SCIENCE NEWS of the week

The 'Killer Lake' of Cameroon

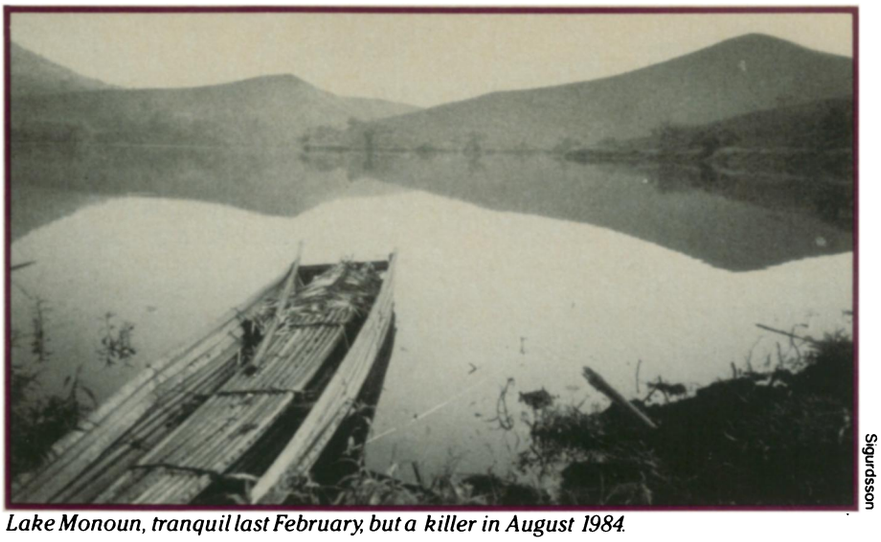
In the early morning hours of Aug. 16, 1984, a parish priest, a young man named Foubouh Jean and others were riding in a van past Lake Monoun in the Republic of Cameroon, when they noticed a man on the roadside who appeared to be asleep on his motorcycle. But when the priest drew near the motorcycle, he discovered that the man was dead. As he turned back toward the van, he, too, collapsed. Jean and a companion, smelling a strange odor like that of car battery fluid, realized the air was deadly and began to run away. Jean's companion soon succumbed, but Jean managed to escape to the nearby village of Njindoun.

By 10:30 a.m., authorities had found a total of 37 people lying lifeless on the road, apparent victims of a mysterious chemical cloud that had enveloped a 200-meter-long stretch of the road that morning. No autopsies were conducted, but Emmanuel M. Njock Bata, a physician who examined the bodies, concluded that the people who had been traveling to market in the open air before dawn had died of asphyxia. Bata, now at Tulane University Medical Center in New Orleans, told SCIENCE NEWS that mucus and blood had oozed as foam from the victims' noses and mouths, and their bodies were rigid from seizure. They also had first-degree chemical burns on their skin, though their clothes were unaffected.

The results of an investigation, now being made public, indicate that the cloud that killed the people was generated naturally in Lake Monoun. This is the first known incidence of such a lethal, natural cloud, say the investigators.

There were several signs on Aug. 16 that the lake was involved. When Bata and a police commandant first neared the area at 6:30 that morning, they saw the smokelike cloud coming from the direction of the lake. The cloud reportedly tasted bitter and made them nauseated, dizzy and weak, so they retreated until 10:30 a.m., when it had dissipated. Between the lake and road, animals, grasses and shrubs had been killed, and plants on the shore had been flattened. Njindoun villagers also reported hearing a loud explosion from the lake about 11:30 the night before. And on Aug. 17, authorities noted that Lake Monoun was reddish brown, indicating that the normally placid waters had been stirred up.

The government of Cameroon, which had at about that time put down an attempted coup, was worried that the incident might have had political overtones, so they kept the event quiet, according to volcanologist Haraldur Sigurdsson. With the help of the U.S. Agency for International Development, Cameroon invited Sigurdsson and Joseph Devine, both at the University of Rhode Island in Narragansett, to Africa to work with Cameroon volcanologist Felix Tchoua in a study of the lake. The researchers were to determine whether the cloud had been produced naturally or by humans — whether, for example, chemicals or explosives had been dumped into the lake.



Sigurdsson

Lake Monoun, tranquil last February, but a killer in August 1984.

Sigurdsson's group could find no evidence of human wrongdoing. And now that the U.S. and Cameroon governments have granted permission to air the story, the researchers can divulge their theory of the "killer lake." William Evans, who along with Theresa Presser and Katherine Pringle at the U.S. Geological Survey in Menlo Park, Calif., conducted the chemical analyses for the study, will present the researchers' findings Dec. 13 in San Francisco at the fall meeting of the American Geophysical Union.

When he first arrived at the lake, Sigurdsson suspected that the cloud had been produced by an abrupt volcanic eruption, because Lake Monoun is one of many small volcanic crater lakes in the region. Volcanic gases might have rushed up through the lake, expanding into an asphyxiating cloud of carbon dioxide and other gases. Indeed, the researchers found a 350-meter-wide volcanic crater on the lake bottom, close to where the people were killed. They also discovered tremendously high levels of bicarbonate ions — which form from the dissociation of carbon dioxide — and of carbon dioxide gas in the deep water of the lake. Later isotopic analysis of the carbon atoms produced results consistent with a volcanic origin.

But the complete chemical study of Lake Monoun worked against the idea of an abrupt eruption. The researchers report that the bottom waters contained little of the sulfur, halogens or other chemical signs typically associated with high-temperature volcanic activity. Moreover, Sigurdsson's group measured exceptionally high concentrations of ferrous ions (iron atoms with a +2 charge) in the deep water and large amounts of siderite, an iron-carbonate mineral, in the bottom sediments. The researchers concluded that the iron in the lake comes from the red dust that blows from the Sahel and Sahara. When the iron-rich dust falls into the lake, the ferric ions (iron with a +3 charge) are reduced to ferrous ions. This process is maintained as long as the dissociation of carbon dioxide to bicarbonate continues to make the lake acidic. And as long as ferrous ions and bicarbonate are pumped into the lake system, siderite is created. Given the chemical balances set up in the lake and the fact that the iron had accumulated slowly, over hundreds of years, the researchers concluded that the carbon dioxide, too, had seeped very gradually into the lake, and not as a result of a sudden volcanic eruption.

What, then, caused the cloud? Sigurdsson believes that the delicate chemical balances had strongly stratified the lake by maintaining high levels of bicarbonate in the deepest waters. Something disturbed this stratification, bringing carbonate-rich deep water up toward the surface. This sudden change in pressure would have released carbon dioxide gas "like when you open a soda bottle," says Sigurdsson. Such a burst created a 5-meter-high wave, which flattened the shoreline plants. And the resultant cloud, heavy in dense carbon dioxide gas, was carried by the westerly

winds to the road, where it stayed near the ground. Apparently, says Sigurdsson, in the predawn hours there was not enough light for the Njindoun villagers to see the cloud. He suspects there might have been nitric acid in the cloud, which could have helped to make it visible in daylight and which might account for the skin burns. But at this stage, he says, "the burns remain a complete mystery."

Also left unanswered is what triggered the overturn of the lake water. Two Italian tourists 6 kilometers north of Lake Monoun reported feeling an earthquake on Aug. 15, but according to Sigurdsson this cannot be verified because the Cameroon seismograph was down at the time. The researchers also found an underwater landslide on the steep slopes near the lake bottom crater. Another possibility, says Sigurdsson, is that the pattern of winds blowing across the lake generated a current in the otherwise stagnant bottom waters.

"As far as we know, this event was unique – certainly in its lethal effects," says Sigurdsson. "This type of process, however, had been considered in a very large lake in the East African Rift called Lake Kivu." This lake, too, is strongly stratified. According to Sigurdsson, engineers had considered using this stratification as a source of energy but abandoned the idea because they were afraid that they would induce a large gas burst. The big concern now, he says, is that this might occur naturally again in any one of the many other crater lakes in Cameroon, which may be stratified just like Lake Monoun. *– S. Weisburd*

Air-crew radiation doses climbing

Because studies conducted through the early 1970s indicated that the average cosmic-radiation dose to commercial flight crews was only about 90 percent of the recommended annual public-exposure limit, the Federal Aviation Administration (FAA) decided against developing radiation safety regulations. But for a variety of reasons, those earlier dose estimates are no longer valid, according to Edward T. Bramlitt, a health physicist working for the Defense Nuclear Agency in Albuquerque, N.M. Calculations he reports in the November HEALTH PHYSICS suggest that many occupational air-crew exposures are "comparable in magnitude to doses received by ground-based radiation workers." Yet, he notes, unlike those "radiation workers," air crews are neither routinely monitored for radiation nor informed of their exposures and the risks they may pose.

Bramlitt sees several implications of this finding. First, female flight attendants, who can now work into their seventh month of pregnancy, may receive radiation doses to the fetus that exceed the annual 500 millirem (mr) limit recommended by the National Council on Radiation Protection (NCRP). Second, Bramlitt suspects that within 15 or 20 years, crew veterans will begin questioning – in court – whether any cancer they have is radiation-induced.

Last year Bramlitt petitioned FAA to implement rules that could head off these problems. They would require: that airlines begin monitoring doses to crews; that FAA set standards for allowable radiation exposures to crews; and that crews be informed of their exposures and the risks these might pose. They would not affect passengers, Bramlitt notes, because their cumulative radiation increases – except, perhaps, for some very frequent fliers – would still be negligible. An FAA spokeperson says the agency is formally considering Bramlitt's petition.

Natural cosmic radiation, which bathes the solar system, is largely shielded from earth's surface by the atmosphere. According to the Air Transport Association, today's planes try to fly as high as possible to maximize fuel efficiency. And an increase in cruising altitude from 36,000 feet (the peak altitude for many older jets) to 45,000 feet (the peak allowed many newer jets) can double exposures, Bramlitt says.

Those earlier analyses studied by the FAA considered only domestic routes at midlatitudes, he says. Since cosmic rays tend to flow along magnetic field lines, the earth is not shielded as well from them at high latitudes – especially the poles – as it is at the equator. Moreover, he says, dosimeters used in early tests were not designed to measure the high-energy neutrons spawned by cosmic rays' interactions with the atmosphere. According to NCRP, those particles are 10 to 20 times more hazardous than the gamma rays measured.

The FAA also assumed flight crews worked an average of 60 hours per month. Today, work hours are higher. Bramlitt notes that one U.S. carrier requires attendants on international routes to work at least 95 hours per month.

Finally, Bramlitt says FAA ignored solar flares when estimating crew exposures, even though flares can substantially boost exposures. Herbert Sauer at the National Oceanic and Atmospheric Administration's Solar Environment Laboratory in Boulder, Colo., told SCIENCE NEWS that at 40,000 feet, flares can increase cosmic radiation for several hours from about 0.7 mr/hr to 200 mr/hr; very rare events could spike it to 2,000 mr/hr or higher. *– J. Raloff*

Unemotional data on startle response

Some psychologists believe that the startle reaction, which has been examined by numerous researchers since 1939, lies at the far end of the emotion of surprise and provides a good model for the study of other emotions. Others say it is a reflex and add that bona fide emotions occur after internal appraisals of thoughts or events.

Detailed measurements of facial muscles during the startle reaction suggest that it is probably a reflex, according to a report in the November JOURNAL OF PERSONALITY AND SOCIAL PSYCHOLOGY. Still, it is not yet clear whether prior appraisal is always necessary to arouse emotions, say psychologists Paul Ekman and Wallace V. Friesen of the University of California at San Francisco and Ronald C. Simons of Michigan State University in East Lansing.

The researchers examined the startle reactions of 17 healthy individuals who, on different occasions, did or did not know when a blank pistol would be fired. Subjects were also asked to suppress startle responses after being warned of an impending gunshot and to simulate a startle when there was no gunshot. High-speed motion pictures were used to analyze facial expressions.

Within 200 milliseconds after an unanticipated startle, most subjects displayed horizontal stretching of the lips, tightening of eye and neck muscles, eye blinking, eyebrow lowering and jerking of the head and trunk. Responses to anticipated startles were similar but less intense. Subjects had little success in squelching their responses to the gunshot and also had problems simulating a startle reaction.

With emotions such as surprise, happiness and disgust, note the researchers, facial expressions can be inhibited and simulated fairly successfully and are far more difficult to elicit experimentally than is the startle reaction.

Some psychologists who argue that prior appraisal is not required to experience emotion also contend that data on the startle reaction would resemble findings for other emotions if stimuli as strong as the blank pistol shot were used. But the startle is unique in two ways, say the investigators. While several recent studies indicate that the same muscle movements are made in moderate and extreme emotional expressions, different muscles are used in surprise and startle reactions; thus, the startle is not "extreme surprise." And even with strong stimuli, no single emotional expression has been shown by all subjects on the first trial; a gunshot, however, always produced a startle reaction in all subjects.

– B. Bower