

treated with the excessive carbon dioxide grew more luxuriantly, and exhibited more complete internal differentiation than those deprived of this source of carbon.

This result is perhaps hardly surprising, as the one set of his plants was entirely deprived of its source of atmospheric carbon dioxide, and it would have been interesting to have compared his specimens at the end of the experiment with others grown in normal air, but otherwise under similar conditions of temperature, illumination, &c.

It is, however, worthy of notice that Téodoresco kept the atmosphere round his plants in a tolerably dry condition by means of sulphuric acid. This might tend to promote transpiration, and it may be that the apparent discrepancies between his plants and our material as regards both structure and histological differentiation is partly perhaps to be attributed to this circumstance. But only further investigations can settle this and many other points of interest connected with the influence, direct as well as indirect, of alteration in the constitution of the atmosphere on plant-structure.

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“Preliminary Report on the Recent Eruption of the Soufrière in St. Vincent, and of a Visit to Mont Pelée, in Martinique.”

By TEMPEST ANDERSON, M.D., B.Sc., F.G.S., and JOHN S. FLETT, M.A., D.Sc., F.G.S. Communicated by the Secretaries of the Royal Society. Received August 11, 1902.

[PLATES 11-13.]

Dr. Tempest Anderson and Dr. John S. Flett, who received a commission from the Royal Society to investigate the recent volcanic eruptions in the West Indies, more especially in St. Vincent, submit the following preliminary report:—

We arrived at Barbados on June 8 (having left London on May 28), and thence proceeded to St. Vincent, where nearly 4 weeks were spent, mostly at Chateaubelair and Georgetown, in the vicinity of the Soufrière. On June 29, Dr. Tempest Anderson went to Grenada to examine the lagoon at St. George's, returning some days later, Dr. Flett remaining at St. Vincent to complete his investigations.

On July 6 we arrived at Martinique, and on the 12th left that island for Dominica, where we remained until July 17, when we returned to Barbados. In all 6 weeks were spent in the West Indies.

In the Windward Islands, in the month of July—the middle of the rainy season—the work of a geological expedition is necessarily attended with many difficulties, but these were greatly mitigated by the kindness rendered by all with whom we came in contact. To Sir Robert Llewellyn, K.C.M.G., the Governor of the Windward Islands, and to the Administrators of St. Vincent, St. Lucia, and

Dominica—and other officials connected with the Colonial Office—we are especially indebted for information, advice, and assistance. Dr. Morris, C.M.G., of the Imperial Department of Agriculture for the West Indies, and the members of this department in the various islands, received us with the greatest kindness, and gave us invaluable help throughout. The many planters and overseers of estates, medical men, and merchants to whom we made application for information or for assistance, received us with that courtesy and hospitality which is characteristic of the Colony, and did everything in their power to forward our work in every way. In Martinique, the Governor of the island gave us every facility for conducting our scientific investigations. In this brief preliminary report it is impossible for us to mention by name even a small proportion of those who, often at considerable inconvenience to themselves, lightened our labours by their kind provision and forethought. In every place we visited we found friends who were willing to direct, assist, and accompany us; and without their help it would often have been impossible for us to make satisfactory arrangements or to accomplish our work. In this way what might have been a very arduous undertaking was greatly lightened, and we wish to place on record our deep indebtedness to our many kind friends in the Windward and Leeward Islands.

The island of St. Vincent is of oval form, 18 miles by 11 miles, the longer diameter being nearly north and south. A mountain chain stretches along the main axis of the island and reaches to a height of 2000 to 4000 feet—the highest point being just over 4000. It is entirely composed of volcanic materials, the beds of lava and tuff dipping away in all directions from the central mass towards the sea. In the southern part of the island, volcanic action has long been extinct or dormant, but at the northern end stands the still active Soufrière—a striking volcanic cone 4048 feet in height, with a crater nearly circular in form, and about 1 mile in diameter. Along the leeward side of the island very fine sections are exposed, and these show it to consist of volcanic rocks of which by far the commonest is a coarse andesitic agglomerate or tuff, though there are many lava streams which may be traced as vertical cliffs along the valley sides alternating with the gentler slopes, due to the thick beds of ash. The scenery is bold and picturesque, the heavy tropical rains acting on steep slopes having effected rapid and intense erosion. As a consequence, deep valleys radiate out from the central ridge, separated by high narrow spurs running down to the sea. On the windward side below the level of 700 feet above the sea there are considerable stretches of flat or gently sloping ground, on which stand many of the most important arrowroot and sugar estates. The first glance at these lower grounds suffices to show that they are very distinct in configuration from the highly eroded and deeply sculptured uplands,

and further investigation reveals the presence of more or less well-marked beaches or terraces—a system of old sea beaches or rock platforms partly obliterated by subaerial erosion, and in some places covered with *débris*. On both sides the submarine slopes are steep, but most so on the leeward coast; as on the east or windward side there is a considerable expanse of shallow water in which a submerged terrace at a depth of 150 feet can be traced by means of soundings, as indicated on the charts. There are no raised coral beaches here as in some of the other islands, and the latest movements of the land have probably been in a downward direction.

The Soufrière mountain forms the northern extremity of the island, and its general form at once suggests a comparison with Vesuvius. It is a simple cone without lateral or parasitic craters. The one at its summit is surrounded on the north side by the remains of a gigantic crater ring, which has the same relation to the present crater as Somma has to Vesuvius. On the north-east lip of the main crater there is a smaller one known as the New Crater, as it is believed to have originated in the eruption of 1812. It is only one-third of a mile in diameter. It is doubtful whether the New Crater was active during the late eruption, and there can be no doubt that it was from the principal or “Old Crater,” that the materials mostly were emitted. Deep valleys, often with precipitous sides, have been cut in the slopes of the mountain, especially on its southern side, and it is in these—and particularly in the Wallibu, Rozeau, and Rabaca Dry River—that the greater part of the ejecta of the recent eruption have collected.

The eruption of May, 1902, though sudden in its outburst and disastrous in its effects, was far from unexpected. In the north of St. Vincent there were two settlements of the aboriginal Caribs, and these had been so startled by the frequent violent earthquakes, that in February of last year they were considering the advisability of deserting the district. But the first signs of actual volcanic activity were on Tuesday, May 6. The inhabitants of the leeward side were fortunate in having a clear view of the crater, and warned by the outbursts of steam they fled to Chateaubelair, and other places along the coast-line to the south, so that few lives were lost in this quarter. But, on the windward side, the summit of the mountain, as is frequently the case, was wrapped in cloud. Here, at the base of the mountain, there is an extensive stretch of flat land, known as the Carib country, on which were situated some of the largest and richest estates in the island, with a dense population mostly black or coloured. So little alarm was felt here, that even on the morning of Wednesday, May 7, when the leeward side was practically deserted, sugar-making was in progress on several estates, and all the operations of tropical agriculture were being conducted as usual. From Kingstown, telephonic messages

were sent to Georgetown, which is not far from the base of the hill, stating that the Soufrière was in eruption, but they appear to have occasioned little anxiety. And when, about mid-day on Wednesday, the danger was too obvious to be overlooked, the Rabaca Dry River, and some of the streams on the windward side, usually dry except after rains, were running boiling hot, and could not be crossed. Many fugitives in this way found their escape cut off. It was here that the loss of life was greatest, which, though many escaped, is estimated to have amounted to 2000, including about a dozen white men—the overseers of the plantations. The exact number will never be known, as many were entombed in the ashes where they fell.

About mid-day on Tuesday the first signs of the eruption were observed by those dwelling on the south-western side of the mountain. At 2.40 that afternoon there was a considerable explosion, and a large cloud of steam ascended into the air. By 5 o'clock a red glare was visible in the steam cloud on the summit. Activity continued during the evening, and at midnight there was a great outburst, and red flames were noticed on the lip of the crater. Next morning from Chateaubelair a splendid view could be obtained of gigantic mushroom-shaped clouds rising to a great height in the air—estimated at 30,000 feet—and drifting away before the north-east trade wind. As the day advanced the eruption increased in violence; by 10.30 A.M. enormous clouds of vapour were being emitted with loud noises, accompanied by much lightning. It is remarkable that at that time the inhabitants of the windward side were still in doubt about the reality of the eruption, since they mistook the dark cloud covering the mountain for a thunder cloud. The mountain was now in a state of continuous activity, and from Chateaubelair it could be seen that the materials were mostly discharged from the old or principal crater. Vast clouds of steam, showers of dark matter (probably mud), and of stones, could be seen projected from it, partly on the leeward, but mostly on the windward side. At mid-day the slopes of the mountain were still green, and the rich mantle of tropical vegetation had not yet been destroyed. A thin layer of fine ash had fallen over the lower ground, only sufficient to give the leaves a greyish colour. The enormous columns of vapour continued to ascend from the crater, with frequent violent outbursts, projecting showers of stones and mud.

About this time it was noticed that steam was rising from some of the valleys on the south side of the hill, and this increased till at 12.50 the whole mountain was suddenly enveloped in a dense cloud of vapour. Just before this the Rivers Wallibu and Rabaca had been seen rushing down in raging floods of boiling water. It is most probable that these phenomena were due to the escape of the crater lake which was driven over the lower or south lip of the crater between



12 o'clock and 1 o'clock on the Wednesday afternoon, and poured down the valleys to the sea. So far as we know there were no mud lavas, in the ordinary sense, flowing down these valleys, but only a tremendous rush of boiling water, which left no traces which we could recognise when we visited the district.

By 1 o'clock the roaring of the volcano was tremendous. Showers of stones were being projected both to windward and to leeward. The enormous columns of steam continued to ascend from the crater. The lightnings were terrific, and after the large outbursts, which took place every few minutes, volumes of vapour might be seen covering the whole area. Hitherto the eruption had been of a type with which geologists are familiar, and the destruction done was confined to the higher parts of the mountain in the close vicinity of the crater.

But about 2 o'clock—to quote the words of an eye-witness (Mr. T. M. McDonald, of Richmond Vale Estate)—“there was a rumbling and a large black outburst with showers of stones, all to windward, and enormously increased activity over the whole area. A terrific huge reddish and purplish curtain advanced to and over Richmond Estate.” This was the strange black cloud which, laden with hot dust, swept with terrific velocity down the mountain-side burying the country in hot sand, suffocating and burning all living creatures in its path, and devouring the rich vegetation of the hill with one burning blast.

On the leeward coast few were overtaken by the black cloud, as the inhabitants had fled and taken refuge in the villages south of Chateaubelair. Those who were caught were killed or badly burned. One boat was near Richmond at the time the blast swept down. They describe the heat as fearful. Hot sand rained into the boat, and the sea around was hissing with its heat. The darkness was so complete that a man could not see his hand. They saved their lives by diving into the water; when they returned to the surface the air was suffocating, but they continued to dive again and again, and, when at their last gasp, they found that the air cleared, and they could breathe again. This occupied only a few minutes—probably much less in reality than it appeared to them. One man was too exhausted to continue diving; he clung to the gunwale of the boat, and the tops of his ears were severely scorched.

It may be worth while to quote the descriptions of a few spectators who saw this cloud from a safe distance. Dr. Christian Branch, of Kingstown, writes: “We saw a solid black wall of smoke falling into the sea about 2 or 3 miles from us. It looked like a promontory of solid land, but it rolled and tumbled and spread itself out until in a little time it extended quite 8 miles over the sea to the west . . . . Then began the most gorgeous display of lightning one could conceive . . . . It was still bright daylight, but the whole atmosphere quivered and thundered with wavy lines intersecting one

another like trellis-work. We were encircled in a ring of fiery bayonets."

Another eye-witness (the Rev. Mr. Darrell, of Kingstown), who was in the same boat with Dr. Branch, describes it as follows:—"We were rapidly proceeding to our point of observation when we saw an immense cloud—dark, dense, and apparently thick with volcanic material descending over our pathway, impeding our progress and warning us to proceed no further. This gigantic bank of sulphurous vapour and smoke assumed at one time the shape of a gigantic promontory, then as a collection of twisting, revolving cloud whirls, turning with rapid velocity—now assuming the shape of gigantic cauliflowers, then efflorescing into beautiful flower-shapes, some dark, some effulgent, some bronze, others pearly white, and all brilliantly illumined by electric flashes."

On the windward side of the island an uninterrupted view of the progress of the eruption could not be obtained, owing to the veil of cloud which obscured the summit. By mid-day on Wednesday even the most sceptical were convinced that the Soufrière was in eruption, and that the noises heard continuously were not due to a thunderstorm. Before mid-day there had been very heavy rain-showers, and it was noticed that the rain-drops carried down fine particles of ash. Work ceased on the plantations, and those labourers who still remained endeavoured to escape to Georgetown or shut themselves up in their houses. By 2 o'clock fine ashes, with occasional larger stones, were falling steadily, but, as yet, little damage had been done, and no one had been injured. Then came the climax of the eruption, and those who were in the open air saw a dense black cloud rolling with terrific velocity down the mountain. They took refuge in their houses and in the plantation works, where they crowded together in such numbers that in one small room eighty-seven were killed. The cloud was seen to roll down upon the sea, and was described to us as flashing with lightning, especially when it touched the water. All state that it was intensely hot, smelt strongly of sulphur, and was suffocating. They felt as if something was compressing their throats, and as if there was no air to breathe. There was no fire in the ordinary sense of the word, only the air was itself intensely hot and was charged with hot dust. The suffocating cloud only lasted a few minutes. Those who survived this ordeal mostly escaped, though many died within a few hours from shock, or from the severity of their injuries. In some cases a few survived, entirely or almost entirely uninjured, in a room in which many others died. Most of those who escaped had shut themselves up in the rum cellars or in substantially built houses, and had firmly closed all doors and windows. By the time the hot blast had reached the coast the sand it contained was no longer incandescent, and though still at a very high temperature it did not set fire to wood or

burn the clothes of those exposed to it. The burns on the survivors were chiefly on the outer aspect of the arms and legs, and on the faces, and confined to parts not protected by their clothes.

Complete darkness now covered the whole north-end of St. Vincent—a darkness more intense than any that the inhabitants had ever before experienced. The fugitives had to creep along the roads or feel their way along the roadsides. The roaring of the mountain was terrible—a long, drawn-out, continuous sound resembling the roar of a gigantic animal in great pain. Fine ash and sand rained down over the whole country with occasional showers of large stones. Some of these were so hot as to set fire to the “trash” roofs of huts in the south-end of Georgetown, at a distance of 7 miles from the crater. In Kingstown, 12 miles from the Soufrière, the ash was at first moist but afterwards dry. It had a strong sulphurous smell, and pattered on the roofs like a heavy shower of tropical rain. Around the volcano the earth shook and trembled continuously, and the motion was described to us as undulating rather than resembling the sharp shock of an earthquake. Only in one or two cases were the walls of houses injured. What was taking place on the summit of the mountain no one can tell, but all who passed that night in the vicinity of the Soufrière agree that there was one black suffocating cloud and only one. In all probability the eruption had reassumed the ordinary phase, and the showers of ash and stones were produced by violent upward explosions of steam. By half-past 5 o’clock the ash was falling in Barbados, 100 miles to the eastward, whither it had been carried by the upper currents of air in a direction opposite to that of the trade winds. In St. Vincent the darkness lessened slightly before nightfall, but the rain of dust and the noises lasted till early in the ensuing morning.

When day broke it was seen that in St. Vincent, and even in Barbados, everything was covered with fine grey ash, resembling a fall of snow. The dust had penetrated into the interior of the houses, where it lay in a thin film on walls and furniture. In Kingstown there were stones as large as a hen’s egg; in Georgetown and Chateaubelair some had fallen as much as 1 foot in diameter. Little damage, however, appears to have been done to growing crops, except in the north end of the island. In fact, many believe that the sulphurous ash had insecticidal properties, and benefited the vegetation. From Chateaubelair it could be seen that the volcano was still emitting puffs of slaty coloured steam, and showers of fine dust were falling on the leeward side of the mountain. For several days these discharges of vapours continued, but a new phenomenon now attracted more attention. The ravines which furrow the south side of the mountain were found to be discharging clouds of vapour, and this gave rise to reports of fissures having opened on the flanks of the Soufrière, of subsidiary eruptions arising from these fissures, and of streams of lava flowing

down the valleys. As a matter of fact, they were really due to the action of water flowing through the hot sand, which in some places had almost obliterated the old stream courses, as will be explained more fully later on. By the 15th the volcanic activity had apparently subsided, and the mountain remained clear and unclouded. The explosions of steam in the valleys continued, and are probably still going on.

The state of quiescence continued till Sunday, May 18. Confidence was being restored, and the inhabitants of those districts near the mountain which had not suffered severely were returning to their homes. On the windward side, the work of burying the bodies had been completed and things were resuming their normal course. But about 8 o'clock that evening an ominous sound was heard from the crater. Its nature was at once recognised and struck the black population with terror. The noises were as loud as those of the first eruption, and the lightning was very vivid. On the leeward side complete darkness prevailed, and ashes and sand fell freely for some hours. In Georgetown the fall of ashes was quite inconsiderable, not exceeding a thin film on the roof of the houses. Gradually the noises lessened, the darkness lifted, and the moon appeared again. No lives were lost and practically no damage was done, but exactly what happened on those parts of the mountain nearest the crater it is, under the circumstances, impossible to say. This second eruption was the last which proceeded from the main crater. Clouds of steam were sometimes seen gently rising for some days later, but nothing of the nature of a volcanic outburst has since taken place.

We arrived at Kingstown on Tuesday, June 10, and proceeded at once to Chateaubelair, where Mr. Jas. E. Richards, of Kingstown, kindly placed a house at our disposal. The geological products of this eruption proved to be of very simple character. The Soufrière and the surrounding country were covered with a layer of ashes mostly in the form of fine dark coloured sand, but mixed with spongy bombs of various sizes and many ejected blocks composed of fragments of the old rocks of the hill. Lapilli and scoria are there in plenty, as is obvious where the heavy rains have washed away the finer material, but the greater part of the ejecta consist of fine sand which, when dry, is hot and yellowish-grey in colour, but when wet becomes almost black. This sand, as has already been noted by many observers, contains plagioclase feldspar, hypersthene, augite, magnetite, and fragments of glass, and represents a fairly well crystallised hypersthene-andesite magma which has been blown to powder by the expansion of occluded steam.

The coarser material is mostly a slaggy andesite with crystals of plagioclase and pyroxene. There is little pumice, though we obtained a few fragments which floated on water and contained but few crystals visible to the naked eye. The larger bombs are often black, highly

lustrous and glassy when broken across. Some were seen at Wallibu (4 miles from the crater) 3 feet in diameter. The ejected blocks consist of weathered andesites and andesitic tuffs such as can be seen in the walls of the crater. They are very numerous, and some are over 5 feet across. In addition to these, fine-grained dark-green banded rocks occur, which appear to be baked and indurated sediments, probably the mud from the bottom of the crater lake, or the finer beds intercalated in the older volcanic series. Another type of ejected block which is very common in some parts of the hill is a coarse-grained aggregate of felspar, hornblende (brown under the microscope), and perhaps olivine. It is not vesicular and contains little or no glass, being apparently holocrystalline. These rocks are very friable, and the crystals are loosely aggregated together. They seemed to us to be comparable to the sanidinites of the Eifel and many other modern volcanic districts. They are certainly quite unlike true plutonic diorites, both in their structure and in the character of their minerals.

It may be noted that none of these rocks are characteristic of this eruption, but all can be found among the older materials of the hill. The hardened, baked sediments were well known to the Caribs, who have long used them for the manufacture of their finer stone implements. The felspar-hornblende blocks were found by us among the older rocks, and in some places even as rounded masses enveloped in the old lavas. Some of the fresher bombs in the river beds and on the seashore can hardly be distinguished from those which were the product of this eruption, though undoubtedly of much older date.

At Kingstown, as in Barbados, the deposit of volcanic dust and sand was so slight that, owing to the heavy tropical rains, and the rapid growth of tropical vegetation, it readily disappeared, and when we arrived it was necessary to make careful search to find traces of it. In St. Vincent, to the south of Chateaubelair, on the leeward side, and from 2 miles south of Georgetown, on the windward side, the country had very much its normal appearance. To the north of these points, however, a sheet of volcanic ejecta covered the ground. Where it was thin it was rapidly disappearing. Every shower washed much of the finer matter into the streams, which were flowing full of sand and lapilli to the sea. In the fields the arrowroot was pushing up through the layer of ash, and covering it with a mantle of green leaves. Around Georgetown the deposit is from 1 to 3 feet deep, and some of the blocks are a foot in diameter. On some of the sugar-cane fields in the Carib country the ash lies 4 feet deep, while on the higher slopes of the hill it is from 5 feet to over 12 feet (where it has gathered in the hollows). On the leeward side the ash is very deep in the valleys of the Wallibu and Rozeau Dry Rivers, but north of Larikai it is much thinner, not above a foot or two. The north side of the

mountain has, for reasons to be subsequently discussed, received comparatively little of the deposit, and at Point Espagnol, Owia, Fancy and Quashie Point, along the north shore, the cliffs and the country for some short distance behind them are perfectly green and flourishing.

On the south side of the Soufrière a deep and broad valley has been eroded in the soft volcanic ash and agglomerate, of which this part of the hill consists. It runs almost across the island, between the Morne Garu Mountain and the Soufrière, and it is this valley which has received the greater part of the ejecta of this eruption. The streams which flow into it—the Wallibu River on the west and the Rabaca Dry River on the east—have had their courses filled with fine hot sand mixed with coarse bombs and ejected blocks. We were told that on the west side the ravine of the Rabaca Dry River had been about 200 feet deep. It is now almost entirely filled up, and the river is slowly cutting its way through the hot sand which occupies it. The same thing is happening in the Wallibu Valley, but here erosion is more advanced, and cliffs of grey hot ash, some 80 feet high, overlook the stream at a point about a mile above its mouth. On the flatter ground between the river gorges which trench these broad valley bottoms the deposit is very much thinner, perhaps 3 to 5 feet on the windward side, but often 12 feet, and sometimes 30 or 40 feet, on the leeward side.

The distribution and thickness of the recent ashes is not at all such as would have been expected had these materials merely rained down from above. Wherever there is a hollow it has been filled up, however deep. For some days after the eruption the stream valleys were level with their banks. On the flat ground the deposit is much thinner, and on the ridges and spurs which stand up prominently there was comparatively little accumulation. To the mind of a geologist examining these valleys one comparison was irresistibly suggested—they resembled nothing so much as a rugged country covered with blown snow. The ash had drifted into and filled up the depressions, while comparatively little had rested on the ridges between. It is conceivable that mud lavas flowed down at an early period in the eruption, and occupied the lower parts of the gorges; but we saw no evidence of this, and as wherever the deeper layers of the ash are exposed they are still burning hot, it is obvious that they could never have reached their present position in the condition of a mud lava. When we saw this country its surface had been deeply scored by the rains, but those who visited it shortly after the first eruption described it as having a smooth, gently rolling surface like that of blown sand. This is well shown in photographs taken by Mr. Wilson, of Kingstown, on May 14. The conclusion was forced upon our minds that immense quantities of hot sand had rushed down the hill into these valleys in an avalanche

which carried with it a terrific blast, and piled the ashes deep in the sheltered ravines, at the same time sweeping everything off the exposed ridges which lay between. The rain of volcanic material, which lasted for hours after the hot blast had passed, then covered the surface of the country with a final sheeting of fine dust and scoria.

When we ascended the Soufrière, the evidence of the passage of a hot blast laden with sand was overwhelmingly clear. The various stages of its action, and its varying intensity at different spots, are most easily observed on the windward side, where the country is more flat and open, and there are fewer ravines and spurs to modify the course of its operations than in the Wallibu Valley.

The track to the summit passes across the Rabaca Dry Valley near the shore, then turns upwards through the sugar-cane fields of Rabaca and Lot 14. These were covered with 3 or 4 feet of sand and scoria, the trees all bare, their leaves stripped by the falling cinders; but few branches were broken, and no trees had been uprooted or cast down. The woodwork of the houses was unburnt, though the roofs of some of the verandahs, and of the labourers' huts, had collapsed from the weight of ashes that had fallen on them. Many people were killed on these estates. The survivors described to us how the dark cloud had rolled down from the mountain, and how hot and suffocating the air had been when it enveloped them. But it was evident that the velocity of the blast was not above that of an ordinary gale, and the dust it carried, though hot, was not incandescent.

At Lot 14 it was seen that many trees had their limbs twisted off and broken, and some of the negroes' houses had taken fire (probably mostly from hot falling bombs). The blast was more violent here, but not hot enough to set fire to the woodwork or char the green wood of the standing timber.

On the flat ground above the plantation buildings (at an elevation of about 1000 feet), a further stage of devastation was encountered. The fields were here swept bare, the trees broken down though not as a rule uprooted, their smaller branches swept away; a deep layer of black sand covered the crops of sugar-cane. The blast was here a violent gale.

A little further up the effects of the blast were remarkable. Enormous trees had been uprooted and cast down. Their leaves and finer branches, of course, had disappeared. In every case the fallen trunks pointed directly away from the crater. Even the great cotton-trees, 10 feet or more in diameter, were broken off or uprooted. The smaller trees had in a few cases been swept away like straws. The larger were merely cast down, and lay side by side, their tops directed down the valley, their roots towards the summit of the mountain. Most were charred, some deeply, but, as the wood was green, only the smaller branches had been consumed. The effect was like that pro-

duced by a violent hurricane, only more complete, for many of these trees had withstood the hurricane which ruined St. Vincent in 1898. At the lower limit of this region some curious effects of the hot sand blast could be seen. Where any branches or trunks were still standing, they invariably showed themselves to be burnt and eroded on one side—that next the crater—the wood having been charred and the charred material removed by the action of a hot sand blast. On the side away from the crater, the original bark was still left, unburnt but dry and peeling off; that is, there had been no erosion on the sheltered or lee side of the stems. The wood was too green to take fire, but the sand had been sufficiently hot to char the surfaces which were exposed to it.

Further up the hill—that is to say, above the 1500 feet level, there was little left of the rich tropical vegetation which had covered it from summit to base. Blackened remains of tree-trunks were to be seen, overturned or broken off near the ground, and buried in dark sand. The highest parts of the mountain are as bare and desolate a scene as could be imagined. The ash is 5 to 12 feet deep, and though full of large blocks and spongy bombs, is mostly so fine that when thoroughly wet it becomes a mud, very tenacious and slippery, in which one sinks to the knee. In it there is a good deal of burnt timber, utterly blackened and converted into charcoal. Everything has been mown down, and at the same time the intense heat has consumed all the smaller fragments and charred the larger. There is nothing to show what was the velocity of the blast when it left the crater. After a couple of miles it was that of a hurricane or tornado. The limits between the zone of uprooted trees and that of trees still standing, but broken and much damaged, is surprisingly sharp. At 4 miles from the crater the blast was travelling at 20 to 40 miles an hour, and rapidly slowing down. This agrees with the evidence of an eye-witness who saw it when it reached the sea near Chateaubelair. It came over the water with a wave before it, but it did not overturn the small boats which lay in its course.

Another peculiar feature of this blast is the manner in which its course was modified by irregularities in the configuration of the ground over which it passed. To the north of the crater stands the encircling crater wall, already referred to as the Somma. There can be no doubt that a black cloud descended over this side of the mountain, though here the devastation is comparatively slight, and it is inferred that the high intervening ridge overlooking the crater served as a rampart and helped to protect the country behind it from the effects of the blast. The southern lip of the crater, on the other hand, is the lower, and the avalanche of hot sand seems to have poured over this lip almost like a fluid. Down the deep open valley between the Soufrière and the Morne Garu Mountain it rushed, ever



following the steepest descent. It clung to the valley bottoms and coursed along them in a manner which somewhat recalls a raging torrent in a river. The streams in these valleys after descending the first part of the hill turn sharply at a right angle towards the coast, deflected by the opposing mass of the Morne Garu. The hot blast mostly followed these valleys, and in them it piled up enormous deposits of sand, but part of it swept up the shoulders of Morne Garu, and tore up the heavy timber which was growing there. The direction in which the fallen trunks point shows that the blast was split into two parts—one taking the east and one the west side of the mountain, rushing upwards obliquely from below. The mountain protected the country behind, and the line of demarcation between the burnt and the green forest almost corresponds with the dividing ridge. The south side is green; the north side towards the Soufrière is devastated and burnt.

The effect of even comparatively small ridges in deflecting the blast and protecting the country behind them is still more noticeable near Chateaubelair. Between the Rivers Wallibu and Richmond there is a high dividing ridge. The northern valley (the Wallibu) is filled with ash and utterly burnt up, that to the south (Richmond Valley) is in large part green. One side of the dividing ridge is blasted; on the other the arrowroot is again putting out its green leaves. Another ridge separates Richmond Valley from Chateaubelair. This ridge has been in many places scorched, but the country behind it has been perfectly protected, and, though covered with the rain of ash, has resumed its normal appearance. There can be little doubt these ridges served to direct the path and intercept the violence of the hot blast.

For some days after the eruption no rain fell, and the first to visit the district were able to observe the effects of the eruption unmodified by the erosive action of running water. But on May 25,  $5\frac{1}{4}$  inches of rain fell. On the previous day the rainfall had been  $2\frac{1}{2}$  inches, and the rainy season now set in in earnest. The effect of these deluges acting on loose material lying on steep slopes was phenomenal, and by the time we reached the island the surface of the sheets of ash had been sculptured into innumerable furrows and runnels. They cut down through the incoherent sand to the layer of burnt vegetation on the old soil beneath, or even into this, forming new channels, which varied from a few inches to many feet in depth. To one fresh from a temperate climate and unaccustomed to the power of tropical rains the rapidity of denudation under these conditions was astounding. On the upper part of the Soufrière beautiful feather patterns of rain rills converging towards a central main axis everywhere characterised the surface. The knife edges between the valleys were the only parts retaining the original smooth surface, and they formed excellent paths, as the sand was firm, except near the summit of the hill.

On the windward side of St. Vincent so much material is being swept into the sea by the streams that the coast is covered with black sand, and near Overland Village it is possible to walk for a mile beneath the sea cliffs on a broad, sandy beach, where formerly the heavy surf of a weather shore beat against their base. In the arrowroot fields the original surface is often to a large extent uncovered, and on the upper slopes of the Soufrière there are many places where none of the new ash is left, but the bare surface of the old rocks is everywhere exposed to view. After a heavy tropical shower; valleys which are usually dry may be filled with a thundering torrent several feet deep, and 20 or 30 feet across. Under these circumstances it will easily be understood that already many of the streams have thoroughly cleaned out the ash from the upper parts of their channels where the gradient is steepest.

But when such a torrent reaches the lower valleys, which have been filled with thick masses of hot sand, a strange conflict between fire and water can be witnessed. The river ploughs its way deeper and deeper, constantly sweeping the material into the sea. The valleys, at first almost obliterated, are now reassuming their old appearance. Terraces on their sides give evidence of former levels at which the streams flowed. There are five or six such terraces on the Wallibu. This river flows in gushes of hot steaming black mud, its intermittent flow being due to small land-slides temporarily damming up its channel, only to be swept away as the pressure of the water increases. On the Rabaca Dry River there has been less erosion, and only after heavy rains does it reach the sea, as the water from the smaller showers is apparently evaporated in its passage through the banks of hot ashes. After rains, both rivers can be seen steaming all along the lower parts of their courses.

When one of these streams comes down in force it undermines its banks by washing out the soft new ashes at their base. Then land-slides take place, and a curious spectacle results. When the hot ash tumbles down into the water, an immense cloud of steam rises in the air to heights of hundreds of feet. It expands in great globular masses exactly like the steam explosions from a crater, and as it drifts away before the wind fine dust rains from the cloud. We had the good fortune to witness a magnificent series of these explosions, one day as we were descending from the summit of the Soufrière. It was in the valley of the Rozeau Dry River. After every land-slip a column of muddy water rose to about 200 feet carrying with it pieces of stone. Immense quantities of steam shot up to 700 or 800 feet in the air. It resembled an enormous geyser of black mud and steam. In the Wallibu River, after every shower, these steam explosions may be witnessed taking place on a large scale. After a few hours of dry weather they cease, though the river can still be seen to be steaming strongly as it flows along.

The structural modifications produced upon the hill by this eruption have been astonishingly slight. We saw no fissures, no parasitic craters or cones, and no lava streams. Even the craters at the summit retain essentially their old configuration. All the evidence points to the supposition that it was from the large or old crater that this eruption for the most part proceeded. But the smaller crater has not disappeared, nor has it been filled up. We did not see it, but we can rely on the evidence of several observers, who knew it well before the eruption, and have seen it since. The narrow ridge between it and the large crater still stands, though probably somewhat lower than before, and possibly is slipping down in land-slides on both sides.

Like all the higher mountains of the Windward Islands the Soufrière has usually its summit capped with cloud, especially during the rainy season, and this was the case on both the days on which we made the ascent. On the first occasion the mist lifted for a few minutes, and enabled us to obtain a glimpse of the bottom of the crater. Fortunately we had with us Mr. T. M. McDonald, of Richmond Vale, and Mr. Henry Powell, Curator of the Botanic Gardens at Kingstown, who were both well acquainted with the mountain in previous years. The crater was formerly nine-tenths of a mile across and about 1100 feet deep. Its inner slopes were steep and richly wooded. Its bottom was occupied by a lake, which is said to have been over 500 feet deep. The northern wall is now a naked precipice of rock, perhaps 2000 feet high, from the face of which rock-slides are frequently tumbling into the abyss below, with a loud noise. We did not get a clear view of it, but Professor Jaggard, of Harvard, U.S.A., who ascended shortly before we did, was more fortunate, and obtained some photographs which show that it consists of layers of tuff alternating with beds of lava. What seems to be a thin irregular dyke forms a prominent rib-like mass cutting across the bedding planes. The southern side slopes downwards for several hundred feet at an angle of about 40 degrees, and is covered with a thick layer of fine dark mud deeply grooved with rain channels. The lower part is a precipice of bare rock. The bottom of the crater is nearly flat or slightly cupped. When we saw it, it contained three small lakes of water, greenish and turbid; that in the south-east corner was throwing up jets of mud and steam with a hissing noise. It was in very much the same condition as when seen by the party which first ascended the mountain on May 31—that including Mr. T. M. McDonald and Professor Jaggard—and on a slightly later date by Lieutenant Robinson, R.E. Mr. McDonald thought that there was rather less steam, and the lakes of water were somewhat larger than when he saw it previously. In his opinion and that of Mr. Powell the crater was only slightly larger than before the eruption, but considerably deeper. The estimates of the depth varied a good deal, but it seems, on the whole, to be generally agreed that it is about 1600 feet.

Accurate measurements of the breadth or depth of the crater were, under the circumstances, impossible. As seen from Chateaubelair the outline of the lip of the crater has suffered many modifications, though none of these is of any great importance. It is agreed that the southern edge is now somewhat lower than it was before the eruption, and this is confirmed by our barometric measurements.

It is reported that since we left St. Vincent the amount of water in the crater has increased, and, should this continue, a lake will ultimately be formed not unlike that which previously existed there. When the cliffs which form the north wall have reached, by repeated rock-falls, a condition of adjustment and stability, and when vegetation has again covered the interior slopes, it is possible that the crater of the Soufrière will have regained very much of its old appearance. Should any one who knew it before then return to visit it, he will have difficulty in believing that it formed the orifice from which were emitted the tremendous explosions of May 7, 1902. It was as we saw it an impressive spectacle, its naked rugged walls of rock looking down on the steaming lakes below.

Apart from the changes which have taken place within the crater, and the deposits of ash which have formed in the river valleys, and on the surface of the hill, the only other important geological modification of the country has been the disappearance of a narrow strip of coast along the leeward side of the island. Near the mouth of the Wallibu and from thence northward to Morne Ronde, the sea has encroached on the land for perhaps 200 yards. Below Wallibu plantation there stood a village of labourers' huts on a low flat beach with a bluff behind. Here the sea now washes the foot of a cliff some 30 feet high. This cliff consists of soft tuffs covered with several feet of new hot ashes, and is in an unstable condition, as masses are constantly falling down from its face. In this way a new beach is now forming in front of it. It is agreed by those who knew the district before the eruption that not only has the old beach disappeared, which carried the village and the public road, but that part of the bluff behind has also subsided. We were informed by Mr. T. M. McDonald, who is intimately acquainted with this coast-line, that similar subsidences had also taken place, though on a much smaller scale, at several places further north. There is no evidence elsewhere of any changes of level of land and sea. The tide-marks on the rocks and the landing-stages at the villages enabled us to ascertain that the level of high-water was at any rate within a few inches of what it had been before. It was clear that the alterations in the coast line were due to local subsidence of the foreshores, and that they had mostly affected loose and ill-consolidated deposits, such as beach gravels and the fans of alluvium which had formed at the mouths of the streams.

The submarine slopes on the leeward side of St. Vincent are

very steep, averaging about 1 in 4. Often within half a mile of the shore, or sometimes even less, the depth is over 100 fathoms.

It seems most probable that owing to the concussions and earthquakes produced by the explosions, some of the less coherent accumulations on these steep slopes slipped bodily into the deep. On this supposition most of the facts would be explained, but at the same time it is possible that at Wallibu the inner margin of the depressed tract may be a fault line. It has a very straight trend, and it is a curious fact that this shore was formerly known as Hot Waters. This might indicate the existence of a fissure up which hot springs were rising.

When we arrived at Martinique, we had the pleasure of meeting Professor Lacroix, the head of the French Scientific Commission, which had spent some time in making a preliminary survey of Mont Pelée and the north end of the island; and from him we obtained much valuable information regarding the sequence of events and the geological consequences of the eruptions in that quarter. It was our intention to make merely such reconnaissances as would enable us in a general way to ascertain the points of difference and of similarity between the outburst of Mont Pelée and that of the Soufrière, and to see what light the phenomena in Martinique threw on the events which had happened in St. Vincent.

Both volcanoes are of the same type, simple cones with a large vent near the summit, and without parasitic craters. They are both deeply scored with ravines, and on their south-west sides there is a broad valley—occupied at Martinique by St. Pierre city, at St. Vincent by the Wallibu. It is in these valleys that the destruction has been most pronounced. In both, the recent eruptions have been characterised by paroxysmal discharges of incandescent ashes, and a complete absence of lava streams.

In St. Vincent, however, the mass of material ejected has been much greater, and a considerably larger area of country has been devastated than in Martinique. That the loss of life was not so great can be accounted for by the absence of a populous city at the foot of the mountain. Had St. Pierre been planted at the mouth of the Wallibu valley, there can be no doubt it would have been no less completely destroyed.

On Mont Pelée, we understand that a fissure has opened on the south side of the mountain between the summit and St. Pierre, from which the blast was emitted which overwhelmed the city. But on the Soufrière the old orifices have been made use of. The eruption of Pelée began with the flow of mud lavas, but none such were seen in St. Vincent. On the other hand, the hot blast which swept down on the devoted city was essentially similar to that which we have described as having taken place at the Soufrière. Both eruptions

produced principally hot sand and dust with a small proportion of bombs and ejected blocks. The evidence of the Captain of the "Roddam," and of the survivors of the "Roraima," affords a very good idea, of what happened in St. Pierre on May 8. An avalanche of incandescent sand was launched against the city. In the north-end, which was nearest the crater, the inhabitants were instantaneously killed, the walls of the houses levelled with the ground, and the town was ablaze in a moment. In the south-end the ruin was less. Those walls of the houses which faced the crater were demolished; those which run north and south still stood, even when we were there, after the second eruption. In this quarter also all were killed, except a prisoner who was confined in an ill-ventilated cell in the prison, but we were told that for some minutes after the blast had passed people were seen rushing about in the streets, crying aloud with pain, and many threw themselves into the sea to escape the agony of their burns. It must be remembered that a terrible conflagration followed the eruption, and for 36 hours the city was a burning pile. Another eruption followed on the 18th, and cast down many of the buildings which were left. Hence it was difficult to be sure exactly what were the effects of the volcanic blast, and what had to be ascribed to the conflagration. But we saw enough to satisfy us that the hot blast was probably no less violent here than at St. Vincent. An iron statue of the Virgin, standing on a stone pedestal on the wooded cliff overlooking the town, had been broken off and carried 40 feet away. It lay with the head pointing to the mountain, and the direction of the statue showed that the blast was travelling straight from the crater over the city. The cannon in the fort had been overthrown and had fallen away from the mountain, that is to say, in the same direction as the statue. The projecting ironwork of the verandahs of the houses was twisted and bent. The lighthouses were razed. The ships riding at anchor in the harbour, were lying side-on to the blast. Some were capsized, others had their rigging cut clean away; only the "Roddam" escaped, and she was near the south-end of the town. It was said that one man was blown clean off the "Roraima." The trees which were growing in the streets were uprooted and cast down. Many of them showed charring and sand-blast erosion on the side which faced the crater, while the lee side was still covered with the original bark.

During the minute or two which this blast lasted, so much dust fell on the "Roddam," that Captain Ford, the Harbour Master at St. Lucia, estimated that 120 tons were removed from her decks when she arrived there, and the Chief Engineer of the R.M.S. "Esk," who inspected her for Lloyd's, told us that the depth of the layer of ash was in some places 2 or 3 feet. Enough has been said to indicate the general similarity of the volcanic phenomena in Martinique

and in St. Vincent. A fuller comparison, and more particularly the investigation of the outstanding points of difference, is best deferred till the detailed results of the French Commissioners' investigations are to hand.

We were fortunate in having an opportunity of witnessing one of the more important eruptions of Mont Pelée before we left Martinique, and this enabled us to see how far the actual phenomena corresponded with the ideas we had been led to form from an inspection of the effects of the earlier outbursts. On the 9th July we were in a small sloop of 10 tons, the "Minerva," of Grenada, which we had hired to act as a convenient base for our expeditions on the mountain. The morning was spent in St. Pierre city, and among the sugar-cane plantations on the lower slopes of the mountain on the banks of the Rivière des Pères. The volcano was beautifully clear. Every ravine and furrow, every ridge and crag, on its gaunt naked surface stood out clearly in the sunlight. (See Plate 11.) Thin clouds veiled the summit, but now and then the mist would lift sufficiently to show us the jagged broken cliff which overlooks the cleft. From the triangular fissure which serves as the crater hardly a whiff of steam was seen to rise, and the great heap of hot boulders which lies on the north side of and above this fissure, could be perfectly made out. (See Plate 12.) Small land-slides took place in it occasionally, and small jets of steam rose now and again from between the stones.

A little after mid-day large steam clouds began to rise, one every 10 or 20 minutes, with a low rumble. As they rose they expanded, becoming club-shaped and consisting of many globular rolling masses, constantly increasing in number and in size as they ascended in the air. They might be compared to a bunch of grapes, large and small, or to a gigantic cauliflower. When their upward velocity diminished they floated away to leeward, and fine ash rained down in a dense mist as they drifted over the western side of the mountain. They occasioned no anxiety in our minds, as we had found that the mountain was never long without exhibiting these discharges, and they were due merely to an escape of steam carrying with it fine dust. They rose, as a rule, to heights of 5000 or 6000 feet above the sea.

That afternoon as the sun was getting lower in the heavens, and the details of ravine and spur showed a contrast of light and shadow which was absent at mid-day, we sailed along from St. Pierre to Prêcheur, intent on obtaining a series of general photographs of the hill. The steam puffs continued, and, about 6 o'clock, as we were standing back across the bay of St. Pierre, they became more numerous, though not much larger in size. We ran down to Carbet, a village  $1\frac{1}{2}$  miles south of St. Pierre, where there is a supply of excellent water and good anchorage. About half-past six it was obvious that the activity of the mountain was increasing. The cauliflower clouds were no

longer distinct and separate, each following the other after an interval, but arose in such rapid succession that they were blended in a continuous emission. A thick cloud of steam streamed away before the wind so laden with dust that all the leeward side of the hill, and the sea for 6 miles from the shore, was covered with a dense pall of fine falling ash. (See Plate 13.) The sun setting behind this cloud lost all its brightness, and became a pale yellowish-green disc, easily observable with the naked eye. Darkness followed the short twilight of the tropics, but a 4 days' old moon shed sufficient light to enable us to see what was happening on the hill-side.

Just before darkness closed in, we noticed a cloud which had in it something peculiar hanging over the lip of the fissure. At first glance it resembled the globular cauliflower masses of steam. It was, however, darker in colour, and did not ascend in the air or float away, but retained its shape, and slowly got larger and larger. After observing it for a short time, we concluded that it was travelling straight down the hill towards us, expanding somewhat as it came, but not rising in the air, only rolling over the surface of the ground. It was so totally distinct in its behaviour from the ascending steam clouds that our attention was riveted on it, and we were not without apprehension as to its character. It seemed to take some time to reach the sea (several minutes at least), and as it rolled over the bay we could see that through it there played innumerable lightnings. We weighed anchor and hoisted the sails, and in a few minutes we were slipping southward along the coast with a slight easterly wind and a favourable tide. We had, however, scarcely got under way when it became clear that an eruption was impending. As the darkness deepened, a dull red reflection was seen in the trade-wind cloud which covered the mountain summit. This became brighter and brighter, and soon we saw red-hot stones projected from the crater, bowling down the mountain slopes, and giving off glowing sparks. Suddenly the whole cloud was brightly illuminated, and the sailors cried, "The mountain bursts!" In an incredibly short space of time a red-hot avalanche swept down to the sea. We could not see the summit owing to the intervening veil of cloud, but the fissure and the lower parts of the mountain were clear, and the glowing cataract poured over them right down to the shores of the bay. It was dull red, with a billowy surface, reminding one of a snow avalanche. In it there were larger stones which stood out as streaks of bright red, tumbling down and emitting showers of sparks. In a few minutes it was over. A loud angry growl had burst from the mountain when this avalanche was launched from the crater. It is difficult to say how long an interval elapsed between the time when the great glare shone on the summit and the incandescent avalanche reached the sea. Possibly it occupied a couple of minutes: it could not have been much more. Undoubtedly the velocity was terrific.



Had any buildings stood in its path they would have been utterly wiped out, and no living creature could have survived that blast.

Hardly had its red light faded when a rounded black cloud began to shape itself against the star-lit sky, exactly where the avalanche had been. The pale moonlight shining on it showed us that it was globular, with a bulging surface, covered with rounded protuberant masses, which swelled and multiplied with a terrible energy. It rushed forward over the waters, directly towards us, boiling, and changing its form every instant. In its face there sparkled innumerable lightnings, short, and many of them horizontal. Especially at its base there was a continuous scintillation. The cloud itself was black as night, dense and solid, and the flickering lightnings gave it an indescribably venomous appearance. It moved with great velocity, and as it approached it got larger and larger, but it retained its rounded form. It did not spread out laterally, neither did it rise into the air, but swept on over the sea in surging globular masses, coruscating with lightnings. When about a mile from us it was perceptibly slowing down. We then estimated that it was 2 miles broad, and about 1 mile high. It began to change its form; fresh protuberances ceased to shoot out or grew but slowly. They were less globular, and the face of the cloud more nearly resembled a black curtain draped in folds. At the same time it became paler and more grey in colour, and for a time the surface shimmered in the moonlight like a piece of silk. The particles of ash were now settling down, and the white steam, freed from entangled dust, was beginning to rise in the air.

The cloud still travelled forward, but now was mostly steam, and rose from the surface of the sea, passing over our heads in a great tongue-shaped mass, which in a few minutes was directly above us. Then stones, some as large as a chestnut, began to fall on the boat. They were followed by small pellets, which rattled on the deck like a shower of peas. In a minute or two fine grey ash, moist and clinging together in small globules, poured down upon us. After that for some time there was a rain of dry grey ashes. But the cloud had lost most of its solid matter, and as it shot forwards over our heads it left us in a stratum of clear pure air. When the fine ash began to fall there was a smell of sulphurous acid, but not very marked. There was no rain.

The volume of steam discharged must have been enormous, for the tongue-shaped cloud broadening as it passed southwards covered the whole sky except a thin rim on the extreme horizon. Dust fell on Fort de France and the whole south-end of Martinique. The display of lightning was magnificent. It threaded the cloud in every direction in irregular branching lines. At the same time there was a continuous low rumble overhead.

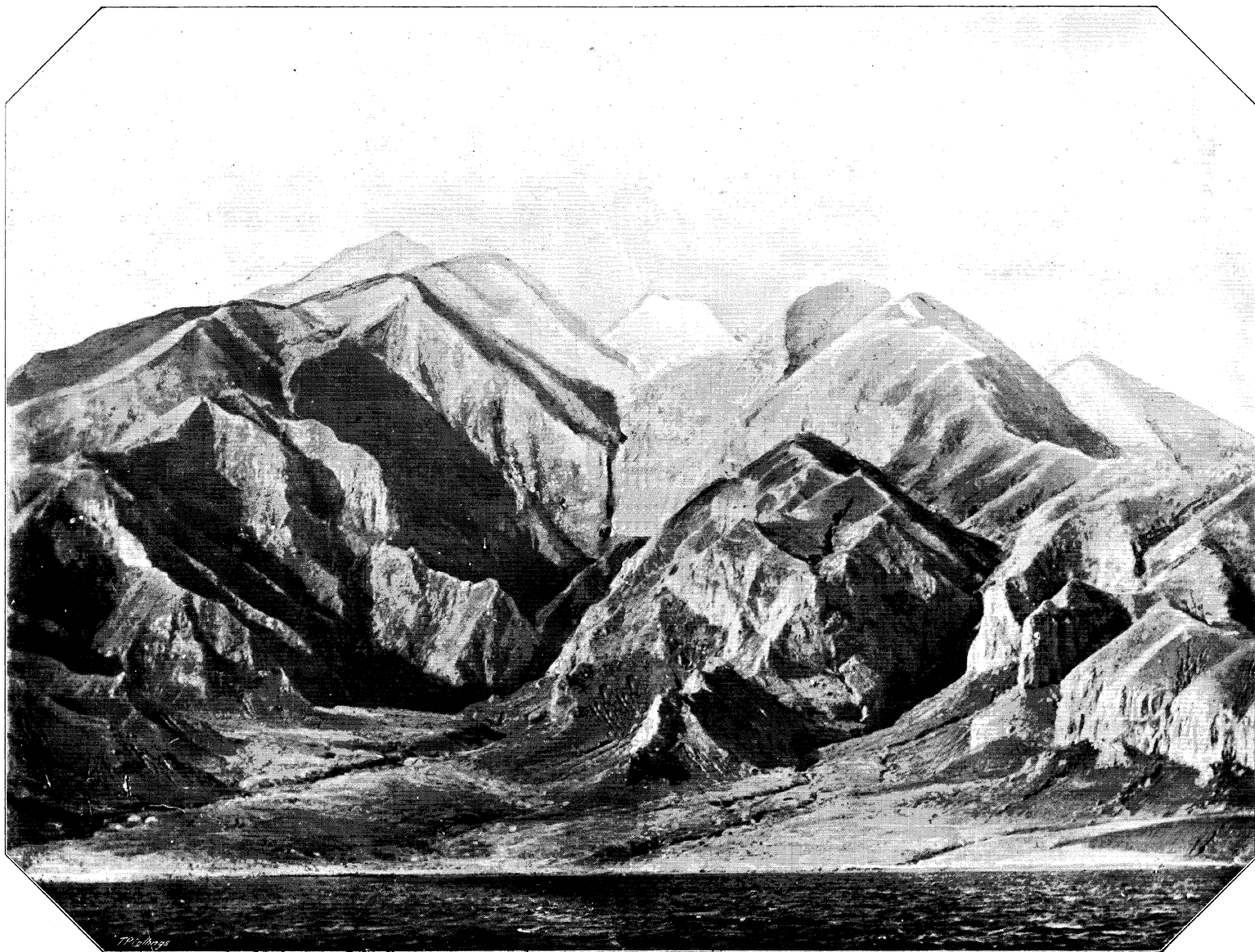
What happened on Mont Pelée after this discharge cannot be

definitely ascertained. For some hours afterwards there were brilliant lightnings and loud noises which we took for thunder. That night there was a heavy thunderstorm over the north-end of Martinique, and much of the lightning was atmospheric, but probably the eruption had something to do with it, and the noises may have been in part of volcanic origin.

There can be no doubt that the eruption we witnessed was a counterpart of that which destroyed St. Pierre. The mechanism of these discharges is obscure, and many interesting problems are involved. But we are convinced that the glowing avalanche consisted of hot sand and gases—principally steam; and when we passed the hill in R.M.S. "Wear" a few days later, we had, by the kindness of the captain, an excellent opportunity of making a close examination of the shore from the bridge of the steamboat. The south-west side of the hill along the course of the *Rivière Sèche* was covered with a thin coating of freshly fallen fine grey ashes, which appeared to be thickest in the stream valleys. The water of the rivers flowing down this part of the hill was steaming hot. This was undoubtedly the material emitted from the crater on the night of the eruption. There was no lava. We saw no explosions of combustible gases, and nothing like a sheet of flame. We were agreed that the scintillations in the cloud were ordinary lightnings which shot from one part of its mass to another, and partly also struck the sea beneath.

The most peculiar feature of these eruptions is the avalanche of incandescent sand and the great black cloud which accompanies it. The preliminary stages of the eruption, which may occupy a few days or only a few hours, consist of outbursts of steam, fine dust, and stones, and the discharge of the crater lakes as torrents of water or of mud. In them there is nothing unusual, but as soon as the throat of the crater is thoroughly cleared, and the climax of the eruption is reached, a mass of incandescent lava rises and wells over the lip of the crater in the form of an avalanche of red-hot dust. It is a lava blown to pieces by the expansion of the gases it contains. It rushes down the slopes of the hill, carrying with it a terrific blast, which mows down everything in its path. The mixture of dust and gas behaves in many ways like a fluid. The exact chemical composition of these gases remains unsettled. They apparently consist principally of steam and sulphurous acid. There are many reasons which make it unlikely that they contain much oxygen, and they do not support respiration.

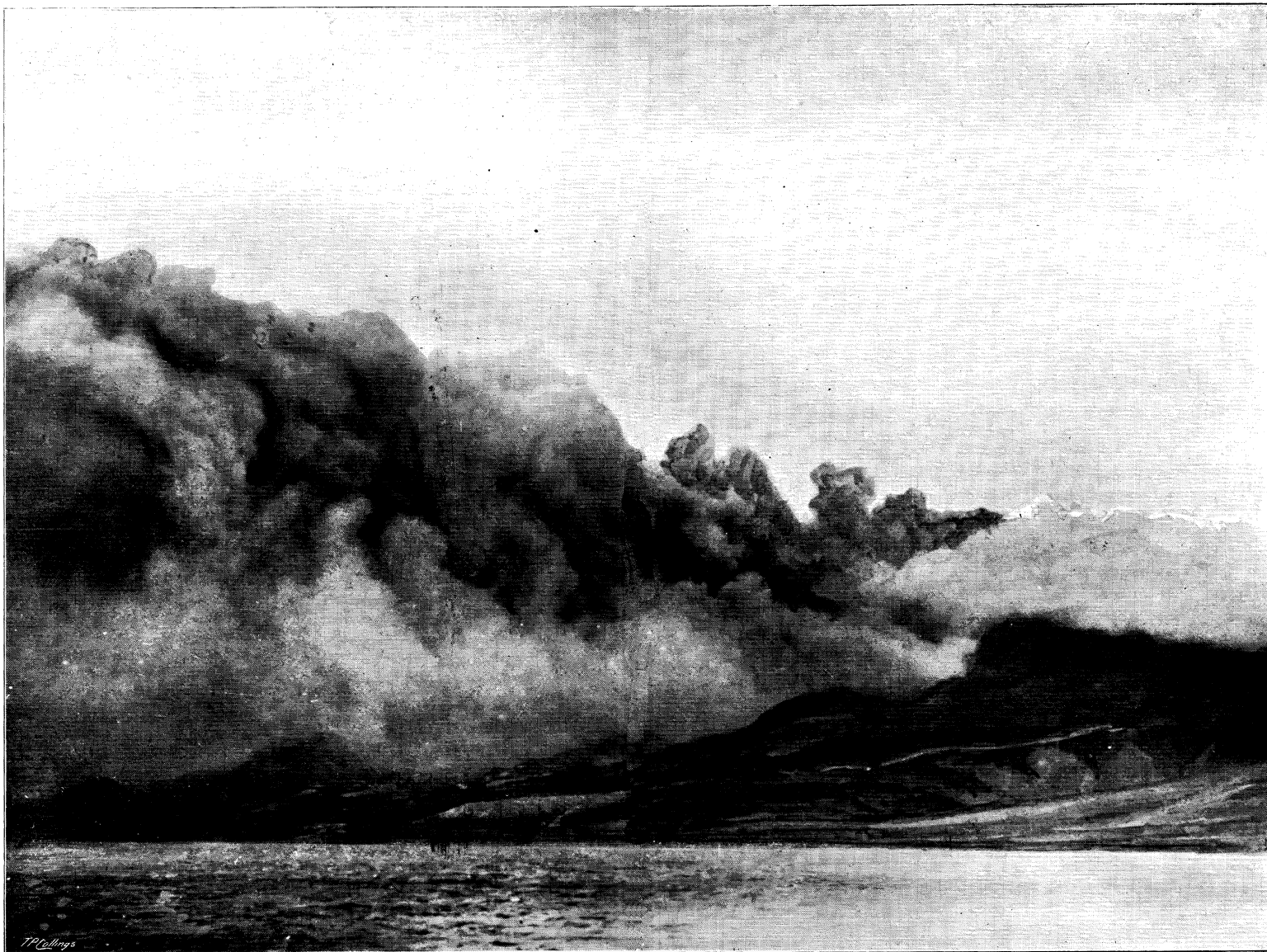
After visiting Martinique we proceeded to Dominica, where Dr. Flett visited the Soufrière at the south-end of the island, and the famous Boiling Lake and Grand Soufrière. There have been few signs of increased volcanic activity here or in St. Lucia during the recent eruptions. Dr. Tempest Anderson spent some days in



MONT PELÉE FROM THE W.



MONT PELÉE FROM THE S.W.



*TP Collings*

MONT PELÉE IN ERUPTION.



Grenada in an examination of the lagoon at St. George's, but particulars regarding these islands may be reserved till a fuller report appears.

## DESCRIPTION OF THE PLATES.

### PLATE 11.

#### MONT PELÉE FROM THE WEST.

Taken from the sea near Prêcheur, a village north of St. Pierre. This view shows how the mountain is cut up into deep ravines by the tropical rains. Part of the summit is concealed by clouds, and the fissure from which the eruption was proceeding was apparently behind and to the right of the small central peak.

### PLATE 12.

#### MONT PELÉE FROM THE SOUTH-WEST.

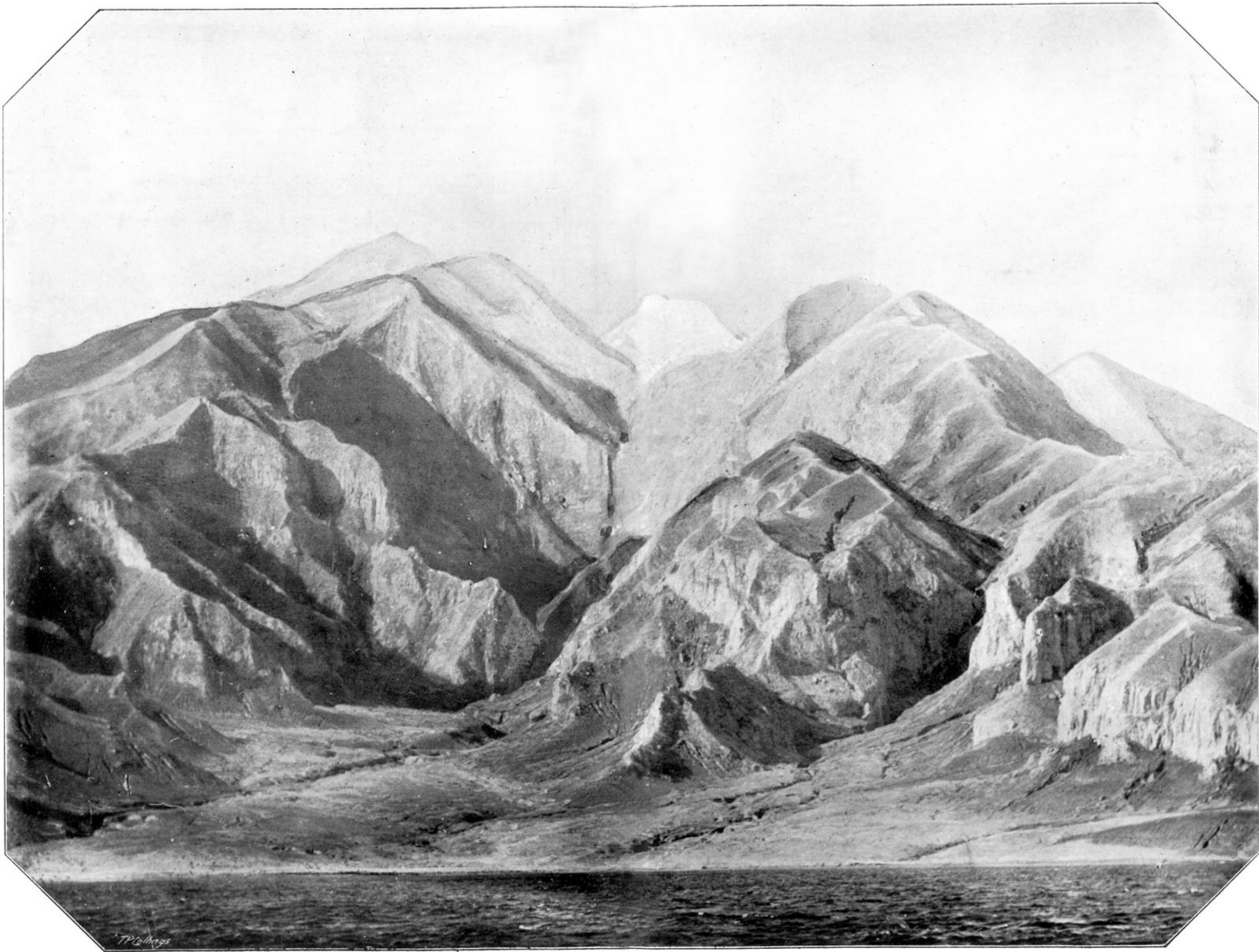
This photograph was taken from the sea off the mouths of the Rivière Sèche and Rivière Blanche, which are about 2 miles north of St. Pierre. It shows the rugged character of the mountain, the summit of which is concealed by clouds. The slope in the foreground is the track of the avalanches which descended from the triangular (light-coloured) fissure to the right of the central peak.

### PLATE 13.

#### MONT PELÉE IN ERUPTION.

Taken from a sloop off St. Pierre on the afternoon of July 9. It shows the "cauliflower" shapes assumed by the clouds of dust and steam as they drifted westward out to sea. The lighter-coloured cloud to the east (or right) is the trade-wind cloud which so constantly covered the summit. A small light-coloured cloud-patch just below this, on the right-hand (eastern) side, indicates the fissure from which the eruption chiefly proceeded. The eruptive "avalanche" of volcanic material descended the slopes in the centre and rather to the left of the foreground. St. Pierre is to the right, outside the picture.

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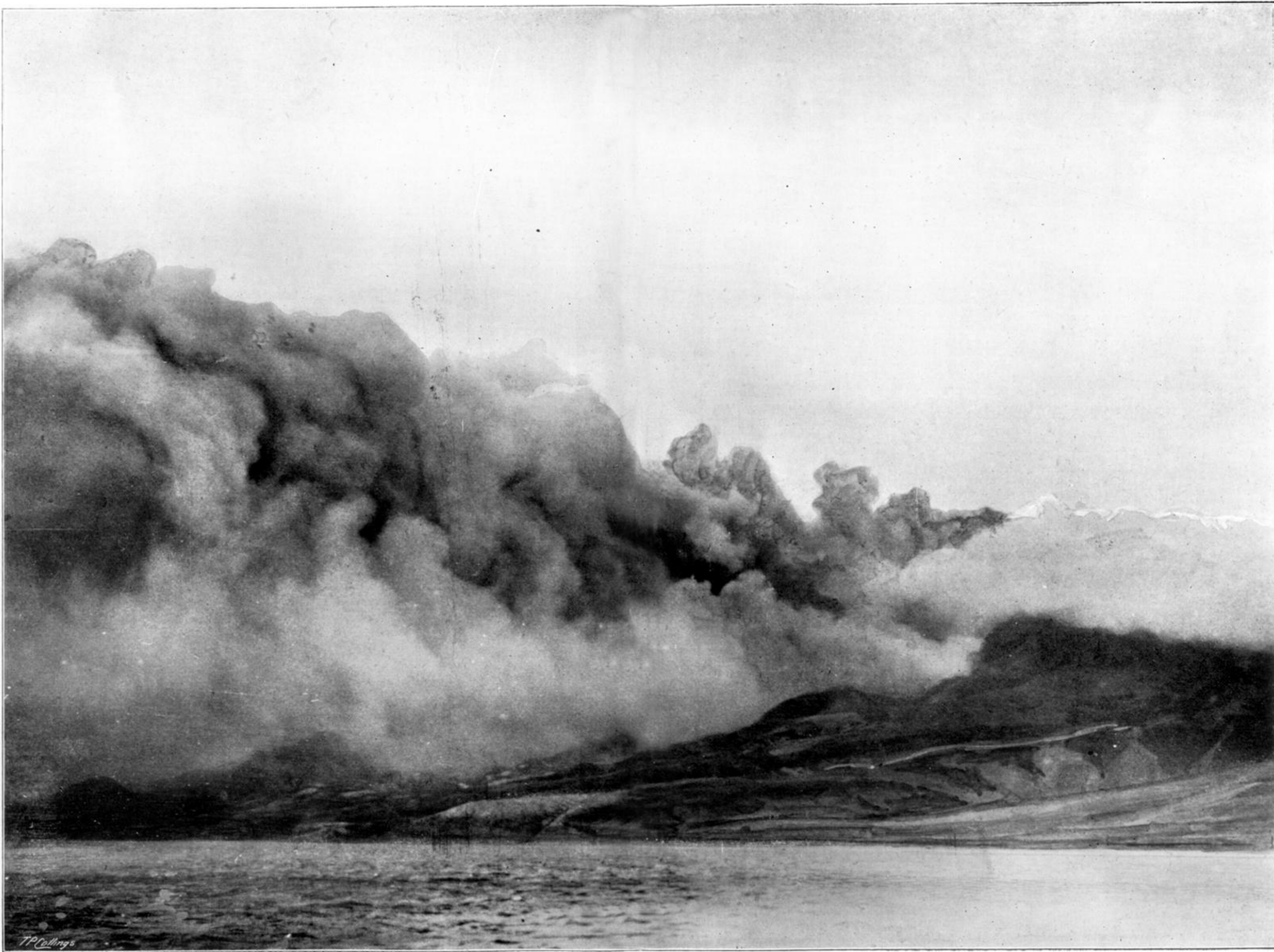
MONT PELÉE FROM THE W.





MONT PELEE FROM THE S.W.





MONT PELÉE IN ERUPTION.