil may be the result of earthquakes, without the inhabitants being in the least degree conscious of any change of level.

A more recent survey of Cutch by Sir A. Burnes, who was not in communication with Capt. Macmurdo, confirms the facts above enumerated, and adds many important details.‡ That officer examined the delta of the Indus in 1826 and 1828, and from his account it appears that, when Sindree subsided in June, 1819, the sea flowed in by the eastern mouth of the Indus, and in a few hours converted a tract of land, 2000 square miles in area, into an inland sea, or lagoon. Neither the rush of the sea into this new depression, nor the movement of the earthquake, threw down entirely the small fort of Sindree, one of the four towers, the north-western, still continuing to stand; and the day after the earthquake, the inhabitants, who had ascended to the top of this tower, saved themselves in boats.§

Elevation of the Ullah Bund. — Immediately after the shock, the inhabitants of Sindree saw, at the distance of five miles and a half

* Macmurdo, Ed. Phil. Journ. vol. iv. p. 106.

† I was indebted to my lamented friend the late Sir Alexander Burnes for the accompanying engraving (Plate XL) of the Fort of Sindree, as it appeared eleven years before the earthquake; but I am assured by Captain Grant, and others well acquainted with the scene, that the land introduced by the artist in the back-ground is ideal. The flat plain of the Bunn could alone be seen in that

direction as far as the eye can reach. The mirage so common there may have caused the apparent inequalities which have been introduced as rising ground into the sketch.

‡ This Memoir is now in the Library of the Royal Asiatic Society of London.

§ Several particulars not given in the earlier edition were afterwards obtained by me from personal communication with Sir A. Burnes in London.



Small handwritten marks or characters, possibly a signature or date, located in the upper right corner of the photograph.

Vertical handwritten text or a signature, oriented vertically along the right edge of the photograph.

from their village, a long elevated mound, where previously there had been a low and perfectly level plain. (See Map, pl. 10.) To this uplifted tract they gave the name of "Ullah Bund," or the "Mound of God," to distinguish it from several artificial dams previously thrown across the eastern arm of the Indus.

Extent of country raised. — It has been ascertained that this new-raised country is *upwards of fifty miles* in length from east to west, running parallel to that line of subsidence before mentioned which caused the grounds around Sindree to be flooded. The range of this elevation extends from Puchum Island towards Gharee; its breadth from north to south is conjectured to be in some parts *sixteen miles*, and its greatest ascertained height above the original level of the delta is ten feet, — an elevation which appears to the eye to be very uniform throughout.

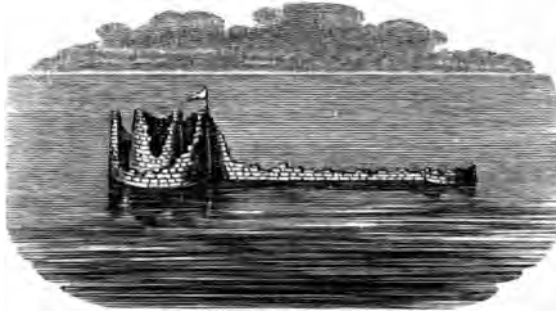
For several years after the convulsion of 1819, the course of the Indus was very unsettled, and at length, in 1826, the river threw a vast body of water into its eastern arm, that called the Phurraun, above Sindree; and forcing its way in a more direct course to the sea, burst through all the artificial dams which had been thrown across its channel, and at length cut right through the "Ullah Bund," whereby a natural section was obtained. In the perpendicular cliffs thus laid open Sir A. Burnes found that the upraised lands consisted of clay filled with shells. The new channel of the river where it intersected the "bund" was eighteen feet deep, and forty yards in width; but in 1828 the channel was still farther enlarged. The Indus, when it first opened this new passage, threw such a body of water into the new mere, or salt lagoon, of Sindree, that it became fresh for many months; but it had recovered its saltness in 1828, when the supply of river-water was less copious, and finally it became more salt than the sea, in consequence, as the natives suggested to Sir A. Burnes, of the saline particles with which the "Runn of Cutch" is impregnated.

In 1828 Sir A. Burnes went in a boat to the ruins of Sindree, where a single remaining tower was seen in the midst of a wide expanse of sea. The tops of the ruined walls still rose two or three feet above the level of the water; and standing on one of these, he could behold nothing in the horizon but water, except in one direction, where a blue streak of land to the north indicated the Ullah Bund. This scene presents to the imagination a lively picture of the revolutions now in progress on the earth — a waste of waters where a few years before all was land, and the only land visible consisting of ground uplifted by a recent earthquake.

Ten years after the visit of Sir A. Burnes above alluded to, my friend, Captain Grant, F. G. S., of the Bombay Engineers, had the kindness to send at my request a native surveyor to make a plan of Sindree and Ullah Bund, in March, 1838. From his description it appears that, at that season, the driest of the whole year, he found the channel traversing the Bund to be 100 yards wide, without water, and encrusted with salt. He was told that it has now only

four or five feet of water in it after rains. The sides or banks were nearly perpendicular, and nine feet in height. The lagoon has diminished both in area and depth, and part near the fort was dry land. The annexed drawing, made by Captain Grant from the

Fig. 51.



View of the Fort of Sindree, from the west, in March, 1838.

surveyor's plan, shows the appearance of the fort in the midst of the lake, as seen in 1838 from the west, or from the same point as that from which Captain Grindlay's sketch (see Plate XI.) was taken in 1808, before the earthquake.

The Runn of Cutch is a flat region of a very peculiar character, and no less than 7000 square miles in area : a greater superficial extent than Yorkshire, or about one fourth the area of Ireland. It is not a desert of moving sand, nor a marsh, but evidently the dried-up bed of an inland sea, which for a great part of every year has a hard and dry bottom uncovered by weeds or grass, and only supporting here and there a few tamarisks. But during the monsoons, when the sea runs high, the salt-water driven up from the Gulf of Cutch and the creeks at Luckput overflows a large part of the Runn, especially after rains, when the soaked ground permits the sea-water to spread rapidly. The Runn is also liable to be overflowed occasionally in some parts by river-water : and it is remarkable that the only portion which was ever highly cultivated (that anciently called Sayra) is now permanently submerged. The surface of the Runn is sometimes encrusted with salt about an inch in depth, in consequence of the evaporation of the sea-water. Islands rise up in some parts of the waste, and the boundary lands form bays and promontories. The natives have various traditions respecting the former separation of Cutch and Sindh by a bay of the sea, and the drying up of the district called the Runn. But these tales, besides the usual uncertainty of oral tradition, are farther obscured by mythological fictions. The conversion of the Runn into land is chiefly ascribed to the miraculous powers of a Hindoo saint, by name Damorath (or Dhoorunnath), who had previously done penance for twelve years on the summit of Denodur hill. Captain Grant infers on various grounds, that this saint flourished about the eleventh c

twelfth century of our era. In proof of the drying up of the Runn, some towns far inland are still pointed out as having once been ancient ports. It has, moreover, been always said that ships were wrecked and engulfed by the great catastrophe; and in the jets of black muddy water thrown out of fissures in that region, in 1819, there were cast up numerous pieces of wrought iron and ship nails.* Cones of sand six or eight feet in height were at the same time thrown up on these lands.†

We must not conclude without alluding to a *moral* phenomenon connected with this tremendous catastrophe, which we regard as highly deserving the attention of geologists. It is stated by Sir A. Burnes, that "these wonderful events passed *unheeded* by the inhabitants of Cutch;" for the region convulsed, though once fertile, had for a long period been reduced to sterility by want of irrigation, so that the natives were indifferent as to its fate. Now it is to this profound apathy which all but highly civilized nations feel, in regard to physical events not having an immediate influence on their worldly fortunes, that we must ascribe the extraordinary dearth of historical information concerning changes of the earth's surface, which modern observations show to be by no means of rare occurrence in the ordinary course of nature.

To the east of the line of this earthquake lies Oojain (called Ozene in the *Periplus Maris Erythr.*). Ruins of an ancient city are there found, a mile north of the present, buried in the earth to the depth of from fifteen to sixteen feet, which inhumation is known to have been the consequence of a tremendous catastrophe in the time of the Rajah Vicramaditya.‡

Since the above account was written, a description has been published of more recent geographical changes in the district of Cutch, near the mouth of the Koree, or eastern branch of the Indus, which happened in June, 1845. A large area seems to have subsided, and the Sindree Lake had become a salt marsh.§

Island of Sumbawa, 1815.—In April, 1815, one of the most frightful eruptions recorded in history occurred in the province of Tomboro, in the island of Sumbawa, about 200 miles from the eastern extremity of Java. In the April of the year preceding the volcano had been observed in a state of considerable activity, ashes having fallen upon the decks of vessels which sailed past the coast.|| The eruption of 1815 began on the 5th of April, but was most violent on the 11th and 12th, and did not entirely cease till July. The sound of the explosions was heard in Sumatra, at the distance of 970 geographical miles in a direct line; and at Ternate, in an opposite direction, at the distance of 720 miles. Out of a population of 12,000, in the province of Tomboro, only twenty-six individuals survived. Violent

* Capt. Burne's Account.
 † Captain Macmurdo's Memoir, Ed. Phil. Journ. vol. iv. p. 106.
 ‡ Von Hoff, vol. ii. p. 454.; for further particulars, see book iii. chap. xiii.
 § Quart. Geol. Journ., vol. ii. p. 103.
 || MS. of J. Crawford, Esq.