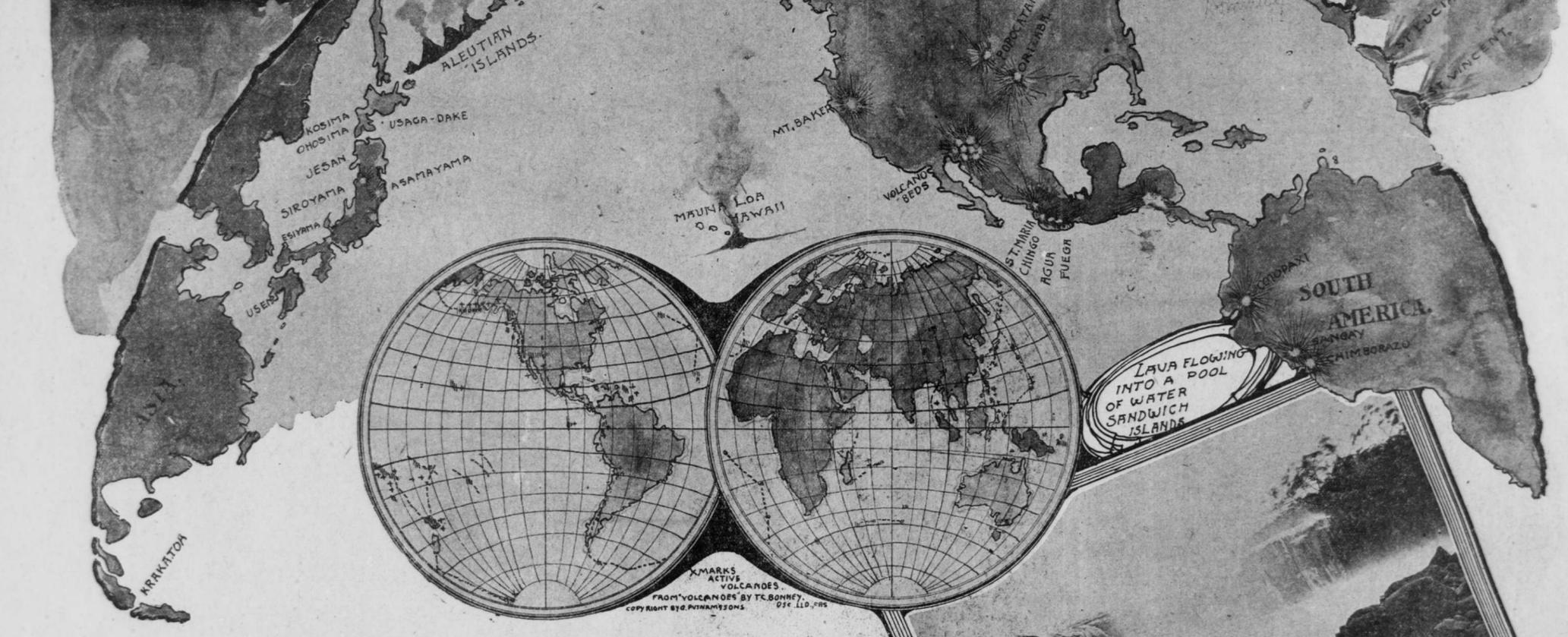


DANGER SPOTS ON THE EARTH'S CRUST



By Dr. J. W. Spencer, author of "Reconstruction of the Antillean Continent," "Geological and Physical Development of the Windward Islands, Cuba, Jamaica, Etc.," "The Duration of the Niagara Falls" and "History of the Great Lakes."

Dr. Spencer, accompanied by Mrs. Spencer, has just reached Washington, after a winter spent in Mexico and Guatemala, where the earthquakes and volcanic eruptions, recently reported, occurred, and indeed, one of the hotels where they stayed is among the buildings destroyed. Five years ago they spent the winter in the Windward Islands and were at Martinique, being for two days at St. Pierre. The investigations which called Dr. Spencer to Central America included a study of the stupendous changes of level of land and sea in recent geological times and the object in visiting Central America was for the study of the physical features of that region in comparison with the submarine features of the Windward Islands, so vividly presented to the public at the present moment.

Many years ago in my investigations of the origin of our great lakes it was found that the continent stood at least 3000 feet higher than at the present time during the ages when the great lakes' valleys were being carved out by the rains, rills and rivers. These investigations revealed the occurrence of deep, riverlike valleys extending seaward across the submerged margin of the continent. Carrying the investigations farther south to the coast of Florida and the Bahama Islands and Cuba, it was found that these submerged valleys form the continental rivers, barrancas and canyons, such as are seen at the Grand Canyon of the Colorado, in Arizona, and in Central America. Such valleys originate in high plateaus of 6000 to 10,000 feet altitude and extend down to low level plains and the sea.

As these valleys extend down to the floor of the Gulf of Mexico and the Caribbean Sea they become evidence that the West Indian Islands once stood as high as these riverlike valleys are now submerged beneath the sea. Thus the investigation showed that the Windward Islands and the Bahamas and, indeed, the whole eastern part of the American continent stood once at more than two miles above the present altitude. Herein, as we shall see, lie the causes of the volcanic disturbances resulting in such great disaster.

Gulf of Mexico Drained Into Pacific.

At the time North and South America were bridged together by way of the Windward Islands Mexico and Central America were low and the valley of what is now the Gulf of Mexico was drained into the Pacific Ocean across Mexico by way of the Tehuantepec isthmus, and the valley of the Caribbean Sea discharged its waters into the Pacific Ocean. Then the Windward Islands formed the backbone of the now submerged continent. While this continent existed long before the historical period, yet from the standpoint of the geologist it was very recent, so that in the early glacial period North and South America were connected and stood at an altitude of two miles or more. During the changes of level of land and sea, which occupied a long period, there were many migrations of animals be-

tween the two continents, such, for instance, as the small elephant found in Guadeloupe; other animals in Anguilla as large as Virginia deer and the remains of extinct animals reached even the region of Philadelphia from South America by way of this bridge in the early pleistocene period. During this period of high elevation the deep canyons were formed upon the surface, which cut up the continent now forming the Windward Island region into a number of hills and valleys, which, upon the subsequent subsidence, left only the isolated chain of islands which we call the Windward group; but the subsidence reduced even these islands to a smaller area than we now find, owing to the subsequent rise in the land, which enlarged their area, but the drowning of the island land just mentioned, and which occurred in the middle of the pleistocene period, after the early glacial epoch, exterminated the animals of the islands, which have not since been repopulated, as such could not migrate thither from either continent owing to the broad intervening straits.

Represent the Sunken Continent.

In a general way, the Windward Islands represent the sunken continent. Central America and Mexico illustrate the earth's movements accompanied by volcanic activity of the western region which has been raised into high plateaus, while the eastern region had been sinking. Thus in that region we can see a repetition of the features discovered by the soundings about the Windward Islands.

These two great lines of volcanic activity, situated of miles apart, have no connection with each other whatever, and the coincidence of stupendous activity occurring in the two localities only goes to show that terrestrial movements are now in progress along both margins of the continents. These movements are along lines of weakness. In the first place, great heat is developed by the great friction. In the second place, these weak lines facilitate the escape of the molten matter which may arise, either through a friction of the earth's crust or from the cisterns of lava beneath.

While the volcanic eruptions are more

or less restricted in the area of action and to the distance occupied by the chains of cones, the earth movements are very much more widely felt in the form of earthquakes. Indeed, the slipping of even one inch in the rocks at considerable depth may produce a very damaging earthquake over hundreds of miles of extent, and the volcanic activity compared with the earthquake shocks gives only a very limited evidence of the great earth movements in progress, which are very slow.

Returning now to the Windward Islands proper, we find a double chain of islands extending from near the coast of South America to the St. Martin group, and thence swinging around to Porto Rico, Hayti and Cuba, on one side and the Bahamas on the other until they almost join our Southern States. Indeed, they would do so were not the old river valleys completely submerged. The inner chain of these islands begins with the Grenadines, near the coast of South America, a vast number of small islands rising above a submarine plateau now less than 200 feet below the sea.

A Chain of Volcanoes.

Continuing in this chain are St. Vincent, St. Lucia, Martinique, Dominica, the mountainous portions of Guadeloupe, Nevis and the island of St. Kitts, beyond which the chain becomes broken down into the numerous virgin islands rising up out of a shallow sea. From Granada, in the Grenadines, to St. Kitts, there is a repetition of volcanic cones, rising to heights of 4000 or 5000 feet. Eastward of this chain we find Barbadoes, some granite banks east of Martinique, Grande Terre, or the great limestone plains of Guadeloupe, parts of Antigua, Barbuda, St. Martin and Anguilla. The chain ends in Sombrero, the lonely lighthouse to the West Indies; but again begins in the Bahamas, the remains of great coastal plains like those along our Atlantic, which escaped the destruction of the West Indian region when it stood at the elevation formerly mentioned. This outward chain is nowhere volcanic, but it is liable to earthquake action, and throughout these islands great damage is periodically produced.

Some of the earthquakes of these islands arise directly from the volcanic activity of the inner chain. They come from the slipping of the earth's crust, such as that at Charleston, far removed from volcanoes. There is no reason to suppose, however, that our Atlantic border should be permanently free from earthquakes any more than the coast of Carolina.

It must not be supposed that the whole of the Windward chain was born of volcanoes such as we see in the elevated peaks of to-day. In fact, the foundations of all are of very great age, although they were carved out by the atmosphere and the rains from older volcanic materials, but so ancient as not to be the ancestors of the modern cones. Indeed, the southern part of Martinique,

most of St. Lucia, St. Vincent and the foundations of Dominica belong to the ancient formation, but the volcanic cones mentioned had their birth no longer ago than about the beginning of the early glacial period.

Since the historic period some of the islands have never been in activity, although the cones and craters are complete, such as St. Kitts and Nevis. Many eruptions have been recorded in the mountains of Guadeloupe, but I believe none has occurred there since the earlier part of the nineteenth century. Dominica had a great eruption about 1830, but Martinique was supposed to be quiescent until the recent indications, a few months since, the neighbor, St. Vincent, erupted in 1912, and darkened the sun for a period of eighty-three days at Barbadoes, a hundred miles away, when the whole surface of that island was covered with the ashes.

St. Vincent Isle of Calamity.

The island of St. Vincent is one of the most beautiful of the group, but at the same time is one of the most calamitous. Three or four years ago a hurricane swept over it, when every tree is said to have been broken off, buildings destroyed and even the insects swept from the land, and now we find another destruction scarcely inferior to that of a century ago.

In the island of Martinique we find the northern side of Mont Pelee gently descending in the form of sloping plains to the sea, with here and there a baby volcano. On the western side of the mountain the descent is comparatively steep, and we find a high, elevated terrace just back of the town of St. Pierre, which lay on a narrow ledge between the terrace and the sea. This terrace, however, is bisected by the valley of the mountain torrent, which made an excellent pathway for the lava, and the volcanic mud which overwhelmed the city. In these volcanic eruptions the great danger is not so much the streams of lavas as from the clouds of mud formed by the condensing steam and hot ashes blown off the top of the mountain by the infiltration of waters into the molten lava itself.

The greater West Indian islands have scarcely any traces of volcanic eruptions except in ancient times. Whole sheets of igneous matter occur along the eastern sides of our North and South American mountains, still there are no remains of volcanic cones in Eastern America except a few in the vicinity of Montreal, which is built upon the flanks of an ancient volcano.

The changes of level upon the Pacific coast of North and South America have been much more stupendous in later times than those on the eastern side, and consequently we find many more and greater volcanoes. Many of these are frequently in a state of activity. Thus we find Orizaba, a cone rising 10,000 feet above the level of the sea. Colima, only a short distance south of Mexico City, is frequently in eruption.

In Guatemala, Santa Maria, which gave rise to the terrible destruction in April, 18, began to be active last November, and is now said to be more active than any volcano known in America since Spanish occupation. While that is near the Mexican frontier, Chingo, on the Salvador border, is also in a state of general activity.

Never So Many Eruptions as Now.

Again in Alaska another volcano is in eruption. So many widespread eruptions in the northern continent have never been known in the historic period.

Some twenty-five miles south of Guatemala City is the old site of the city itself, one of the most magnificent spots in the world, and being a most delightful climate. Nestled in a beautiful valley among the mountains lies the city of Antigua. From one side rises the great solitary volcanic cone of Agua, while a little further away, on the other side, is the volcano of Fuego and its companion. Fuego is said to be always hot. The crater of Agua was filled with water when in the middle of the sixteenth century it burst and overwhelmed the original site by a flood and buried it in volcanic ashes. The city was moved three miles farther away and grew to be one of great magnificence. In 1781 an earthquake leveled it, leaving the ruins of seventy-six churches alone, some of great magnificence. Then the city was moved to its present site, twenty-five miles away over the mountains.

While there have been many great eruptions recorded, still there have been only two eruptions vividly before us equal to that of ancient Vesuvius, and both of these within our memory—that of

Martinique last week and the still greater eruption of Krakatoa, in the Straits of Sunda, southeast of Asia, in 1883. So great was the eruption of Krakatoa that it filled the atmosphere of the whole world with a number of fine particles by which months produced the crimson glow of sunrise and sunset, so noticeable even in this country. At that time a wave was produced in the sea which overwhelmed

many cities on the neighboring coast and St. Vincent, early activity would not be expected. While the volcanic activity of the Windward Islands appears to be dying out, still all those mentioned as having cones are liable to reawakening activity, but less so than those at the extreme northern end of the chain. The tension on earth's crust having been somewhat re-

lieved by the eruptions at Martinique and St. Vincent, early activity would not be expected. Wherever there are chains of cones, with one occasionally active, there is always danger of other cones bursting into eruption, and most dangerous of all are those peaks which have been quiescent so long that their dangerous character has been forgotten.

UNCERTAINTY OF VOLCANOES!

BY PROFESSOR HENRY SHALER WILLIAMS OF YALE.

REALLY, there is absolutely no telling what the volcanoes may do," said Henry Shaler Williams, Silliman professor of geology in Yale University. "They are not well understood by any one, for the laws upon which they operate are not well known. There are certain signs by which experts can tell within a comparatively short time what some of them are likely to do; but in the instance of other volcanoes they may break forth without any warning at all."

"Speaking only from what I have read of the recent eruption in Martinique, and from what we know geologically and historically of the region, I am of the opinion that inasmuch as there was more than one eruption, it appearing that there was also one on St. Vincent, there will be no immediate successive eruption. The tendency will be to subside, now that some relief has been afforded the volcanic forces beneath the surface."

"A volcanic eruption is, on a grand scale, an explosion caused by the generation of steam in the great boiler under the surface. I am of the opinion that the vicinity of the island of Martinique, through which water either percolated for many years or by the subsiding of the sea a great inrush of water took place. The fact that the sea is said to have sunk a number of feet there would seem to indicate that there is a very great crack or crevice somewhere, and that the water that rushed in was great in volume. That produced a generation of steam which found vent through the craters of the two volcanoes. "Cut in our own Yellowstone Park the geysers are instances of this steam generation. The volcanoes there have not been active for thousands of years, but the earth has not cooled very far down yet, and the steaming water that spouts out and up is in the nature of its action volcanic. In Mexico not very long ago there was one volcano, long inactive, upon which the rocks were still so hot that one could light a cigar by touching the end of it to the stone. The modern scientific theory of the emission of lava is simply that the tremendous pressure upon the rocks, down a few miles, is so great that despite the intense heat they are kept not quite molten, almost solid, perhaps. "When the explosion takes place, relieving the pressure, it happens oftentimes that the rocks turn from their solidified state to a molten condition. Men spoke of

the red hot mud that poured down the mountain. When that matter comes to the cooler air at the surface, especially if there is water with it, it is broken up into fine particles by atmospheric influences, and falls for great distances in the form of what people describe as ashes. They are not ashes, however, but particles of lava. "As to whether there will be sympathetic action of volcanoes in other parts of the world, I rather doubt that. I think the easement is local, as was the disturbance, and that there will be no effect at any great distances. The thunder and lightning which accompanied, or followed, the eruption in Martinique were due to the fact that the tension of the electric forces in the air was disturbed. The disturbances in the center of the earth being very great and having an upward tendency in relieving, there follow great changes in the configuration of the territories. Great masses of rocks slide and the earth opens. That is an earthquake effect. It is possible that those effects are felt at great distances. "Volcanoes are peculiar in their action. We really know but very little about them. Scientists collect all the data possible and study them carefully, but unfortunately it is not possible to study them in action with safety. You know down at the bottom of the rich Cornucopia lode, the atmosphere is still so hot that it costs more to cool the air than the gold is worth when mined, and volcanoes have not been active in our country for a long time."

THE MYSTERY OF "VULCANITY."

VULCANOLOGISTS" of to-day are as much at a loss to define the volcano as were the geologists and astronomers of the days of Darwin. "Vulcanity" is as much a stupendous mystery to the Christian students and observers now hurrying to the scene of the unparalleled disaster at Martinique as was the new coined word of heathen origin to the Latin survivors who gazed in awe upon the ruins of Pompeii. Similar were the conditions; similar the ignorance of the spectator.

Among the first and best equipped of special students to leave for St. Pierre was Dr. E. O. Hovey, curator of the department of geology in the American Museum of Natural History. I found him rushing to make ready for his departure the next day on the Government relief ship Dixie.

There was only one time for him to speak in a general way of the previous investigations of leading geologists. He was mindful mostly of the large opportunity opening to him for personal observation, but he outlined certain salient results of the studies of such men as Professors Dana, Russell, Judd, Bonney and Hill, the last named having prepared a monograph on volcanic conditions in the West

Indies. From Dr. Hovey's suggestions and other sources this sketch of the known facts about volcanoes has been carefully compiled.

The number of great habitual volcanic vents upon the globe is estimated at between three hundred and three hundred and fifty. There is but one on the whole continent of Europe, Vesuvius, although elsewhere in the Mediterranean there are six—Stromboli and Vulcano, in the Lipari Islands; Etna, in Sicily; Grahams Island, a submarine volcano off the Sicilian coast, and Santorini and Nisyros, in the Aegean Sea. The African continent is known to contain ten active volcanoes, four on the west and six on the east coast, and there are about ten others on neighboring islands. In Asia there are twenty-four active volcanoes, but no less than twelve of these are situated on the peninsula of Kamchatka. There are no volcanoes in Australia.

The American continent contains more than the countries of the Old World—twenty in North America, twenty-five in Central America, and thirty-seven in South America. Thus, taken altogether, there are about 117 volcanoes on the great continents and nearly twice as many on the islands scattered over the several oceans.

These volcanoes usually assume in their distribution a linear arrangement, and nearly all of them have been thrown up along three well-marked bands and the branches proceeding from them.

The whole eastern coast of both the Americas was thought to be entirely free from volcanoes of anything like recent date, and, just as Professor Judd a few years ago complacently asserted, "as a matter of fact, the actual amount of damage to life and property which is affected by volcanic eruptions is small," so Professor Benney declared that the whole western border of the Atlantic is destitute of volcanic activity, "were it not for the long island chain of the Lesser Antilles which separates that ocean from the Caribbean Sea."

R. T. Hill made a special study of conditions in the Windward Islands. It had been well known that many of the West Indian islands are of limestone, chiefly coralline; that some contain crystalline rocks, while others are volcanic. Quate recently it was noted that seven craters still gave signs of life by emitting steam and that the curving line of volcanic vents occurred on a submarine plateau between the deep basin of the Central Atlantic and that of the Caribbean Sea. The activity of the Soufriere on St. Vincent was remarked years ago.



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