Observations on Air Pollution Aspects of Irazú Volcano, Costa Rica

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AT THE REQUEST of the Pan American Sanitary Bureau, we visited San José, Costa Rica, in December 1963 to observe the effects of air pollution from eruptions of the volcano Irazú and to help assess the impact of the ashfall on the economy and public health of the area. The Pan American Sanitary Bureau sponsored this activity in response to a request for assistance from the Government of Costa Rica.

Irazú Volcano is the fourth tallest mountain in Costa Rica (11,260 feet). It is approximately 15 miles east of San José, the capital, which has a population of approximately 100,000 (fig. 1). Prevailing easterly winds carry ash from Irazú directly over San José. The next closest town, Cartago, is approximately 9 miles southwest of Irazú and generally out of the path of volcanic ashfall.

Volcanic Activity

The volcanic activity of Irazú has been studied for many years (*1*). Various observers in San José report that the volcano, active in 1841 and again in 1910, had been relatively inactive until March 1963. At that time there was extensive volcanic activity resulting in heavy ashfall in San José, which has continued intermittently (fig. 2).

Elliot Coen, chief of the national meteorologic services, Costa Rica, has maintained a daily record of ashfall in San José starting in March 1963. The greatest ashfall occurred December 3, 1963, between 2 a.m. and 11 a.m., when 1,248 grams of ash per square meter settled on the city. This marked the beginning of intense activity that continued until December 6 and gradually tapered off to modest activity by December 9.

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Composition of Volcanic Emissions

To assess possible respiratory hazards associated with the ashfall, it is necessary to know the size distribution, concentration, and composition of the ash.

Murata reported on the chemical analysis of erupted materials collected from Irazú on September 10, 1963 (*2*). The sample was broken down as follows: 55.5 percent silica (SiO_2), 17.1 percent aluminum oxide (Al_2O_3), 2.4 percent iron oxide (Fe_2O_3), and a variety of lesser constituents. A comparative study indicates that this composition is similar to that of seven other volcanoes around the world (*3*).

Since air samples collected during periods of heavy ashfall were not available to us, we collected and analyzed samples of the ash that had settled on San José and a few atmospheric dust samples. These give some indication of the size distribution and composition of the ash. They do not, however, describe the concentration of the ash in the atmosphere during volcanic activity.

The ashfall we collected in San José was sized and counted under the microscope. The results are shown in the first two columns of the table. In addition, three samples of atmospheric ash were taken by drawing approximately 4 liters of air through a 37-mm.-diameter

millipore filter. The collected samples of ash were reentrained into the atmosphere by the passage of nearby vehicles. Results of this sampling are shown in the last three columns of the table.

It appears that particles up to 3 microns in diameter are most readily retained in the alveoli, and somewhat larger particles are most readily retained in the nose. In general, the particles of less than 5 microns are of greatest physiological significance (*4*). Our data show that a substantial proportion of particles in the ashfall were within a respirable range.

The next determination was whether or not sufficient free silica was present to produce a silicosis hazard. Microscopic morphologic examination of the ash indicated that it was composed of a variety of glassy (amorphous) materials, but no free silica was observed. To corroborate this finding, the ash was analyzed by the phosphoric acid method (*5*), and the results indicated that about 1 percent of the material was in the form of free silica. This suggests that the silicosis hazard was minimal but in no way discounts the irritant and nuisance effects of the ash.

In addition to ashfall, there is the question of pollution by gases. According to Naughton (*6*), Hawaiian magmatic gases are composed principally of water (79 percent), carbon dioxide (11.6 percent), sulfur dioxide (6.5 percent), and a number of lesser constituents.

We attempted to collect sulfur dioxide and hydrogen sulfide samples from the cone of the volcano. Difficulties of getting into a suitable downwind position on the crater and an un-

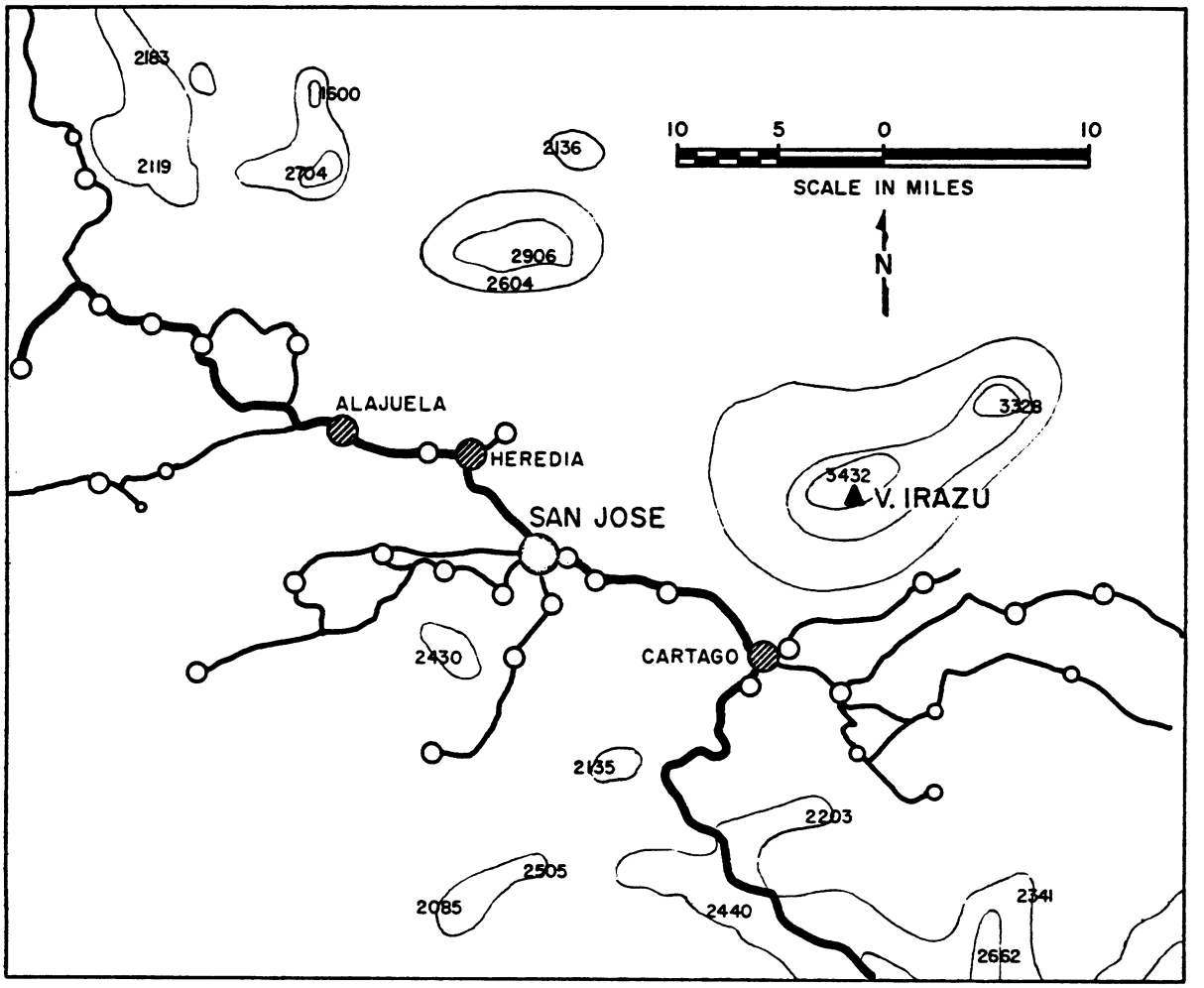

Figure 1. Irazú Volcano and vicinity, Costa Rica

Particle size distribution of ashfall and atmospheric samples collected at San José, Costa Rica, December 10–13, 1963, in percentages [1]

Diameter range, microns	Ashfall samples		Atmospheric samples		
	No. 1	No. 2	No. 1	No. 2	No. 3
0–5	40	54	65	10	1
5–10	23	10	9	16	24
10–20	13	7	11	34	54
20+	24	29	15	40	21

[1] Percentages are based on the number of particles in each size range.

timely increase in volcanic activity discouraged our efforts, however, and no satisfactory samples were obtained. Conversations with various individuals revealed that the acrid taste of sulfur gases was noted only to a minor extent in San José. The minimum quantity of sulfur dioxide that can be detected by taste is considered to be approximately 0.3 ppm.

The actual atmospheric concentrations of ash and gas in San José must be determined by sampling at the time of volcanic activity. Selected pieces of air-sampling equipment have been sent to Costa Rica to assist the Ministry of Health in such sampling, and thus far they have collected one sample during a period of volcanic activity. Airborne particulates measured in San José January 24–28, 1964, averaged about 800 micrograms per cubic meter of air. This is about eight times the U.S. urban average. Microscopic examination of the sample disclosed that about one-third of the particles were less than 5 microns in diameter. For urban air pollution in the United States, one would expect to find 95 percent or more of the particles in this size range.

Effects of Eruptions

People. The effects of the recent and previous ashfalls on the people who live in the affected area were determined by questioning individuals and by discussing the problem with physicians who practice in the community. The effects during eruptions and during subsequent periods of windblown resuspended ash were apparently similar, though the effects of resuspended ash were less severe, probably because a lesser quantity of dust was in the air when the ash was resuspended.

Acute conjuctivitis was produced by ash particles in the conjunctival sac, leading to redness and burning of the eyes without any marked swelling. The effects apparently subsided rapidly when exposure to the dust ceased. Throat irritation, sometimes accompanied by a dry cough, was common; also inflammation and burning of the throat without much swelling of the tissues. This effect also cleared up within a short time after exposure ceased. Nearly everyone was afflicted except those who protected themselves with masks and goggles. These effects are similar to those reported by daCorogna during an eruption of a Santorin volcano (7).

Some persons were also affected with nasal irritation and discharge. When exposure to ash was combined with an upper respiratory infection, the effects of both stresses together were severe and prolonged. A few persons developed severe bronchitic symptoms that lasted for some days beyond the period of exposure to the ash. This type of reaction apparently was found

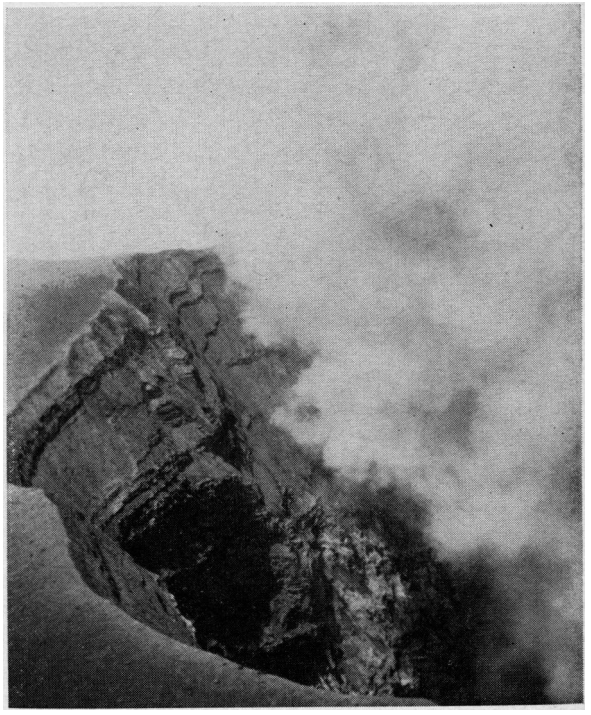

Figure 2. Irazú Volcano, Costa Rica, during eruption of December 11, 1963

particularly, if not solely, in persons with a preexisting chest disease, such as chronic bronchitis. Whether or not such exacerbations result in any permanent damage cannot be determined except by prolonged observation, and perhaps not with certainty even then.

Since we arrived immediately after a period of heavy eruption and were able personally to observe that little illness remained, it appears that the effects of the ash are principally transient. This should not minimize the fact that these effects are severe and widespread during the periods of eruption. There was agreement among local physicians that the effects of the ashfall were not severe enough to produce any deaths, even of those already ill.

Animals. From two-thirds to three-quarters of the slope of Mount Irazú has been used for agricultural purposes. The eastern slope is forest, and the remainder, to about half a kilometer below the crater, has been used for pasture, with some cultivation of potatoes and other root vegetables. About 16,500 acres of good pastureland is now sufficiently damaged by ash to be unusable.

Most of the cattle, about 6,000 head, formerly pastured in this area have been moved down to the plain, which has produced some undesirable crowding. Control programs for cattle diseases have been intensified to compensate for the increased dangers caused by the crowding. Some increase in slaughter in addition to normal culling of the herds has been required owing to illness from the ash and also from the moving. Cattle illness due to the ash has been mainly intestinal—irritation by swallowed ash with resulting diarrhea. No respiratory illness has been seen. Illnesses from moving are mainly increased abortion and nutritional disturbances, thought to be caused by bringing animals acclimatized to high altitude down to the level of the plain. No evidence of injury to cattle from volcanic gases has been reported at any time.

Milk production has decreased to slightly below current requirements of the community for fresh milk, but no shortage of milk is anticipated. Production will not return to the normal level for several years because of increased slaughter, abortions, and decreased breeding.

Vegetation. Vegetation on the slope of Mount Irazú has suffered extensive damage.

Figure 3. Collapse of roofs and roof gutters caused by ashfall from eruptions of Irazú Volcano, San José, Costa Rica, December 1963

It is reported that some of the earlier eruptions in the spring and summer caused extensive damage also to the forests on the eastern slope. Much of the good pastureland to the west and southwest of the crater for the distance of 10 kilometers has been severely affected by ash, and the recovery time of this land is uncertain, depending to a large extent on how long the ash cover remains before being blown off. Areas to the northwest and south have been spared major damage owing to the prevailing wind directions. Where the ash deposit blows or is washed off before suffocating the plants, the pasture is actually improved by the fertilizing effect of the ash. In hollows and ravines, however, the deposits are sometimes 4 to 6 feet deep owing to drifts, and all vegetation is destroyed. Near the crater the deposits are so heavy that all plant life was destroyed.

Farther down the slope of the mountain and on the plain in San José and in other areas, we did not hear or see any evidence of damage to vegetation. Presumably the ash cover was not thick enough in these areas to cause any dif-

ficulty for plants. No plant damage due to volcanic gases was reported for the mountain or the plain. Either gas production during the eruption was not extensive or the effect of the ash was so dominant that other damage was not apparent.

Materials. Ranchers and farmers on the upper slopes of the mountain have always noted that galvanized fence wire and roofing panels deteriorate more rapidly there than down on the plain. Whether advanced deterioration is due solely to difference in climate or partly to volcanic gases has not been studied, but no major increase was noted in the rate of deterioration of these materials in this area during the eruption.

One readily recognized hazard has been ashfall on roofs and roof gutters. In addition to blocking the flow of water, the weight of the ash has been sufficient in some cases to cause the gutters to collapse (fig. 3).

Rainfall. On the evening of December 9, 1963, a torrential rain on the slopes of Irazú caused flooding in the town of Cartago, killing at least 15 persons. Whether or not the Cartago flood was related to prior volcanic emissions is at this time a matter of speculation, but the possible relationship bears further examination (*8*,*9*).

Summary

Based on observations, examination of available data, and analyses of limited samples, it appears that the heavy ashfall resulting from the recent volcanic activity of Irazú, in Costa Rica, contains a substantial portion of particles in a respirable size range. The free silica content of these particles is about 1 percent, which minimizes the silicosis hazard. Although sulfur gases have not been measured, reports of taste and odor indicate that they may be only minor factors in the emissions from Mount Irazú.

During periods of volcanic activity, the ashfall reportedly reduces visibility, gets into clothing, hair, and eyes, and is a general nuisance. Specifically, it causes a redness and burning of the eyes, a dry, raw, and sore throat, and irritation of the airway passages. All these effects apparently subside rapidly when exposure to the ash ceases.

Recent ashfall has ruined much of the Irazú mountain slope pastureland. This has made it necessary to reduce the size of the cattle herd and remove remaining cattle from the high pastures and crowd them on lowland pastures with other herds.

Ashfall in San José has been extensive and had to be removed from roofs and roof gutters to prevent their collapse. It has required constant cleaning indoors and made it necessary to sweep or shovel outdoor walks frequently. Large crews of men and trucks have been required to remove the collected ash from the city.

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