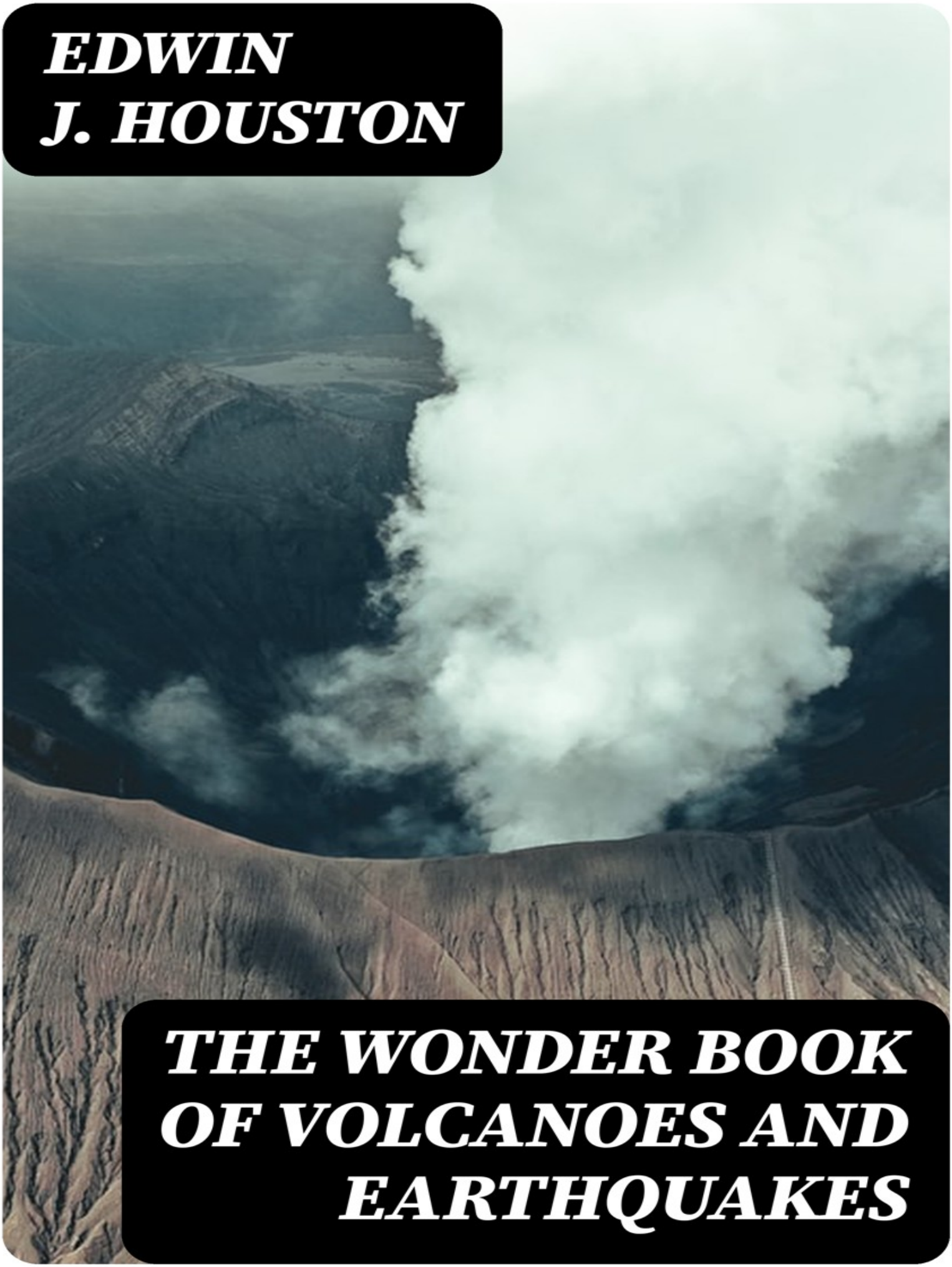
EDWIN J. HOUSTON



THE WONDER BOOK OF VOLCANOES AND EARTHQUAKES

Edwin J. Houston

The Wonder Book of Volcanoes and Earthquakes

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CHAPTER I

THE VOLCANIC ERUPTION OF KRAKATOA IN 1883

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Krakatoa is a little island in the Straits of Sunda, about thirty miles west of the island of Java, and nearly the same distance east of the island of Sumatra. It is uninhabited and very small, measuring about five miles in length and less than three miles in width. Its total area is only thirteen square miles. This little piece of land made itself famous by what took place on it during the month of August, 1883.

Krakatoa is one of the many islands that form the large island chain known as the Sunda Islands. The most important islands of this chain are Sumatra, Java, Sumbawa, Flores, and Ceram. Between Sumatra and Java, the largest two of these islands, there is a channel called the Straits of Sunda that connects the waters of the Indian Ocean with those of the Pacific Ocean. The Straits of Sunda is an important piece of water that forms one of the great highways to the East. Shipping is, therefore, always to be found in its waters.

As can be seen by the map, Krakatoa is not far from the Equator, being situated in lat. 6° 7' S. and long. 105° 26' E. from Greenwich. Since there are about sixty-nine miles in every degree of latitude, Krakatoa is about 420 miles south of the Equator, and is about twenty-five miles from Java. Java is part of the Dutch East Indies, which includes Java, Celebes, the Spice Islands, and parts of Borneo and

Sumatra. Batavia, the principal seaport of Java, near the northwest coast, is a great shipping centre, visited by vessels from nearly all parts of the world. It has, however, no harbor, but is approached from the ocean by means of a canal two miles in length, the sides of which are provided with massive brick walls. Besides Batavia, which is situated about one hundred English miles east of Krakatoa, there are many smaller towns or villages, the most important of which is Anjer, a thriving seaport town, where sailing vessels obtain their supplies of food and fresh water. Before the eruption of Krakatoa, Anjer was provided with a strong, stone lighthouse.

Java is especially noted for its production of coffee, in which it is second only to Brazil. Its area is about the same as that of the State of New York. Java is one of the most densely populated parts of the world, containing nearly four times as many people as the whole State of New York.

These facts about the situation and surroundings of Krakatoa are necessary to an understanding of the wonderful thing that happened on it during the month of August, 1883. In that month Krakatoa suffered a most tremendous explosive volcanic eruption, for it is a volcano.

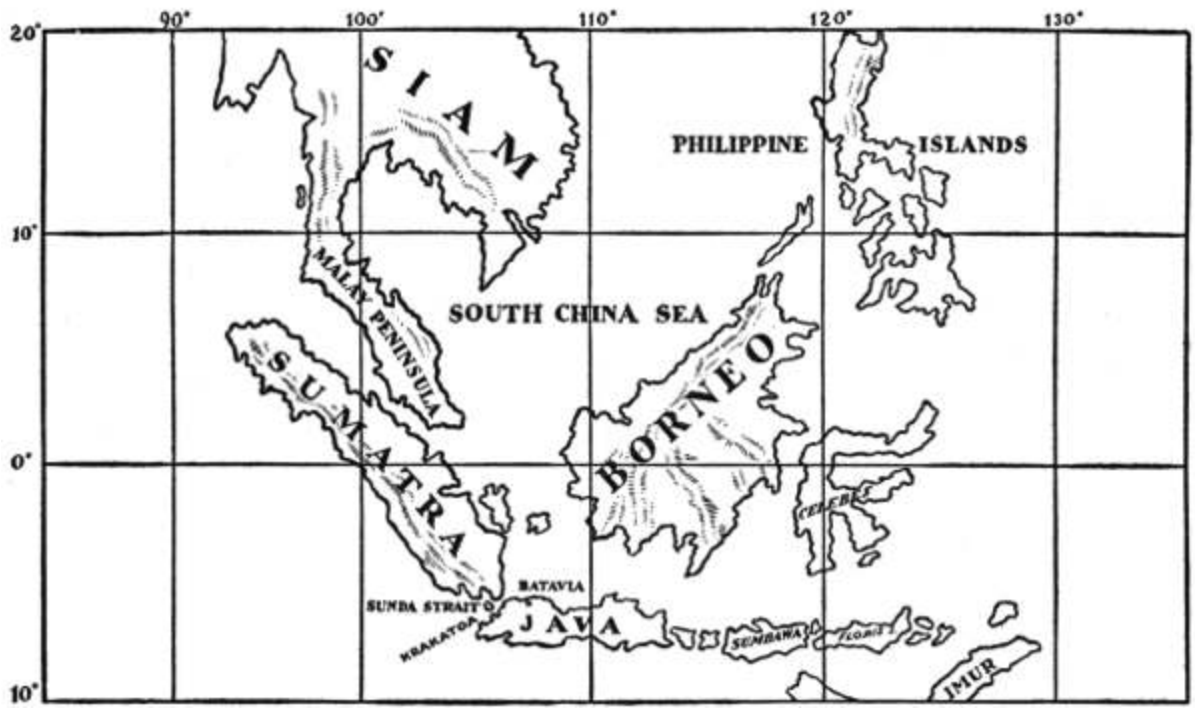

FIG. 1. THE SUNDA ISLANDS

A volcano is a mountain or hill, generally conical in shape, having at the top a nearly central opening, called a *crater*, from which at times melted rock and lava, vapor and gases escape. The lava either flows down the side of the mountain in a liquid condition, or is thrown upwards into the air. If the distance the lava is thrown upwards is sufficiently great the melted matter solidifies before it falls to the earth. In such cases the largest fragments form what are called *volcanic cinders*, the smaller pieces, *volcanic ashes*, and the extremely small particles, *volcanic dust*. If, however, the lava is thrown to a comparatively small height, it is still melted when it falls, and is then known as *volcanic drops* or *driblets*.

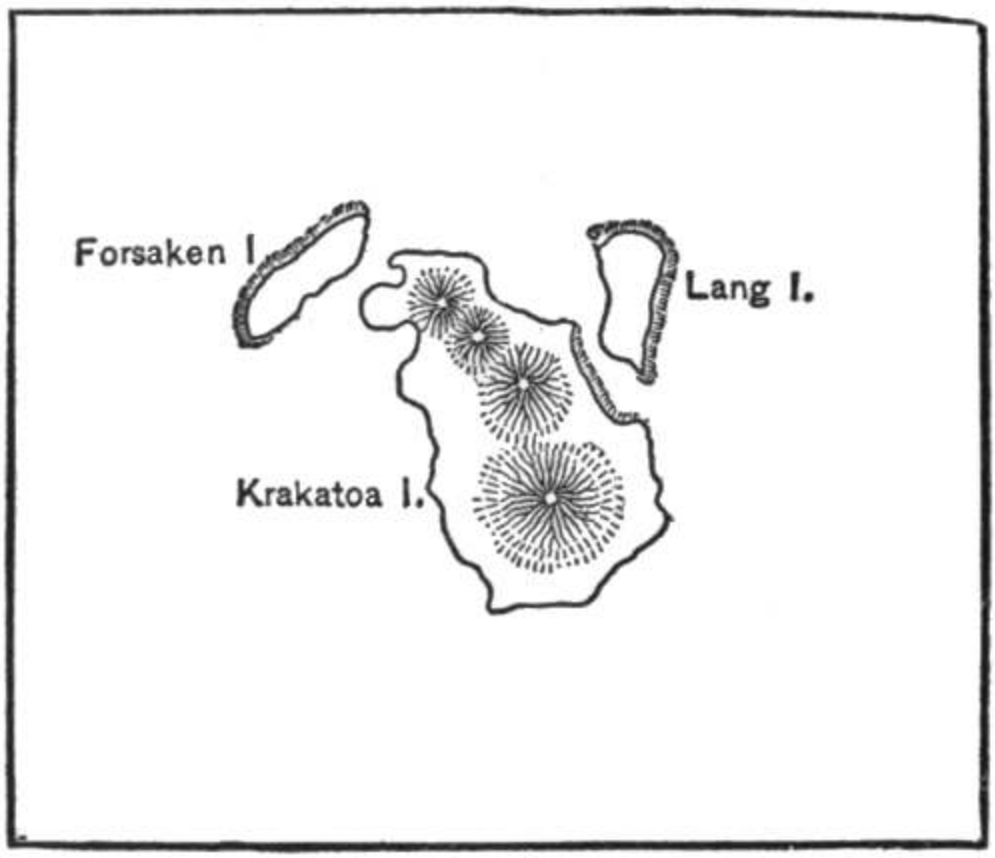

FIG. 2. KRAKATOA BEFORE THE ERUPTION

It is not surprising that Krakatoa is a volcanic island, since it lies in one of the most active belts of volcanic islands in the world, and near the coasts of the most active of these islands; i. e., Java. This belt, as shown in the map, includes, besides the Sunda Island chain, parts of Gilolo, Celebes, Mindanao and the Philippine Islands. These islands lie between Asia on the northwest and Australia on the southeast.

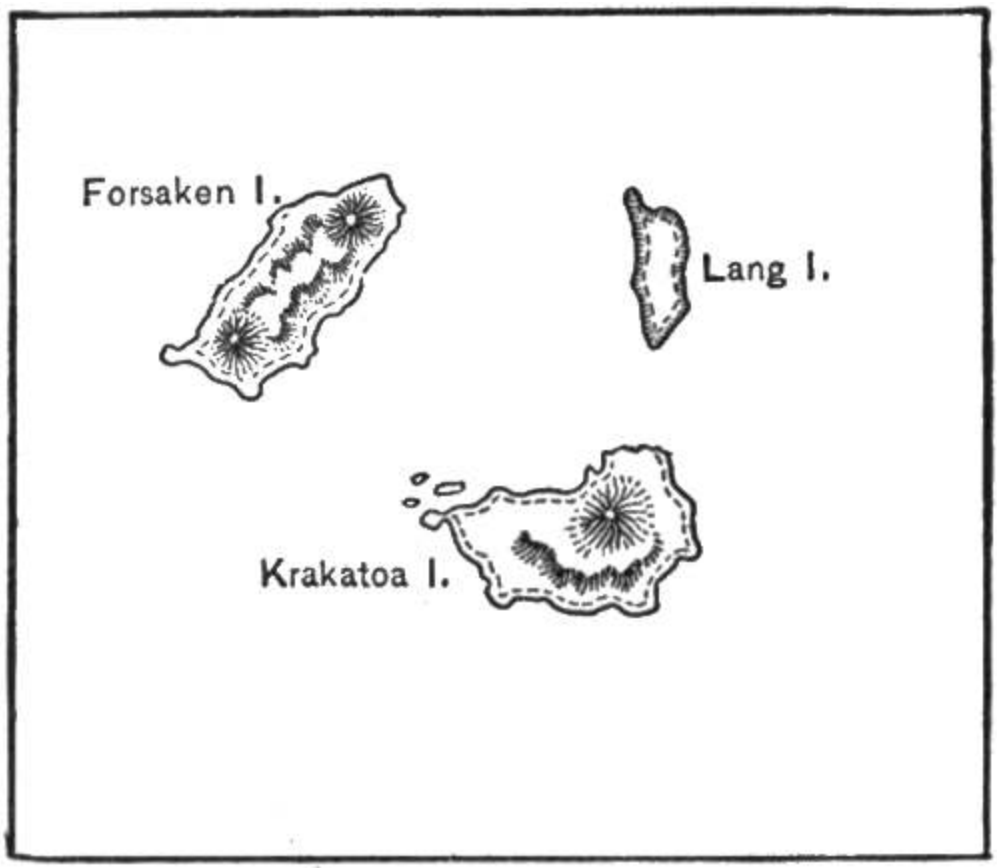

FIG. 3. KRAKATOA AFTER THE ERUPTION

There is no other part of the world with, perhaps, the single exception of Japan, where so many active volcanoes are crowded in so small a space. The island of Java, small as it is, has nearly fifty volcanoes, of which at least twenty-eight are active. They are situated in a lofty range running from east to west, some of the peaks of which are more than 10,000 feet above the level of the sea. Volcanic eruptions are so frequent that the island is seldom free from them.

As will be seen from the map shown in Fig. 2, Krakatoa consists of three groups of volcanic mountains, the southern group giving the name of Krakatoa to the island. Strictly speaking, this mountain was called *Rakata*, but as it is now generally known as Krakatoa, it would be unwise to attempt

to call it by any other name. The central mountain or group of mountains is known as Danan, and consists largely of part of an old crater. The group of mountains which lies near the northern end of the island was known as Perboawatan. From the centre of this latter group of mountains are several old lava streams consisting of a variety of lava resembling a dark-colored glass, known to mineralogists as *obsidian*, or *volcanic glass*.

Although Krakatoa was always a volcano, yet between the years 1680 and 1883, it was in the condition of a sleeping or extinct volcano. There had been a severe explosive eruption in the year 1680, that caused great loss of life and property, but ever since that time all activity had ceased and it seemed that the volcano would never again burst out. In other words, it was generally regarded as a trustworthy, sedate, quiet, inoffensive and perfectly safe volcano, that had become extinct.

The long continued quiet of Krakatoa was broken on the 20th of May, 1883, when the inhabitants of Batavia on the island of Java were terrified by noises like the firing of great guns, that were first heard between ten and eleven o'clock in the morning. These noises were accompanied by the shaking of the ground and buildings. The sleeping volcano of Krakatoa was evidently growing restless, but no great damage was done and soon all was again quiet. The disturbances were merely the forerunner of the terrible eruption soon to follow, and confidence was soon restored. But suddenly, on Sunday, August 26th, 1883, almost without any further warnings, Krakatoa burst into terrible

activity and began an explosive eruption that has never been equalled in severity in the memory of man.

That memorable Sunday of August 26th, 1883, came during a season of the year known as the *dry monsoon*, a name given the season of the periodical winds from the Indian Ocean. Batavia, and the surrounding country, greatly needed rain, for in this part of the world it seldom rains from April to October, although the air is very moist and damp. For this reason the beginning of the wet season is always welcomed. When, therefore, the rumbling sounds of the approaching catastrophe of Krakatoa were heard in Batavia, the people, believing that the noises were due to peals of thunder, rejoiced, for all thought they heralded an earlier setting in of the wet monsoon. But when the rumbling sounds increased and reports were heard like heavy artillery, it was clear that the sounds were the beginning of a volcanic eruption, a phenomenon with which they were only too well acquainted, but, as volcanic eruptions were far from being uncommon in Java, no one was very greatly frightened.

But this time the noises increased to such an extent that the people became alarmed. Throughout the night the appalling sounds continued and were accompanied by shakings of the earth sufficiently strong to shake the houses violently. Sleep was out of the question. Many of the people left their houses and remained all night in the open air, fearing the shocks would bring the houses down over their heads.

The morning instead of heralding the dawn of a beautiful tropical day, with its bright, cheerful sunlight, brought with it

skies covered with gray clouds that completely hid the sun. The rumbling sounds, however, had decreased, and the people were beginning to congratulate themselves that the dangers were over, when suddenly, the sky grew darker, and there began a shower of ashes that soon covered the streets and houses of the city. About seven o'clock on the morning of August 27th, a most tremendous crash was heard. The sky rapidly became so dark that it was soon necessary to light the lamps in the houses of Batavia, and some of the neighboring towns in the western part of Java. In addition to this the air was filled with vapor, while every now and then earthquake shocks were again felt. These shocks were accompanied by terrific noises like those produced by the explosion of heavy artillery. The noises rapidly increased in number and intensity until they produced a nearly continuous roar, the nature of which it is almost impossible to describe since it is probable that such sounds had never been heard before by man. It is a curious fact, which, I believe, has never been satisfactorily explained, that in most cases the people in the immediate neighborhood of the volcano, as, for example, those on board vessels in the Straits of Sunda, did not hear the terrific noises at all. Possibly they were too loud and simply gave a single inward impetus to the drum of the ear and then held it in position.

Probably some of my readers may remember that witty description given by Dr. Oliver Wendell Holmes of an alleged effort made by all the people of the world to find out whether or not there is a man in the moon. This wonderful plan was as follows:

Careful calculations were made to ascertain when it would be the same time over all the earth so that all the people of the earth could simultaneously shout at the top of their voices. In this way it was hoped that the man in the moon, if there were such a person, would notice the noise.

The story goes on to tell how when the time approached for the great experiment, and all were ready to shout as loud as they could, that each person reasoning to himself or herself, that amid so great a noise no one could notice whether his or her voice was omitted, determined to remain silent, so as to be able to hear the noise and the better to observe what the man in the moon would do when the sound reached him. The result was that every person on the earth remained silent and simply listened, so that the earth was never so quiet before.

Had Oliver Wendell Holmes, or any other person conceiving the witty idea, lived during the time of the great explosive eruption of Krakatoa, on that memorable August 27th, 1883, he might have taken the opportunity of observing the man in the moon, had he not been frightened by what was occurring, for certainly never before were such tremendous or terrifying sounds produced, for these sounds, as we shall see shortly, were actually heard for distances of more than 3,000 miles from the volcano.

There were two different kinds of waves produced in the air by the tremendous forces at work in the eruption of Krakatoa; namely, atmospheric waves and sound waves.

The atmospheric waves showed their presence in the air by means of changes produced in the atmospheric pressure. Now, while these changes cannot readily be felt by man, yet

their presence can be easily shown by the use of instruments called *barometers*.

There are in different parts of the world, buildings called *meteorological observatories*, that are provided, among other instruments, with recording barometers. These instruments caught the great atmospheric waves that were produced by the eruption of Krakatoa. In this manner, the astounding fact was learned that the waves starting from the volcano travelled no less than seven times around the world. When we say astounding, it must not be understood that the formation of such waves was at all contrary to the known laws of physics. On the contrary, provided the force of the eruption was sufficiently great, such waves must have been produced in the great ærial ocean. The astonishing, or wonderful thing, was that the force setting up these waves was so great that it caused them to move seven times around the globe.

The atmospheric waves were so powerful that it will be worth our while to describe them in detail. Starting from the volcano of Krakatoa, as a centre, these waves moved outwards in all directions, becoming gradually larger and larger until they reached a point halfway round the globe, or 180° from Krakatoa. The waves did not, however, stop here, but continued moving onward, now growing smaller and smaller until they reached a point in North America, immediately opposite Krakatoa. Such a point on a globe is called an *antipodal point*.[1] The waves did not stop at this point, but again advanced moving toward Krakatoa, growing larger and larger until they again reached a point halfway around the globe, or 180° from Krakatoa, when they again

continued moving but now continually growing smaller and smaller, until they reached Krakatoa. Here they again began moving completely around the globe, and this was continued for as many as seven times. It must not be supposed that the waves ceased on the seventh time around. On the contrary, they, probably, kept on moving for many additional times, but they were then so feeble that even the sensitive recording barometers were unable to detect their presence.

There was another kind of waves in the atmosphere that did not require barometers for their detection. These were the sound waves, and can readily be detected by the human ear.

Now, in the case of the great eruption of Krakatoa, the intensity of the sounds was so great that the sounds could be heard distinctly at distances of several thousand miles from Krakatoa.

The sound waves so closely resembled the explosion of artillery that at Acheen, a port on the northern coast of Sumatra, 1,073 miles from Krakatoa, the authorities, believing that an attack was being made on the port, placed all their troops under arms to repel the invaders. The sounds were also distinctly heard at Bangkok, in Siam, a distance of 1,413 miles from the volcano. They were also heard at the Chagos Islands, a group of islands situated in the Indian Ocean about 2,267 miles from Krakatoa.

Two steamers at Singapore, 522 miles distant, were despatched to find the vessel that was believed to be firing guns as distress signals.

The sounds were distinctly heard in parts of South Australia, 2,100 miles distant, and in Western Australia, at 1,700 miles distance.

But it will be unnecessary to give any further details of the great distances at which these sounds were actually heard. It will suffice to say that they were heard as far off as about 3,000 miles.

It is difficult to picture to one's self such great distances. Assuming the greatest distances to be in the neighborhood of 3,000 miles, it would be as if a sound produced, say, in Boston, New York, or Philadelphia, was so loud that it could be heard in Amsterdam, London, or Paris.

Some idea of the intensity of these sounds can be had from the fact that in Batavia, when, in accordance with usage, a gun was fired from one of the forts at eight o'clock in the morning, two hours before the greatest intensity of the sounds had been reached, the sound of the gun could scarcely be heard above the continuous roar.

While, of course, the principal reason the sound waves were carried so far was the great force causing the eruption, yet these distances were increased by the fact that the explosion occurred in a region almost entirely surrounded by great bodies of water. The waves could, therefore, be readily carried along the surface of the sea. Had there been a high mountain wall, like the Andes of South America, on one side of the volcano they would probably have been shut off in this direction a short distance from where they were produced.

CHAPTER II

SOME EFFECTS OF THE ERUPTION OF KRAKATOA

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Besides the sound waves in the air, there were waves in the waters of the ocean. Suddenly, without any warning, the people of Batavia were surprised by a huge wave that, crossing the Straits of Sunda, entered the ship canal before referred to as connecting the city with the ocean, and, rising above the brick wall, poured over the surrounding country.

Although Batavia was 100 English miles from Krakatoa, yet after travelling this distance the wave was sufficiently strong to enter the city and flood its streets with water to a depth of several feet. Fortunately, the loss of life was small in the city of Batavia, but very great in the surrounding towns and villages.

The ocean waves varied in height at different times of the eruption. The greatest were from fifty to eighty feet high. Just imagine the effect of a wave twice the height of an ordinary house. The waves caused great damage to the shipping in the neighborhood. In one instance, a vessel was carried one and a half miles inland and left on dry land thirty feet above the level of the sea.

The total loss of life by the waves has been estimated at 35,000 people; besides this, of course, there was a great amount of property destroyed. The greatest loss was in the immediate neighborhood of Krakatoa. Gigantic waves swept over the lowlands lying near the shores of Sumatra and

Java, where over areas several miles in width nearly everything was destroyed, the houses, trees, and people being swept away and the surface of the land greatly changed. The towns of Karang and Anjer, as well as numerous smaller villages, were almost completely destroyed.

The seaport town of Anjer, by far the most important of the above towns, was almost completely swept away. The heavy stone lighthouse was so completely obliterated that no traces of its heavy stone foundations could afterwards be found. The Rev. Phillip Neale, formerly a British chaplain at Batavia, from whose account of the eruption of Krakatoa some of the above facts have been taken, tells of the brave action of the keeper of the lighthouse at Anjer. Besides his work as lighthouse keeper, to see that the light was constantly burning during the night, he was charged with telegraphing to Batavia the names of all passing vessels. On the fateful morning of the great catastrophe, observing that the sun did not rise, he kept the light of the lighthouse burning, and, notwithstanding the danger to which he was exposed, continued at his post in order to send word to Batavia of the passing of an English steamer. While doing this the lighthouse was swept away and the brave man perished.

The following verbal account of the destruction of the port of Anjer was given by a Dutch pilot stationed at Anjer. This description is quoted by the Rev. Mr. Neale from an article prepared by him for publication in "The Leisure Hour."

"I have lived in Anjer all my life, and little thought the old town would have been destroyed in the way it has. I am getting on in years, and quite expected to have laid my bones in the little cemetery near the shore, but not even that has escaped and some of the bodies have actually been washed out of their graves and carried out to sea. The whole town has been swept away, and I have lost everything except my life. The wonder is that I escaped at all. I can never be too thankful for such a miraculous escape as I had.

"The eruption began on the Sunday afternoon. We did not take much notice at first, until the reports grew very loud. Then we noticed that Krakatoa was completely enveloped in smoke. Afterwards came on the thick darkness, so black and intense that I could not see my hand before my eyes. It was about this time that a message came from Batavia inquiring as to explosive shocks, and the last telegram sent off from us was telling you about the darkness and smoke. Towards night everything became worse. The reports became deafening, the natives cowered down panic-stricken, and a red, fiery glare was visible in the sky above the burning mountain. Although Krakatoa was twenty-five miles away, the concussion and vibration from the constantly repeated shocks were most terrifying. Many of the houses shook so much that we feared every minute would bring them down. There was little sleep for any of us that dreadful night. Before daybreak on Monday, on going out of doors, I found the shower of ashes had commenced, and this gradually increased in force until at length large pieces of pumice stone kept falling around. About six A.M. I

was walking along the beach. There was no sign of the sun, as usual, and the sky had a dull, depressing look. Some of the darkness of the previous day had cleared off, but it was not very light even then. Looking out to sea I noticed a dark, black object through the gloom, travelling towards the shore.

"At first sight it seemed like a low range of hills rising out of the water, but I knew there was nothing of the kind in that part of the Sunda Strait. A second glance—and a very hurried one it was—convinced me that it was a lofty ridge of water many feet high, and worse still, that it would soon break upon the coast near the town. There was no time to give any warning, and so I turned and ran for my life. My running days have long gone by, but you may be sure that I did my best. In a few minutes I heard the water with a loud roar break upon the shore. Everything was engulfed. Another glance around showed the houses being swept away and the trees thrown down on every side. Breathless and exhausted I still pressed on. As I heard the rushing waters behind me, I knew that it was a race for life. Struggling on, a few yards more brought me to some rising ground, and here the torrent of water overtook me. I gave up all for lost, as I saw with dismay how high the wave still was. I was soon taken off my feet and borne inland by the force of the resistless mass. I remember nothing more until a violent blow aroused me. Some hard, firm substance seemed within my reach, and clutching it, I found I had gained a place of safety. The waters swept past, and I found myself clinging to a cocoanut palm-tree. Most of the trees

near the town were uprooted and thrown down for miles, but this one fortunately had escaped and myself with it.

"The huge wave rolled on, gradually decreasing in height and strength until the mountain slopes at the back of Anjer were reached, and then, its fury spent, the water gradually receded and flowed back into the sea. The sight of those receding waters haunts me still. As I clung to the palm-tree, wet and exhausted, there floated past the dead bodies of many a friend and neighbor. Only a mere handful of the population escaped. Houses and streets were completely destroyed, and scarcely a trace remains of where the once busy, thriving town originally stood. Unless you go yourself to see the ruin you will never believe how completely the place has been swept away. Dead bodies, fallen trees, wrecked houses, an immense muddy morass and great pools of water, are all that is left of the town where my life has been spent. My home and all my belongings of course perished—even the clothes I am wearing are borrowed—but I am thankful enough to have escaped with my life and to be none the worse for all that I have passed through."

As is common in cases of earthquake waves a great depression in the level of the sea occurred at places great distances from Krakatoa. For example, at the harbor of Ceylon, the water receded so far that for about three minutes the boats were left high and dry, and then a huge wave carried them with it as it rushed over the land.

Perhaps one of the best evidences of the immense power of ocean waves is to be seen in the massive blocks of white coral rock that were washed up by the waves, on parts of the coast of Java for distances of from two to three miles

from the ocean. Many of these blocks weighed from twenty to thirty tons. Indeed, some of them reached the weight of from forty to fifty tons.

It is probable that the island of Krakatoa and its neighboring smaller islands formed portions of a huge cone about eight miles in diameter, that has been broken up at some very remote but unknown time by, perhaps, a greater catastrophe than that of August, 1883.

In the Straits of Sunda the water was raised fifty feet to eighty feet above the ordinary level, and produced tremendous destruction especially on the coasts of Java and Sumatra, sweeping away many villages and drowning many thousands of people. The wave had a velocity of progression of nearly 400 miles per hour, or eight times faster than an ordinary express train.

When it is said that the *velocity of progression of the wave* was nearly 400 miles per hour, it is not meant that a body floating on the ocean, such, for example, as a ship, would have been carried forward at this high velocity, but would merely rise and fall in a to-and-fro swing to about the height of the wave; that is, fifty to eighty feet according to what may have been the height. As in the case of the sound waves these motions of water covered or passed over nearly all the waters of the earth. The waves progressing toward the west, crossed the Indian Ocean reaching to the coast of Hindostan, and Madagascar, and sweeping around the southern part of Africa, finally reached the coasts of France and England, as well as the eastern part of North and South America. Sweeping towards the east, they reached the coasts of Australia, New Zealand, and crossing the vast

Pacific Ocean were felt at Alaska and the western coasts of North and South America.

But besides the enormous waves caused by the eruption, there were marked changes in the level of the land. Large portions of the coast of Sumatra and Java were almost annihilated, much of the original surface near the coast being submerged, and places that were formerly dry land are now covered with water to a depth of from 600 to 900 feet.

The enormous amount of material thrown into the air by the forces of the eruption is especially characteristic of this phenomenon. Such quantities of pumice stone and ashes fell from the clouds that, sinking in the water and collecting on the bed of the channel, they changed the depth of the water, so as to render navigation dangerous. Indeed, the Sebesi Channel, lying on the north of the island of Krakatoa was completely blocked by a huge bank of volcanic material, portions of which projected above the water, forming two smaller islands. These, however, have since been washed away by the waves.

We will not attempt to give at present any explanations as to the causes of this great volcanic eruption, since the different theories as to the cause of volcanoes will be better understood when other volcanic eruptions have been described. It is sufficient here to say that if a large quantity of water should have suddenly reached a great mass of molten rock, frightful explosive eruptions would have occurred, and if the island was resting on a submerged crater its sudden disappearance may be explained.

Another great wonder connected with the explosive eruption of Krakatoa was the enormous heights to which the fine dust was thrown up into the air. It has been asserted that during the most intense of these eruptions the particles reached elevations of perhaps more than twenty-five miles above the level of the sea. Carried by the winds, the fine particles remained suspended in the air for many months, and gave rise to magnificent sunlight effects, such as early dawn, lengthened twilights, lurid skies, and gorgeous sunsets of a reddish tint. There were also caused curious haloes, as well as green and blue moons.

The fine dust particles consisted of minute crystals of feldspar and other minerals, and when examined under the microscope presented the appearance shown in Fig. 4.

These mineral substances permitted a portion of the light to pass through them, thus producing wonderful optical effects in the atmosphere either because they acted like minute prisms and so produced rainbow colors, or because they turned the rays of light out of their course as to produce what is called interference by color effects of a nature similar to the colors seen in mother-of-pearl, rainbow coal, or in the wing cases of many beetles. The explanations of these phenomena are too difficult for a book of this character.

An explosive volcanic eruption is a very terrifying and wonderful phenomenon. Frightful roaring sounds are suddenly heard, the earth shakes for many miles around, when suddenly a vast quantity of molten rock, and sometimes huge stones, are thrown out of the crater high up into the air. So great is the force that throws these

materials out of the opening that heavy masses of rocks often are ejected very much faster than the projectiles from the largest guns that are used in any of the navies of the world.

FIG. 4. VOLCANIC DUST AS IT APPEARS UNDER THE MICROSCOPE

As the molten lava cools and falls in the form of prodigious clouds of ashes, cinders and dust, for many miles around the volcano, even the light of the sun is obscured, and one cannot see the hand before the face. Some of the materials in these clouds are so light that they remain suspended in the air for many hours, often indeed for many days, and sometimes even for years. The heavier particles, however, soon begin to fall, and before long the earth's

surface both around the volcano, and often at considerable distances from it, is covered with a thick layer of ashes.

The sounds accompanying a volcanic eruption are often terrifying. Amid shakings and tremblings of the earth's crust, known as earthquakes, there are occasionally heard noises like the explosion of huge guns. Sometimes these sounds follow one another so rapidly that they produce an almost continuous roar. Through the roar of the explosion a curious crackling noise can be heard, due to the fragments of stone hurled out of the crater striking against one another, especially as the stones which are thrown out of the crater and have commenced to fall back again to the earth, are struck by others that are still rising.

Immense quantities of ashes, stones, vapor and gases are thrown upwards for great distances into the air, while, at the same time, a lava stream pours over the lowest side of the crater. As the column of ashes and cinders reaches its greatest height in the air, it begins to spread outward on all sides, rapidly growing like a huge dark mushroom. This soon shuts out the light of the sun, and from it showers of red hot ashes and cinders fall to the earth.

It would be extremely dangerous to be on the side of the volcanic mountain during an explosive eruption; for, even should you escape falling into an opening in the side of the mountain, you might be killed by the huge stones that are constantly falling on all sides around the opening, or might be buried under the vast showers of red hot ashes that are poured down from the dense clouds overhanging the mountain, or suffocated by clouds of sulphur vapor that rush down its sides.

When at a safe distance the sight is certainly magnificent. There is no light from the sun. All would be in pitch darkness but for the reddish glare thrown upwards by the red hot lava, by the glowing showers of ashes that are being rained down on the sides of the mountain, or by terrific lightning flashes, due to the discharge of the immense quantities of electricity produced by the forces of the eruption.

Naturally a great volcanic eruption can cause a considerable loss of life and property. When a large lava stream begins to flow down the sides of the mountain, it cannot be stopped, and should it flow toward a village or town it is likely to destroy the town completely. Besides this, the vegetation of the country for many miles around is destroyed by the showers of red hot ashes that fall from the sky. The houses of neighboring cities are similarly ruined by the great conflagrations thus set up. Further destruction is also caused by large streams of mud that rush down the slopes of the mountain, or by huge waves set up in the ocean. If the volcano is situated, as most volcanoes are, near the coast, the showers of ashes and falling stones may set fire to vessels in the neighborhood, or the progress of such vessels may be seriously retarded by layers of ashes or pumice stone that float on the surface. Sometimes these layers are so thick as actually to bring ships to a complete standstill.

It must not be supposed that volcanoes are in a constant state of eruption. On the contrary, nearly all volcanoes, after an eruption, become *quiet* or *inactive*. The air soon clears by the ashes settling, and the sunlight again appears. A

crust forms over the surface of the lava, which rapidly becomes hard enough to permit one to walk over it safely. The vegetation, which has been destroyed by the hot ashes, again springs up, and, if the volcano happens to be situated within the tropics, where there is an abundance of moisture, the land soon again becomes covered by a luxuriant vegetation. Most of the people, who have escaped sudden death during the eruption, return to the ruins of their houses; for it is a curious fact that no matter how great has been a volcanic eruption, or how far-reaching the ruin, the survivors, as a rule, do not appear to hesitate to return to their old neighborhood. In a few years the fields are re-cultivated, the villages are rebuilt, and the people apparently forget they are living over a slumbering volcano, which may at any time again burst forth in a dangerous eruption.

A volcano that throws out molten rock, vapor and gases is known as an *active volcano*. An active volcano, however, is only correctly said to be in a state of eruption when the quantity of the molten rock, lava or vapor it throws out is greatly in excess of the ordinary amount.

Sometimes the volcanic activity so greatly decreases that the molten rock or lava no longer rises in the crater, but, on the contrary, begins to sink, so that the top of the lava in the crater is often at a considerable distance below its edges. The lava then begins to harden on the surface, and, if the time is sufficient, the hardened part extends for a considerable distance downward. In this way the opening connecting the crater with the molten lava below becomes gradually closed, the volcano being thus shut up, or corked,

just as a bottle is tightly closed by means of a cork driven into the opening at its top so as to prevent the escape of the liquid it contains.

It may sound queer to say that a volcano has its crater so corked up as to prevent the escape of the lava, but the idea is nevertheless correct and helpful. To realize the size of these huge volcanic corks one must remember that the craters of some volcanoes are several miles across. A volcano thus choked or corked up is said to be *extinct*.

When we speak of an extinct volcano we do not mean that the volcano will never again become active. A volcano does not cease to erupt because there are no more molten materials in the earth to escape, but simply because its cork or crust of hardened lava has been driven in so tightly that the chances of its ever being loosened again seem to be very small. But small as the chances may seem we must not forget that the volcano may at any time become active, or go into its old business of throwing out materials through its crater. A volcano in an extinct condition is not unlike a steam boiler, the safety valve of which has been firmly fixed in place. If the steam continues to be generated in the boiler, it is only a matter of time when the boiler will blow up, and the explosion will be all the greater because the safety valve did not allow the steam to escape earlier.

Sometimes an intermediate class of volcanoes called *dormant* is introduced between active volcanoes on the one hand and extinct volcanoes on the other. The name dormant volcano, or, as the word means, *sleeping volcano*, is objectionable, since it might lead one to think that an extinct volcano is not sleeping but dead, and this is wrong.