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THE ISLAND OF DOMINICA.

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DOMINICA has always been veiled in a halo of mystery. Vague rumors of "smoking mountains," of springs flowing "liquid sulphur," and of caverns of prodigious dimensions have invested it with more than ordinary interest.

The island was discovered by Columbus on his second westward voyage in 1493. It belongs to the "Windward Group," the whole of which form a portion of a circle directly east of the Caribbean sea. Geographically Dominica is located about at N. lat. 15°, and 61° long. W. of Greenwich, and its climate, consequently, is subtropical. Without entering into details, which here would carry us beyond our limits, it may be said that the entire Windward Group belongs to one geological system. Generally speaking we may regard these islands—excepting Antigua, Barbadoes and Trinidad—as the highest remaining portions of an extensive eruption, the age of which falls near or into the Eocene period. From their orographic character, as well as from their relative position, the temptation is great to consider them the projecting points of the eastern side of one huge, serrated crater-rim. Detailed observations are too meagre as yet, however, to attempt the establishment of any such hypothesis. Lithologically speaking the erupted material shown on Dominica strikingly resembles that of the southern Wasatch range. Even in special arrangement of the trachytic series the analogy is remarkable. It is furthermore borne out, on this and other islands, by the general contours of elevations, and by the similarity of the effects produced by extensive erosion.

Rising abruptly from the sea, the shores of Dominica afford

comparatively few landing places, and unless a shelving beach can be found, the boat may not unfrequently be swamped in an attempt at landing. Owing to the character of the rocks composing the body of the island, erosive action has been productive of varied results. The immediate base is composed of hard, compact sanidine-trachyte; overlying occurs a series of easily decomposing conglomerates, while the higher portions are again formed by trachyte. In giving these facts, it may be stated that the southern end of the island is spoken of. Towards the high interior and north, but few explorations have been accomplished. Wherever the more easily yielding conglomerates have been attacked by erosive agents, almost vertical walls and narrow gorges are found. Steep slopes are not wanting in the trachytes proper, but they seem to be owing less, perhaps, to erosion than to be the expression of original contour.

Towards the interior the highest mountain reaches an absolute elevation of 5500 feet; within a very few miles of shore, however, 3000 to 3500 feet are attained by a number of peaks. It would be difficult to imagine any more beautiful spot than the southern end of Dominica. Combined with outlines which resemble the rigid stability of Alpine scenery is the luxuriant, sub-tropical flora. An abundance of moisture, equable temperature and absence of the destructive hand of civilization allow full scope for the development of plant life, and have preserved for our admiration a region which cannot fail to call forth enthusiasm. Few sights can be more charming than that of a high, vertical wall clothed throughout with abundant vegetation, exhibiting numerous shades of vivid green. The Roseau river is the most important watercourse of the island. It heads in the higher mountains, flows in a westerly direction, forms a fine waterfall near Laudat, and enters the sea on the leeward side of Dominica at the main port, the town of Roseau.

From the earliest days, since its discovery, Dominica has been a bone of contention between England and France. Ample fortifications, now allowed to decay, speak of the importance which each nation attached to its possession. By the treaty of Fontainebleau it was ceded to Great Britain, but in 1802 was again recovered by France. Finally, in 1814, the former power once more added it to her list of colonies, and has retained it since that time. At the time of its discovery, and for many years after,

Dominica was one of the favorite resorts of the Caribs. This warlike nation here found mountains and water, fish in plenty and fruits in the valleys. From their strongholds in wild fastnesses they more than once issued upon aggressive warfare and severely harassed the settlers of neighboring islands. In the course of years, however, the Caribs have become greatly reduced in numbers, until to-day there is but a mere handful remaining. It is certainly a subject for serious reflection to note the almost complete extermination of a once powerful people by the advance of civilized measures and by superior instruments of aggressive warfare. In view of our own vexed Indian question we may feel inclined to allow personal or national interests to warp judgment or to subvert justice. When, however, the same spectacle is seen from the standpoint of an unimpassioned observer, it assumes a totally different aspect. Dominica and Trinidad are said to contain the last surviving Caribs. On the former island perhaps one thousand may still be living, on the latter not so large a number. Secluded in the mountains of the interior, they are but rarely seen at the settlements. Chivalrous as they formerly were, they have retained to some extent their tribal characteristics of veneration for hereditary and accidental authority and good treatment of their women. These latter have been accustomed to wait upon the "lords of creation" most assiduously, and are rewarded by respect and far more consideration than is usually found among savages. In spite of former cannibalism the Caribs have often shown traits of greatness and magnanimity. At present they occupy a reservation set apart by the government. Peaceably passing their time, they devote their energies to the manufacture of exceedingly tasteful baskets. Double plaiting renders the latter waterproof, and the careful work bestowed upon them is recognized by the numerous uses to which they are put.

In physical appearance these people closely resemble the nobler tribes of our North American Indians; long, straight, black hair falls down over their shoulders; the cheekbones are prominent, nose flattened somewhat, mouth broad and chin massive. Much lighter than the negro population, the color of their skin is yellow to brown. The influence of intermarriage between negro and Carib is plainly perceptible in their descendants. A decided lightening of color, an improvement in features and stature as well as decreased curliness of the hair, denote the pres-

ence of blood which for many years controlled the Windward islands. Many of the girls belonging to this class, who may be found some distance away from the coast, are really quite prepossessing in appearance.

A total population of about 26,000, of which Roseau claims 3000, is ascribed to the island. As might be expected, the constant change of ruling power has had a detrimental effect upon the language spoken by the present population. Defying alike the Parisian and the Englishman, a French patôis is used as the means of lingual communication. Indolence in properly framing words on the part of the negro inhabitants, and perhaps an admixture of some Carib phrases or intonations have rendered it difficult for any one but a resident to understand what is spoken. Very few Caucasians are living on Dominica, as the mountainous character of the colony forbids extensive enterprises. Coffee was introduced, during the last century, from Martinique, and was formerly largely cultivated. Recently, however, an insect has attacked the delicate leaf and destroyed the plants. Experimentally the Liberian coffee-plant has been introduced, and it is hoped that its thick, hardy leaf may successfully withstand the ravages to which the other has succumbed. Limes are raised in great quantities, and have become so thoroughly acclimated that they flourish without requiring any particular attention. Citric acid is manufactured from them and exported. One of the staples is sugar, but the annual production does not exceed a few thousand tons.

From the appearance of the town of Roseau, some inferences may be drawn as to the struggles which were made for possession of the island in times gone by. A dyke, capable of being fortified, protects the water front, while forts, located on the "Mornes" near the town, were destined to keep at bay the invading foe. True, to-day, all of the elaborate defences would speedily fall before the heavy armament of a man-of-war, but at the period of their usefulness they were sufficiently formidable. As the inhabitants are mainly negroes, the town does not present an imposing array of fine structures. Small, wooden huts, thatched in part, protect their families from rain and storms. Illustrating the good taste shown on all these islands, there is a "Public Garden" near the town; fountains cool the air, and conveniently placed seats invite the seeker after shade and the admirer of scenic beauty.

During our stay on the island (February, 1880), we had occa-

PLATE III.

ESEQUIBO INDIANS.

sion to visit several points of interest, thanks to the courtesy of gentlemen living there, and the kind offices of Dr. Brown, of Princeton. Prominent among the "mysteries" of Dominica, the "Boiling lake" and the "Soufreurs" have always held their place. The latter are located near the extreme southern end of the island. Leaving Roseau early in the morning, we were pulled along the coast for six miles by four strong oars. On account of the difficulty in landing at some localities, the boats are without rudders. Their place is supplied by a steersman who ably directs the course by means of a short paddle. Boats used by the negroes are built in the shape of canoes, and are partly sharp-keeled dug-outs, the sides being boarded to increase the depth. After we had landed, a very warm climb brought us to the first appearance of chemical changes in the rocks. The feldspathic constituents of the trachyte were thoroughly decomposed, the ground white and dusty with but little vegetation. Some search revealed a number of cavities in the altered material, which were lined or filled with beautiful crystals of sulphur. Although the surface of this decomposed area showed a normal temperature, this increased so rapidly with depth, that at little more than a foot it was unbearable to the touch. Small streams in the vicinity were found to measure 45° C., and the water evidently carried ferric sulphate and alum in solution. Ascending higher, through tall weeds, and plucking guavas on the way, we observed a narrow gully in a rocky mountain side, whence steam was issuing in dense volume. It was a matter of some difficulty to cross a ravine which separated us from this point of greatest chemical activity. Here our colored guides deserted us. Not that their guidance was in the least valuable, but we wanted them to carry specimens. No persuasion, no threat could induce them to follow us to the place where, in their opinion, evil spirits resided. "*They* will throw rocks at you," was their only reply, accompanied by an obstinate negative shake of the head. Who "they" were could not clearly be made out. A prevalent popular superstition regarding evil-minded "mountain spirits," furnished us a clew, however, as to the identity of undefinable enemies. Once within the active region of the Soufreurs it became necessary to be cautious in our movements. The ground was treacherous and of about 60° C. temperature. Small openings lined with crystals of sulphur, steadily emitted sulphurous

gases. At some places it became difficult to breathe, so dense was the volume. After passing over about quarter of a square mile, densely studded with fumaroles, we entered the gorge seen from a distance. Steep, slippery slopes of partly decomposed trachytes here enclosed a narrow stream of water which was found to be heated nearly to the boiling point. Sulphuretted hydrogen was present in great quantities, and hot steam-jets attacked us from the most unexpected quarters. Along the rock-walls we found a number of openings, sometimes nearly half a foot in diameter, from which either steam or gas issued.

> "And it bubbles and seethes, and it hisses and roars,
> As when fire is with water commix'd and contending,"

truly describes what we encountered while slowly climbing upward in the gully. From the bottom, through narrow crevices, by way of cylindrical openings, all around us, steam and gas threatened to bar farther progress. In the bed of the hot creek the water presented an appearance of violent boiling, owing to the rapid emission of large quantities of gas. So thick was the steam at this point that it began to interfere with respiration, and at times our surroundings were entirely shut out from view for several minutes. A large percentage of mineral constituents in the water rendered it totally unfit to drink, even when cooled. Ascending farther in the gorge, escape from which was negatived by barren walls on either side, we finally reached an elevation of about 1200 feet above sea level. Here we found the water cold again, trickling in small streamlets over the rocks. We had escaped from the region of gas and steam and had passed, at the same time, the upper limit of present chemical action. Complete metamorphosis, produced by long-continued decomposition, had placed these rocks beyond the influence of atmospheric agents. Burned out, not now taking part in the phenomena of the immediate vicinity, they remain as mute witnesses of the forces which there must have been at work for ages.

To our satisfaction we were enabled to find in some fragments of fresh and partly decomposed trachyte, the solution of the striking scenes witnessed. Minute crystals or irregular fragments of pyrite impregnate the rock throughout a definite zone. In weight the quantity of this pyrite may amount to about twenty per cent. Moisture in conjunction with atmospheric air will readily decompose this mineral, a process which is accompanied

by generation of heat. Such action will be facilitated and accelerated by the extremely small size of the individual pyritic particles. The postulated reagents are abundantly supplied at the locality in question. In addition to the ferric compound the feldspathic portions of the trachyte are attacked, yield to altering agents, and by increase of volume accompanying chemical change, add their share to the generation of heat. At the same time the decomposing mass is physically disintegrated and then easily removed by natural causes, thus permitting a repetition of the same process, until the supply of unstable chemical compounds may become exhausted. Irregularities of either chemical or physical character within trachytic rocks are by no means of rare occurrence. Should their nature be such as to yield more readily to active reagents than the portions surrounding them, decomposition will progress at a higher rate of speed along certain lines or in certain directions. Thus vents may be formed which besides serving as outlets for gases and liquids, will allow fresh supplies of moisture and air to reach points as yet comparatively intact.

Returning to our darkies we found them unfeignedly surprised to see us still alive, but they evidently concluded that we were reserved for some fate even worse than "having rocks thrown at us."

"Wotten Waven" is another point deserving of special study. A morning ride along the left bank of the Roseau, which led through flourishing lime plantations, brought us to the undisturbed timbered slopes of a subtropical zone. Huge tree ferns overshadowed the narrow path cut into a steep face of trachytic conglomerate, over which we were gradually winding our way upward. It would be impossible to furnish a pen picture capable of giving even a faint idea of the beauty inherent in such a forest. The cool moist atmosphere is refreshing, and every step taken forces admiration from those whose eyes are accustomed to the more sombre grandeur of northern climes. A column of steam slowly wreathing skyward betrayed the presence of Wotten Waven. These "thermal springs" lie about 1600 feet above sea level, but not within pyritiferous trachyte. A short distance from the timber edge we found a creek flowing cold water. Following this down, the first hot springs were soon encountered. Here the water issued from small apertures in trachytic rock

which showed but little decomposition on the surface. Varying temperature, ranging from 85° C. to boiling point, was observed, while the water of the creek measured 68° C. But a few yards to the right, a narrow gully ran off from the creek, ending abruptly in a vertical wall, the lower portions of which were composed of trachyte. In the latter an almost circular opening, about two feet in diameter, led to regions unknown. Standing in front of this opening a regular pulsation within was observed. So far as could be seen, it was the mouth of a somewhat extended cavity into which water rushed simultaneously, at nearly regular intervals, from the two sides parallel with the trend of the ravine. If a comparison be attempted, the total effect might be likened to the noise produced by a ship's engine, accompanied by a similar though slighter tremor. Four pulsations occurred on an average during every seven seconds, and the fifth ejected a large mass of water through the opening. This main "spring" of Wotten Waven must therefore be regarded as a *geyser*. On account of the slippery character of the rocks and the imminent risk of being scalded, the temperature could not be obtained at the moment of emission. As the water flowed off it measured 98° C. Besides this large geyser, numerous small ones occur here, all, however, sending their water in lateral directions, not vertically. In addition to the rock openings ejecting water, there were many from which steam issued. Sometimes this was not visible at the immediate mouth and it became a matter of discrimination as to the selection of standing places. Taking the temperature of several of these jets, we found a maximum of 102° C. Noticeable is the total absence of sulphuretted hydrogen. While at the Soufreurs all the silver we carried with us almost instantly turned black, we could here find no point where bright coins would be at all affected.

Although in a general way the sources of heat are due to the same causes at Wotten Waven as at the Soufreurs, some differences were found. Decomposition is the main factor, but in this instance pyrite is not the material most violently affected. Small quantities of the mineral certainly occur, and it is quite possible that its presence in larger proportion may originally have initiated the process of chemical changes. At this locality the trachytes contain a large percentage of soda feldspar (oligoclase). This is rapidly decomposing, and by the chemical reaction itself, as well

as by the considerable increase in volume incident thereto, heat is produced. In several instances, where the same changes were going on in rocks containing oligoclase, we have found thermal springs in the immediate vicinity. While decomposition of pyrite is more rapid, it does not extend so far from the surface into the rocks as that of the feldspar. In connection herewith it may be mentioned that the waters of Wotten Waven hold an exceptionally large amount of alumina in solution. In spite of the diminutive size of the majority of the geysers, the quantity of water delivered is considerable. As it nearly all flows off, a very large supply must be furnished by percolation, or by entrance through fissures and along subterranean watercourses.

On January 4, 1880, the inhabitants of Roseau had cause to feel somewhat alarmed. Taking into consideration the mysterious legends as to volcanic activity on the island, it will readily be understood that the appearance of a huge, dark cloud over the town shortly before noon of a clear day, might awaken some apprehensions. More so, however, when that cloud began to "rain down" fine particles of gray, mineral-like material which soon changed the green foliage of all vegetation to its own color. Pompeii and Herculaneum saw the initiation of their destruction in a similar cloud. So far as could be determined by cool observers, among whom Dr. Nichols of Roseau was prominent, the cloud extended for a distance of about eight miles beyond the town and then was lost, going seaward. Even in the latter part of February the finely divided "ash" could be found on many plants. It consisted of very minute fragments of trachytic rock and small crystals and particles of pyrite. The general impression was that a volcanic eruption had taken place at "Boiling Lake."

Neither definite detonations were heard nor seismic disturbances felt by the more critical observers. A low rumbling noise seems to have preceded the appearance of the cloud. Several venturesome explorers determined to investigate matters, but were obliged to return without results, as all access to the lake had been barred by dislodged rocks and earth. During our stay at Roseau a party was organized to visit the lake, and a new road was cut through the forest. Numerous colored attendants, whose climbing qualities and endurance we could not but admire, transported baggage and provisions. Reaching a point several miles

beyond Laudat, we were obliged to relinquish our riding animals and proceed on foot. Wet and slippery the newly cut path followed the sharp crest of a narrow ridge until it reached an absolute elevation of 3200 feet. From here the view was overpowering. Before us lay miles of mountain slopes, utterly denuded of vegetation. Dull gray was the color of the entire surface, and the broken stumps of once gigantic trees spoke eloquently of the terrific force which had laid in desolate waste what but two months before had been a dense primeval forest. Behind us was the beautiful valley of the Roseau, the wooded mountains skirting it and withal an expression of serene repose. To our right steam was fitfully issuing from a crater-like depression, to the left rose a majestic column of white steam from Boiling lake.

We descended a very steep slope and found the "erupted" material to consist of broken and disintegrated fragments of trachyte thoroughly impregnated with pyrite. In other words, we had before us fresh rocks which were analogous to those we found decomposed at the Soufreur and identical with the "ash" which had fallen at Roseau. By far the greater portion of the mass was reduced in size so as to pass through a twenty-mesh sieve. Boulders weighing several hundred pounds were not wanting, however. Arrived at the rivulet at the end of the mountain slope, we found the water to be warm. With the limited amount of time at our command, it was impossible for us to visit the right-hand depression, so we turned our steps towards the lake. The former was the scene of greatest activity, and the place from which the dislodged rock material had issued. Recent disturbances had rendered access so precarious, however, that it would have been necessary to spend more time than we could afford in effecting an entrance to the bottom of the "crater." An inky black creek was crossed shortly, and but a few yards beyond it one of milky whiteness running parallel. Both were warm, about 60° C. Probably the presence of iron sulphides accounts for the color of the former, while the latter, judging from its taste, contained mainly alkalies. As a noticeable fact, we observed that these colors were not merely due to the effect of underlying rocks, but that the water was really so colored. Over rocks, through water, knee deep in yielding mud we scrambled along, until we finally stood at the edge of an oval basin surrounded by almost vertical walls, where the Boiling lake had been. Formerly it must have extended about three hundred by

two hundred and fifty yards, but at the time of our visit the disturbances about one and a-half miles distant had destroyed the lake, leaving only a boiling spring of about fifteen by twelve feet. Here the water issued with tremendous ebullition. It was unsafe to approach within a few feet of the spring after the descent to the former lake bottom had been made, and it thus became impossible to ascertain the exact temperature. The spring was located near the center of the lake bed, from where its water flowed off through a narrow opening in the enclosing walls. Every step was taken on hot ground, and a cane pressed down into the earth would be followed by the hissing sound of escaping steam upon withdrawal. Fortunately we found cold water, at the upper end of the lake, trickling down on the face of a rock, and we were spared the torture of

> "Water, water everywhere
> Nor any drop to drink."

From examinations made we found that the lake had not been *filled up* by masses of rock or soil projected into it, but that the confining dam had broken away and the water had flowed off. In view of the fact that seismic action appears to have been very subordinate at the time of the "eruption," it seems probable that the lake suddenly received accessions of water and thus forced its way downward, carrying with it the former barrier. At best the depth of water, unless perhaps immediately over the hot spring, which once formed an integral portion of the lake, must have been inconsiderable. Its elevation is about 2400 feet above sea level.

Had not personal inspection of the surroundings of the lake been convincing that the "eruption" did not take place there, the evidence afforded by mutilated plants would have been conclusive. No other word but "terrific" can express the conception of the mass and overwhelming force with which rocks and boulders were hurled into the forest. On the southerly side—towards the above-mentioned crater-like depression—the bare broken trunks and stumps of trees, rarely over fifteen feet high, were literally mashed, while comparatively untouched on the reverse. About one-sixth to one-tenth of the total diameter was worn away by repeated concussion, and trees of tough fiber, so much as remained of them, were absolutely torn to shreds. Nowhere did we find indications of heat which might have been sufficiently great to fuse any of the minerals contained in the

trachyte. The reduction of the latter in size was purely mechanical, largely due to attrition, although certainly the force producing it was owing to causes entirely different. We estimated the area thus razed, of timber, at about nine square miles, and the average thickness of deposited lithological material at eighteen inches. Allowing for the fact that the latter was not densely packed, this estimate furnishes a total amount of more than 27,000,000 tons which had been removed from their normal position by catastrophic action.

As to the causes which produced the "eruption," the evidence on hand is sufficient to arrive at some conclusions. First of all, the idea of *volcanic eruption* must be dismissed. No grounds for such assumption can be found, and the immediate vicinity of the scene of action exhibits no trace thereof. On the other hand, the decomposition of pyrite and associated minerals is here the evident source of heat. Water is plentifully supplied by precipitation as well as by superficial and subterranean drainage. If we can assume, and it seems reasonable that we should, that either the supply of heat-producing material had increased without adequate vents for accumulating pressure being in existence, or that the vents, at the time acting as safety valves, were by some means reduced in area of cross-section, then, necessarily, an explosion must follow as soon as the pressure of steam and gases is able to overcome superincumbent weight. Added to this we have learned that decided barometric disturbances were observed on Dominica at a time immediately preceding the catastrophy. In case a bare equilibrium were maintained, certain changes of atmospheric pressure alone might account for a sudden release of gases under pressure. Every indication speaks for the assumption that the phenomenon is to be regarded as an *explosion* and not as an eruption, so far as the latter pertains to vulcanicity.

In the course of a few years the damages so suddenly wrought will have been repaired again. Plant life in this climate is vigorous, and it will seem but a short time ere the now barren slopes will once more be clothed in green. Nothing will remain but some scarred veterans to tell the tale of the disastrous explosion of 1880. Although a repetition of such occurrences may be looked for, the area is too limited and the seat of disturbing chemical action too superficial to endanger the safety of Dominica.