There May Be More Than One Way To Make a Volcanic Lake a Killer

Limnologists, feeling neglected in the first rush of news from the Cameroon disaster, are suggesting that volcanism need play no role in the generation or release of toxic gases

To make his point that not only volcanoes release noxious gases, limnologist Peter Kilham of the University of Michigan recounts his ill-advised foray to the edge of Lake Gidamur, a small lake nestled in a volcanic crater in Tanzania. Drawn to the spot from 8 kilometers away by the rotten-egg smell of deadly hydrogen sulfide, he and his wife found the lake dyed "a lovely shade of purple" by bacteria normally confined to the deep, oxygen-free or anoxic waters of the lake.

Scientific curiosity triumphing over good sense, Kilham held his breath and went down to the water for a sample. Husband and wife then retreated in haste, "coughing and with our eyes streaming." But it was not volcanic gas that they were gagging on. The Kilhams had breathed the products of slow, anoxic decomposition that had been stored until then below a lid formed by the lake's stable surface waters.

Many limnologists, experts in the study of lakes, are saying that on a larger scale such a nonvolcanic release of biologically derived gases accumulated in the deep waters of some lakes could account for the devastation of both known lethal gas bursts from lakes. The latest struck Lake Nyos in Cameroon on 21 August and the first occurred at Lake Monoun, 240 kilometers away, on 15 August 1984. The coincidence of the two bursts in August, the time of minimum stability of lakes in Cameroon, points to a nonvolcanic, lake-related trigger for the releases, limnologists say. The only role for volcanism might be the shaping of the deep basins that hold the lakes.

While limnologists are building a case for a purely lacustrine cause of the killer lake disasters, others are questioning the evidence pointing toward a volcanic source for the gases. The crucial evidence in support of volcanic origins comes from analyses of carbon dioxide from Lake Monoun as interpreted by volcanologist Haraldur Sigurdsson of the University of Rhode Island and his colleagues. These researchers explain the relatively old carbon-14 age of 18,000 years as the result of mixing of young, biologically produced carbon dioxide with ancient volcanic carbon dioxide. The stable isotopic composition of the carbon, −7 per mil, reflects a volcanic source, the group says. No samples from Lake Nyos have yet been analyzed for isotopic composition or age.

Some geochemists, such as Michael Arthur of the University of Rhode Island, doubt that the carbon isotopic results can be used to argue for either a biological or a volcanic source. Arthur suggests that the 18,000-year age could reflect the biological decomposition of recently synthesized organic matter near the surface of lake sediments plus the decay of older, more deeply buried organic matter. The stable isotope composition is not definitive either, he says; it is neither clearly volcanic nor clearly biogenic.

Because the evidence for the source of the gases is equivocal, argue the limnologists, due consideration should also be given to a purely lacustrine trigger for their release. Sigurdsson's group has suggested that a submarine landslide dropped deep into Lake Monoun and churned together the normally separated deep and surface waters, triggering the catastrophic release of the gases stored under pressure in the deep waters the way popping a cork on a warm bottle of champagne creates foam. No trigger preceding the Lake Nyos event is yet evident.

More catastrophic explanations aside, the normal change of seasons could have triggered both of the lethal gas bursts, according to a number of limnologists. In temperate latitudes, the arrival of fall routinely cools the warmer, lighter surface waters that have capped deeper waters all summer. With

Curt Stager

Lake Nyos in quieter times: *George Kling of Duke University sampled Lake Nyos almost a year before a burst of noxious gases from this lake killed about 1500 people. The relatively great depth of such lakes and their protection from the wind, evident here in the sheer cliffs of the volcanic crater holding the lake, may have contributed to the disaster.*

the cooling and a bit of a breeze, the surface waters sink and mix with the deep waters, releasing to the atmosphere what little gas might have accumulated below during the summer.

Since lakes in the tropics experience relatively minor seasonal weather changes compared to those of higher latitudes, it might be presumed that they remain permanently stratified, but limnologists have long known that tropical lakes do turn over, if somewhat less predictably than their temperate counterparts. Lake Bosumtwi in Ghana, another West African nation on the Gulf of Guinea, turns over almost every autumn, says limnologist John Melack of the University of California at Santa Barbara. After a turnover, anoxia prevails from top to bottom, tingeing the air with hydrogen sulfide and driving fish to the surface. The occasional failure of the lake to turn over frustrates the local fishermen, who depend on making easy work of the desperate fish.

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Even the most stable lake known in Cameroon, Lake Barombi Mbo, responds dramatically to the changing seasons, according to George Kling of Duke University. Last year he spent 6 months studying 37 of the 50 lakes in Cameroon; 30 of the 37 are set in volcanic craters. In May the stability of Lake Barombi Mbo peaked, but by September it had reached its minimum stability, still considerable but half the value in May. By October, its stability headed back up. This contrary trend, losing stability during the summer instead of gaining it, is driven not so much by increased wind or decreased air temperature, emphasizes Melack, as by the cloudiness of the monsoon season that reduces solar heating.

"It seems like quite a coincidence," says Kling, "that these West African lakes should have minimum stability in August through September and that the two events were on 15 and 21 August. I'm not convinced that it's purely volcanic. It could be purely limnological." Melack, Kilham, and others agree. By their reasoning, Cameroon volcanic lakes are prime candidates for catastrophic turnover. They may not turn over for years or even centuries at a time. The protection from wind afforded by surrounding crater rims and the lakes' relatively great depths—Nyos is more than 200 meters deep but less than 2 kilometers wide—tend to protect them from turning over. The high pressures in the deeper parts of the lakes also allow storage of large amounts of gas.

As long as climatic conditions maintain the stability of a lake, the store of carbon dioxide and other gases could build in the deep, isolated waters. A climate change could then push a lake close to instability and turnover. Climatologist Eugene Rasmusson of the University of Maryland notes that there is a tendency for the tropical belt to be wetter (and its lakes thus cooler and less stable) when the sub-Saharan region is drier than normal. The sub-Sahara just had its worst drought in 150 years. Once driven close to a turnover by long-term climate change, a lake could quickly be pushed over the edge by a summer monsoon. Although a complete turnover takes much longer, the final mixing of anoxic, gas-laden waters to the surface can take less than 2 hours.

The lacustrine explanation has a few hurdles ahead of it. Press accounts of the 1986 event include reports of two explosions, steam, and tremendous heat in streams flowing from the lake. The findings of official investigators, including a party of three earth scientists and three pathologists from the United States, should help clarify these reported phenomena. Chemical analyses of lake water should reveal any injection of volcanic gases by lava. An actual eruption might also leave clues in measurements of lake temperature. As of 2 September, the U.S. scientific team's preliminary evaluation "indicates no evidence of volcanic or seismic activity triggering the event."

Limnologists are hardly adamant about their alternative hypothesis. Most of them readily admit that some role for volcanism cannot be ruled out. A common thought among these researchers is that perhaps there is a mix of volcanic and lake-related factors; much of the gas could be volcanic, seeping into the lake bottom over many years, but the trigger could be lacustrine. Foremost among limnologists' concerns seems to be the respect due their science. After all, they note, the two disasters did spring from lakes, their specialty. Even so, it is the volcanologists who are being quoted in the press and the initial U.S. scientific party included no limnologists, they note. ■ RICHARD A. KERR

Volcanism on Mercury And the Moon, Again

Opinions on the nature of smooth, bright plains on these look-alike bodies have varied in tandem—now such plains on Mercury and some on the moon look volcanic

GIVEN the striking similarity of the heavily cratered surfaces of Mercury and Earth's moon, it is hardly surprising that scientific opinion concerning one of the pair has been mirrored in beliefs about the other. A decade since Mariner 10 took the first and only pictures of Mercury and even longer since Apollo astronauts brought home the last moon rocks, planetary scientists have concluded that early in its history Mercury did indeed spew huge volumes of lava that formed plains. That had been researchers' first thought on seeing the Mariner 10 pictures, but the idea of a volcanic source had been doubted by many since. At the same time, opinion about the nature of some similar plains on the moon has swung back toward pre-Apollo, volcanic explanations.

The first change of mind on the existence and style of volcanism on smallish, rocky bodies came well before anyone saw Mercury as anything more than a nearly featureless, fuzzy ball. Looking at the moon's smooth, relatively bright highland plains, researchers assumed that they were frozen seas of lava that had flooded onto the surface. These plains certainly resembled the larger, darker maria, the plains that form the man (or woman) in the moon. These broad plains were clearly flood basalts that had filled low-lying basins. The highland plains,