Krakatau 1883: The Shock Felt 'Round the World

By CHERYL SIMON

In May of 1883 residents of the Dutch East Indies saw ash and vapor columns spiraling from Krakatau, an island in the nearby Sunda Strait, and knew that the island's volcano was active once again. But none could foretell the colossal eruption that 100 years ago this week transformed their tranquil lives into a desperate struggle against some of the strongest energies the earth can expend.

For a day and a half beginning on the morning of Aug. 26, the island of Krakatau was wracked by explosions. Four cubic miles of volcanic ash and other debris shot as high as 30 miles into the atmosphere, snuffing out the daylight and covering nearby islands with several feet of ash. Vast seawaves pressed out from Krakatau and towards the islands in their paths. The greatest of these watery mountains followed the last explosion at 10 a.m. on Aug. 27. It crested at about 120 feet, and washed several miles inshore on Java and Sumatra, erasing all traces of whole towns and villages. When the wave departed the islands, it carried tens of thousands of victims out to sea. Pumice, the frothy rock expelled by the volcano, fell so thickly on the waters that a land bridge formed temporarily across parts of the strait, allowing searing clouds of volcanic rock and gas to rush across what was ordinarily 25 miles of open water to the shores of eastern Sumatra.

Conservative estimates place the death toll for the eruption at 36,000, but some estimates range to 100,000. By far most of the victims were claimed by the giant seawaves; on Sumatra, the heat and volcanic debris also extinguished countless lives.

The eruption at Krakatau was by no means the largest in history, nor the greatest in terms of lives lost. But in the minds of many, the event remains the classic, and best known, eruption. Much of the reason was the advent of rapid global communication, fostered by the invention of the telegraph 40 years earlier. Krakatau marked the first time in history when news of an eruption preceded its effects, encouraging people the world over to record their observations.

Eyewitness accounts and records by tide- and sky-watchers everywhere provide details that even today are of tremendous scientific consequence. They form a chronology that has been important, for example, to the study of meteorology. The movement of the dust and gas cloud revealed for the first time "dramatic global circulation patterns in the atmosphere," says Tom Simkin of the Smithsonian Institution's National Museum of Natural History in Washington, D.C. The huge amount of particles injected into the atmosphere circled the tropical latitudes of the globe in 13 days, making the sun appear green and blue. Three months later, the fine particles and sulfurous gases had dispersed to higher latitudes, and brilliant crimson sunsets were seen over the Northern Hemisphere. These optical effects persisted globally for several years, and in some places until 1887 or 1888, says J. Murray Mitchell, a research climatologist with the National Oceanic and Atmospheric Administration in Rockville, Md. Global temperatures were nearly .5°C cooler the year after the eruption, as the particles in the stratosphere altered the amount of solar radiation the earth received through the constantly changing cloud.

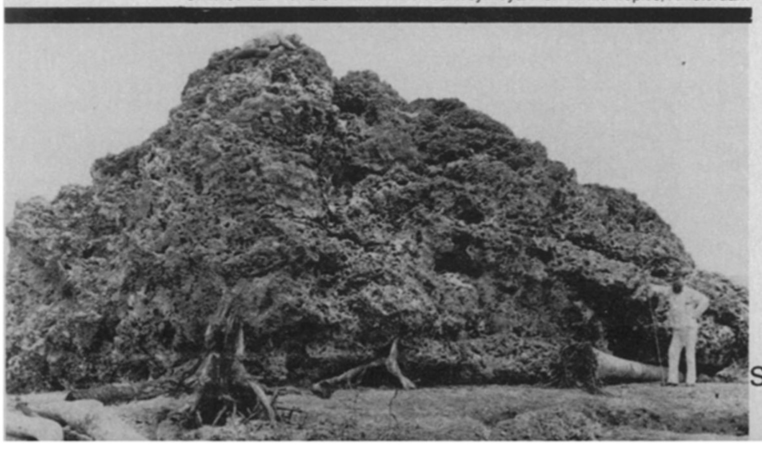
"The optical effects really opened up a whole new chapter in atmospheric exploration," Mitchell says. "The eruption showed that wind currents in the upper atmosphere can carry things like volcanic debris enormous distances." The color effects also reveal quite a lot about the size of the particles, Mitchell says, but adds that real understanding of these phenomena developed fairly recently, in the late 1930s and early 1940s.

The eruption also demonstrated the atmosphere's acoustic properties, as people in locations as far away as the middle of Australia and Rodriguez Island across the Indian Ocean heard the cannon-like sounds from the volcanic blasts. And as recently as 1966, researchers used accounts of barometric

"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.... 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 showed the houses being swept away and the trees thrown down on every side.... I was soon taken off my feet and borne inland by the force of the resistless mass.... I found myself clinging to a coconut palm.... As I clung to the palm-tree, wet and exhausted, there floated past the dead bodies of many a friend and neighbour. Only a mere handful of the population escaped."

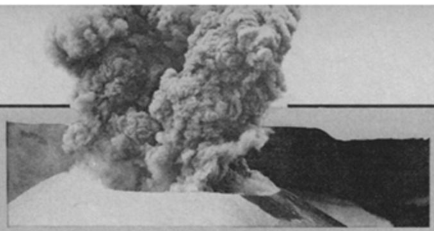
First-hand account of the tsunami, by an old Dutch pilot in the town of Anjer, on Java.

Smithsonian News Service Photo courtesy Royal Inst. for the Tropics, Amsterdam



The eruption ripped this coral block from its offshore home and relocated it inshore on Java, near the town of Anjer.

End of the Lull?



Anak Krakatau ("Child of Krakatau") near the site of the 1883 event.

Photo: From *Volcanoes* by Robert & Barbara Decker. W. H. Freeman & Co. © 1981

A striking aspect of the 1883 eruption at Krakatau is that the volcano had been inactive for 200 years, and was widely viewed as extinct. Though 200 years may be a long time in the frame of human memory, it is but a flicker in a volcano's lifetime, which may be as long as 10 million years. The data bank maintained by the Smithsonian's Scientific Event Alert Network shows that there are 710 volcanoes that probably have erupted in the last 10,000 years, a period called the Holocene. Many of these too have been quiet for the past 200 years. Simkin and Fiske note that "These, together with more that may have been quiet throughout the Holocene, are likely to be the Krakataus of the future."

Some scientists believe that even now things are not so quiet on the volcano front. Mitchell cites a hiatus in worldwide volcanic activity between the eruption of Katmai in Alaska in 1912 and Hekla in Iceland in 1947. In between, there were several spectacular eruptions, he says, but none with sufficient energy to propel a lot of debris into the atmosphere. Consequently, the atmosphere became cleaner. As more solar radiation reached the earth, the continents warmed up. Within 15 years after Katmai, Mitchell says, the oceans were warmer too, and by 1935, the global temperature had increased by as much as 1°C at higher latitudes. Some researchers have drawn a relationship between the mild climate during the middle of this century and the dearth of major eruptions.

In the last several decades, the lull has come to an explosive end. The 1963 eruption at Agung in Indonesia cooled the world by .3°C, and scientists still are waiting to learn what cooling effect the April 1982 eruption of Mexico's El Chichón may exert (SN: 5/15/82, p. 326; 8/21/82, p. 120). More frequent major eruptions can have a significant effect on global climate because a veil of volcanic ash particles and sulfuric acid droplets can absorb some of the incoming solar radiation and scatter it back to space before it reaches the earth.

Mitchell says it was the hiatus that was abnormal, and that more frequent volcanic activity is the way of the world. In 1981 Simkin and colleagues wrote that it is probable that "real fluctuations are present in the volcanic record." However, the researchers find that the incidence of volcanic activity is curiously related to human factors such as population growth and distribution, activity and interest, all of which affect reporting. For instance, there was an apparent increase in volcanism at the time of the invention of the printing press, which enhanced communication, and of the great Spanish and Portuguese explorations around 1500. There was another seeming increase in eruptions during the Industrial Revolution, and clear drops in global volcanic activity during the Great Depression and both World Wars. After major eruptions such as Krakatau or Soufrière in 1902, reporting tends to surge. This has not happened since the 1980 eruption at Mt. St. Helens in Washington, possibly due to more systematic reporting.

It is not that the incidence of eruptions cannot fluctuate, Simkin says. "We're basically trying to inject a healthy note of caution into the interpretation of our data bank, and to show that when you look for a human cause for a pattern, it's there." Nonetheless, some researchers cite geologic, tree ring and historical evidence that in previous centuries the world experienced more volcanic activity than during the current one.

Since the eruption at Mt. St. Helens, volcanism seems neither remote nor unlikely to most Americans. It may seem even less so in years ahead. The United States Geological Survey lists at least 35 volcanoes in the western U.S. where future eruptions are probable (see p. 135). Says Mitchell: "We're just seeing nature getting back to doing its thing. If we miss the significance of that we're going to be in for a lot of surprises in the years ahead." —*Cheryl Simon*

readings and tidal records taken after the eruption to explain the coupling between air and sea. Tidal disturbances were recorded as far away as San Francisco and Panama. These waves were not tsunamis, seawaves directly generated by submarine earthquakes, scientists now believe. Instead the waves formed because the explosion caused large amplitude airwaves, very low in frequency, that can "actually stimulate a wave to develop in the ocean that tries to parallel the propagation of the wave in the atmosphere," Mitchell says.

The eruption also extended understanding of calderas, or sunken craters. In 1883 the concept only was beginning to enter the scientific literature. Seven weeks after the August eruption, Rogier Verbeek, a Dutch mining engineer, studied Krakatau and answered at least one major puzzle of the cataclysm. By the time the eruption subsided early on Aug. 28, a 2,625-foot cliff remained where the greatest portion of the island had been sheared away. Two thirds of Krakatau had vanished. Where had it gone?

Most people believed that the volcano had exploded, and that the debris had either entered the atmosphere or tumbled into the sea. If this were the case, reasoned Verbeek, most of the material would con-

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"... I realised the ash was hot, and I tried to protect my face with my hands. The hot bite of the pumice pricked like needles. Then something got hooked into my finger and hurt.... I noticed for the first time that the skin was hanging off everywhere, thick and moist from the ash stuck to it. Thinking it must be dirty, I wanted to pull bits of skin off, but that was still more painful. My tired brain could not make out what it was. I did not know I had been burned."

Mrs. Beyerinck, wife of the Dutch Controller in the area, describes the volcanic cloud that raced inland from the Sumatra coast.

Smithsonian News Service Photo courtesy Nat'l Museum of Nat. His.

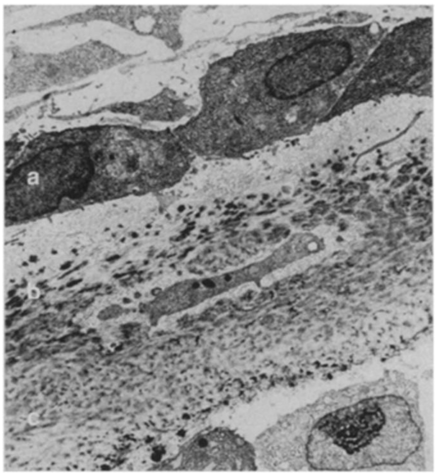
Soon after the eruption, Rogier Verbeek (center) led a landing party to Krakatau for scientific studies. His report still is used in modern studies of the island.

Paul Lips and colleagues at Vrije University in Amsterdam suggests that the disease may be triggered by a vitamin D deficiency, perhaps because of inadequate exposure to sunlight (SN: 6/4/83, p. 367).

Riggs and his team have evidence that excess parathyroid hormone may also be a contributing factor. Furthermore, Seizo Yoshikawa of the University of Tsukuba in Niihari-Gun, Ibraki, Japan, and colleagues have found in a six-month pilot study that when the thyroid hormone calcitonin, which is known to both suppress bone resorption and increase bone formation, is given with calcium supplements, it can increase bone in senile osteoporosis patients. In spite of the difficulties of studying elderly populations over an extended time period, Lips and his co-workers still hope to launch such a study to see whether vitamin D supplementation can prevent bone loss and hip fractures in healthy elderly people.

And still other questions about both kinds of osteoporosis press for answers. For example, Riggs and his team were not able to confirm the finding of Nordin and his colleagues that estrogen levels are lower in postmenopausal osteoporosis patients than in healthy postmenopausal women. So the extent to which estrogen deficiency after the menopause contributes to postmenopausal osteoporosis is unknown, Riggs says.

The mechanism by which estrogens inhibit bone resorption and prevent bone loss in postmenopausal women is also unclear, notes Lawrence G. Raisz of the University of Connecticut School of Medicine in Farmington. A third question is whether postmenopausal osteoporosis and senile osteoporosis involve not just trabecular bone and cortical bone but bone marrow. "It is an intriguing possibility, and a number of investigators are looking into it," says Peck.



Bone showing a row of osteoblasts (A), unmineralized bone deposited by the osteoblasts (B) and mineralized bone (C).

Yet a fourth question is whether the various skeletal growth molecules that influence bone resorption and formation play a role in osteoporosis. For instance, David J. Baylink of the Veterans Administration Hospital in Loma Linda, Calif., and colleagues have isolated a human skeletal growth factor that is probably a protein. They want to learn whether the factor is implicated in osteoporosis.

But whether these particular questions are answered or not, osteoporosis researchers are confident that they will make still more onslaughts against the disease during the next decade or so. For instance, C. Conrad Johnston, an osteoporosis authority with Indiana University School of Medicine in Indianapolis, anticipates that the disease will be better understood and that not just two but even more osteoporotic syndromes will become apparent.

Boy Frame, head of the Bone and Mineral Metabolism Division at Henry Ford Hospital, believes that it will also become possible to routinely identify persons at high risk of osteoporosis, something which is not now the case, thanks to revolutionary new diagnostic techniques like CT scanning and dual photon absorptiometry (SN: 5/12/83, p. 325). Those persons could then receive the best available preventive for their disease. Both Frame and Johnston likewise envision some effective and safe osteoporosis treatments becoming routinely available, at least to postmenopausal osteoporosis patients, as scientists learn how to use currently experimental therapies more appropriately. □

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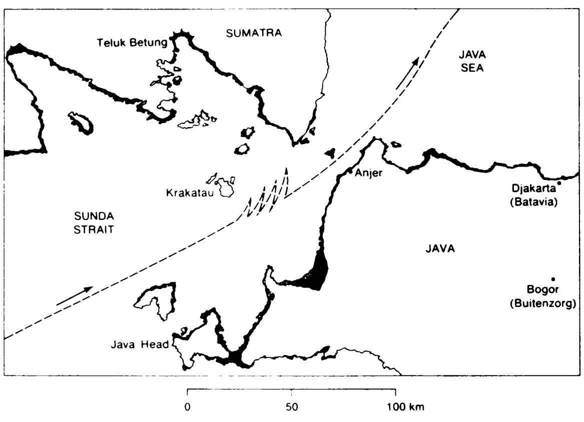
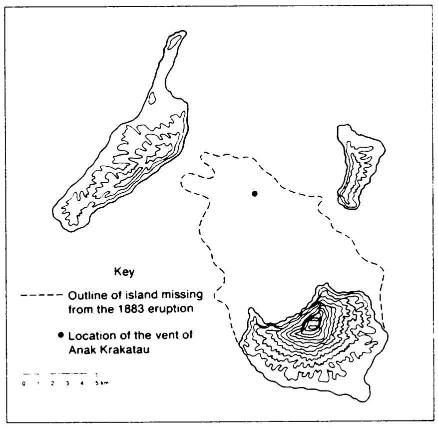


Left: Java and Sumatra took the brunt of the seawaves that shoved through the Sunda Strait after the main explosions at Krakatau. After the eruption, two-thirds of Krakatau was gone, replaced by an underwater crater formed as the volcano collapsed. Right: Lower end of drawing shows what remained of the island.



sist of old rock, rather than fresh melt and ash. His studies revealed that less than 5 percent of the material ejected by the volcano was composed of old rock.

"He reckoned that when the magma left the chamber, the volcano collapsed in upon itself," says Simkin. "That was certainly the first description of the collapse process as a historic event in the history of geology." Subsequent studies have verified Verbeek's conclusion. The volcano *had* collapsed, forming a cavernous basin, five miles wide and more than 700 feet deep, on the floor of the Sunda Strait.

Scientists still have much to learn from the eruption at Krakatau. For instance, controversy persists over the cause of the massive sea waves that were responsible for so much destruction and human suffering. Simkin, who with Richard Fiske, director of the Museum of Natural History, has written a forthcoming book commemorating the Krakatau centennial*, describes four possible stimuli for the waves. One is that as the caldera collapsed, successive landslides sent huge volumes of rock cascading into the sea, generating the waves. Another possible cause is that when the magma chamber caved in, submarine faulting and earthquakes set the waves in motion. Again, the waves might have resulted when the heavier material ejected into the sky quickly fell back to earth and sea, or when a submarine eruption blasted up a large dome of water that collapsed and moved out as a giant ripple. All four actions occurred at Krakatau. It is not known which one was primarily responsible for causing the deadly waves.

A century has passed, and Krakatau remains a classic geophysical event. As Fiske and Simkin note, the eruption's coincidence with growing sophistication and interest in science, and with improved communications, taught the world that impacts from such an event are global, and that the powerful forces of earth, sea and air are complexly, and inextricably, intertwined. □

*"Krakatau 1883—The Volcanic Eruption and Its Effects," by Tom Simkin and Richard S. Fiske, Washington, D.C., Smithsonian Institution Press, 1983.