Cameroon: The First Wave of Clues

Scientists may never know exactly what caused a cloud of gases to escape from Cameroon's Lake Nyos on the evening of Aug. 21, killing more than 1,700 people and scores of animals (SN:8/30/86, p.133). But a few pieces of the puzzle are beginning to come together.

In its Sept. 7 preliminary report to the Agency for International Development (AID), a team of geoscientists concluded that the cloud consisted primarily of carbon dioxide — a finding consistent with the results of medical examinations, which showed that the victims had died of carbon dioxide suffocation (SN:9/6/86, p.148). While they still have little evidence, some geoscientists suspect that the carbon dioxide had very slowly seeped into the lake from underlying molten rock, gradually building up to high levels. But what triggered the escape of carbon dioxide from the bottom waters is still a matter of speculation.

The geoscientists are now analyzing the water, rock and sediment samples they've brought back from Cameroon. In a month or two they will issue their final reports, according to AID. In the meantime, AID and Cameroon government officials are considering strategies to prevent a recurrence of the tragedy of Lake Nyos — and that of Lake Monoun, another Cameroon volcanic crater lake, which killed 37 people when it emitted a lethal cloud two years ago (SN:12/7/85, p.356).

According to the AID geoscience report, some survivors who were near the lake Aug. 21 reported hearing and feeling a rumbling that night. One witness apparently saw a cloud emerging from the lake, and others saw a large wave wash up on the southern shore. From the array of felled trees and vegetation on this shore, researchers estimate that the wave, which they believe was created by the expanding bubble of gas, measured up to 80 meters high.

The scientists think the cloud was mostly carbon dioxide because they found high concentrations of the gas above agitated lake water, as well as high levels of bicarbonate ions in Lake Nyos's bottom waters. There they also found high concentrations of ferrous (iron) ions, which they suspect were stabilizing the bicarbonate. Observing that the normally blue lake turned reddish brown, the team concludes that iron hydroxide precipitates at the surface caused the color change.

Curiously, the team found no evidence of sulfur in the water. Survivors of the cloud had reported smelling rotten eggs or gunpowder — an indication that sulfur compounds were emitted. The medical team had also tentatively concluded that the victims' skin burns were from acids formed by the reaction of sulfur compounds with water droplets in the air or with groundwater. But there was no hydrogen sulfide in the gases that effervesced from deep-water samples, and no hydrogen sulfide or sulfur dioxide was found above aerated surface waters. Moreover, with all those ferrous ions, researchers would expect the sulfides to have combined with the iron to form some kind of iron sulfide. Because iron sulfides typically dissolve only very slowly, it's hard to understand, at first glance, how sulfur gases could have been emitted almost instantaneously.


Wide World

Lake Nyos on Aug. 26.

"That's the big mystery," says Joseph Devine, a volcanologist at Brown University in Providence, R.I., and leader of the geoscience team. "Where did the sulfur come from?"

A low sulfur content, along with high bicarbonate and ferrous ion concentrations, was also found in Lake Monoun, hinting that the chemistries of the two lakes are similar. "But the thing we're most anxious to do at this point," says Devine, "is to avoid telling the data what the data should be telling us."

What the data have told the team so far is that the cloud probably was *not* caused by an abrupt volcanic eruption. The bottom waters are not warm enough, compared with surface temperatures, to suggest that magma might be moving up toward the bottom of the lake. Moreover, a survey of the lake's depth contours revealed a very flat bottom that showed no signs of having been violently disrupted.

If one assumes that the carbon dioxide had slowly seeped into the lake, what then triggered the cloud? A few scientists have suggested that a large bubble of low-temperature magmatic gas, trapped under the lake by presumably impermeable bottom sediments, suddenly burst. "The problem with this scenario is that there is no evidence of massive bottom sediment disruption," the AID researchers write in their report.

Another idea, which the team says cannot be ruled out, is that the carbon dioxide concentration had simply grown to a point where it had exceeded the water's solubility limit — the water could not absorb another carbon dioxide molecule in solution, so added carbon dioxide molecules stayed in the gas phase and precipitated a runaway degassing of the lake.

But the idea that seems to be getting the most play is that the stratified layers of the lake were somehow upset, causing the lake to "overturn." Like many other volcanic crater lakes, Lake Nyos was probably chemically stratified because of its depth, which enables it to hold an enormous amount of dissolved gases at high pressures, and because of its relatively small surface area, which limits how much gas can escape. Moreover, like many other tropical lakes, Lake Nyos is thermally stratified; the perennially warm climate keeps the surface waters much warmer and less dense than the cold, heavy bottom waters. As a result, there is very little mixing between the top and the bottom. Lakes at higher latitudes and in more temperate climates — such as Green Lake in upstate New York — overturn regularly because the seasonal cooling causes their surface waters to sink. The disrupted bottom waters are then depressurized as they move toward the surface, releasing gases.

Some limnologists (lake scientists), among them Daniel Livingstone at Duke University in Durham, N.C., find it significant that both the Lake Nyos and Lake Monoun events, as well as the regular overturning of Lake Bosumtwi in Ghana, occurred in August, when the increased cloud cover from the monsoons cools the surface waters of African lakes. The cooling itself might not have been enough to prompt an overturn, but it would have made it much easier for something else to disrupt the stratification.

In the Monoun case, researchers thought the lake might have been overturned by a landslide. This is also a possibility for Lake Nyos, although if there was evidence of a landslide from nearby slopes, it has been washed away. Another possibility is that changes in the water levels or temperatures of two streams that feed into Lake Nyos might have tipped the stratification balance. According to Livingstone, the most common trigger of overturning in other lakes is wind stress: Winds first pile water on one side of the lake, then stop blowing, releasing the water like "a bowl of soup on a cafeteria tray" and creating an internal wave that can precipitate an overturn.

More clues to the cause and nature of the Lake Nyos cloud may come from laboratory analysis of water samples and, especially, bottom sediments, although the team was unable to collect much sediment or take piston cores of the bottom.

If carbon isotope and other studies confirm that the gases were volcanic and leaked slowly into the lake, then the likelihood that another cloud will be emitted from the lake in the near future is low. The greatest hazard at present, the team reports, is a very weak natural dam made of volcanic ash, which is located where the water leaves the lake at its northern end. The researchers worry that the dam will fail, causing a catastrophic flood, and in so doing might also possibly trigger another cloud by suddenly lowering the lake level.

As for the other volcanic lakes in the region, the team recommends an extensive monitoring program. Team member George Kling, a graduate student working with Livingstone, had previously taken deep-water samples of about 17 Cameroon lakes, including Lake Monoun, and has worked with surface samples of many more, including Lake Nyos. According to Livingstone, Kling had found that Monoun was much more chemically stratified than most of the other 16 lakes.

"If I lived near a deep lake anywhere in the world, I'd go out with my boat and my water sampler and I'd bring up a sample of deep water and see if it fizzed," says Livingstone.

In a Sept. 4 briefing to AID, chemist Jimmy Stewart at the F.J. Seiler Research Laboratory in Colorado Springs, Colo., presented a few ideas about how to render such potentially dangerous lakes harmless. Since lime reacts with carbon dioxide to form chalk, it could be added to a lake to take the carbon dioxide out of solution, he says. Stewart figures that a few thousand tons of lime would keep Lake Nyos safe for quite a while, but he adds that the cost of getting the lime to the lake would be very high. Another idea is to explode a small bomb in the deep waters of the lake, an approach Stewart says might get rid of most of the carbon dioxide for decades if not thousands of years. Both Stewart and Peter Kilham at the University of Michigan in Ann Arbor have also suggested bubbling air through the lake to carry out the carbon dioxide, in a method similar to that used in sewage ponds. The disadvantage of this idea, says Stewart, is that it requires some sophisticated technology.

Like other catastrophes, the Lake Nyos disaster has had its positive sides. As Paul Pondi, Cameroon's ambassador to the United States, commented at one AID meeting, it brought the world's attention to the democratic nation of Cameroon. It has also put limnology in the limelight.

And it has led volcanologists to a remarkable discovery. Devine says the team discovered pieces of peridotite – the primary material of the earth's mantle – up to the size of footballs at Lake Nyos. The finding of peridotites at the earth's surface is a rare occurrence, and usually the erupted chunks are no larger than walnuts. The minerals may hold clues to the Lake Nyos disaster – for example, Devine plans to look for fluid inclusions in olivine crystals that might help determine whether the mantle beneath Cameroon is rich in carbon dioxide or other gases. But the minerals will also be like a "magic submarine" for people studying the mantle, says Devine. "Lake Nyos would be famous even apart from the disaster," he says, "because of the abundance of peridotite brought to the surface."

– S. Weisburd

Possible visitor from the Oort cloud

Cometary orbits are usually either elliptical or parabolic, and it is often difficult to predict them exactly from the first few observations. That of Comet Wilson, which was discovered Aug. 5 by Caltech graduate student Christine Wilson, appears to be parabolic. Up to Sept. 15, at least, calculations had shown no deviation from a parabola, says Brian Marsden, director of the International Astronomical Union's Central Bureau for Astronomical Telegrams in Cambridge, Mass.

A parabola indicates a long orbit. Comet Wilson may be a fresh visitor from the Oort cloud, a collection of cometary material surrounding the solar system a light-year away from the sun. If the comet repeats, it may take centuries or even millennia between returns to the inner solar system. Current calculations make its perihelion date April 20, 1987, when it should approach the sun almost as closely as the earth does (1.2 astronomical units).

Current observations put the comet's brightness at 10th or 12th magnitude, and with fingers crossed astronomers predict it may reach 3rd magnitude at perihelion. This would make it visible to the naked eye under fairly dark conditions, but mainly in the Southern Hemisphere.

If it is a fresh visitor from the Oort cloud, it may fizzle as Comet Kohoutek did in 1973, and for the same reason, Marsden says: Volatiles that now make it bright will have burned off, and, depending only on sublimation of water-ice for brightness, it could become much dimmer. On the other hand, if it breaks up, as Comet West did in 1976, it could provide a spectacular show, he says. Although Marsden hears that the press in New Zealand is already making a fuss about it, he stresses that Comet Wilson will probably be a workout for professional astronomers rather than a spectacle for pedestrians.

– D. E. Thomsen

Coated quartz for detecting toxics

Quartz crystals coated with proteins such as antibodies, enzymes and other biologically active materials may be useful for detecting traces of pesticides and drugs in air. This technique is potentially simpler and cheaper than currently available methods for recognizing and measuring small concentrations of toxic substances.

In the Sept 3 JOURNAL OF THE AMERICAN CHEMICAL SOCIETY, chemist George G. Guilbault of the University of New Orleans and his colleagues report success in using quartz crystals coated with antibodies against the pesticide parathion to measure parathion concentrations down to 36 parts per billion. "The results obtained in this study," the researchers say, "demonstrate that a piezoelectric crystal coated with a specific antibody could be used as an analytical tool in gas-phase analysis."

Each quartz crystal has two surface electrodes, which are coated with a specific agent known to bond with the substance to be measured. For example, parathion antibodies would pick up the antigen parathion. Normally, an electric current drives the crystal to oscillate at a set frequency. When an antigen-carrying gas flows over the crystal, the coated surfaces collect the antigen and as a result grow heavier. This weight increase changes the crystal's frequency, providing a measure of the antigen's concentration in air.

The researchers found that their antibody-coated crystals last for several weeks. Passing pure air over the used sensors reverses the antibody-antigen reaction and restores the crystals to their original state. The same frequency signal is observed before and after repeated exposure to antigen.

Although protein-coated quartz crystals have been used before to detect specific substances, those reactions have all taken place in liquids. The new results, says Guilbault, are the first to show that the analysis can be done directly in the gas phase. Guilbault has a small company that holds a patent on this technique.

Guilbault is now developing antibody-based sensors for detecting cocaine, morphine and heroin in air. These sensors, he says, would be able to detect levels that a dog's nose can sniff out. "But you don't have the upkeep and the mess that you have with dogs," says Guilbault.

However, the researchers say, while a great deal is known about antigen-antibody interactions in solution, much less is known about their behavior in the vapor phase. These aspects will have to be studied further before a practical sensor is ready.

– I. Peterson