

The Killer Lakes of Cameroon

Who's Involved?
Who's Affected?
What happened?



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Others involved:

- U.S. Embassy, Cameroon
- U.S. Office of Foreign Disaster Assistance (OFDA-USAID)
- U.S. Geological Survey
- U.S. EPA
- U.S. Defense Mapping Agency (DOD-NGA)
- *Cameroonian Government*
- *Japanese Government*
- *French Government*

Lakes in the news:

news@nature.com
The best in science journalism

NATURE published online:
26 September 2005; |
doi:10.1038/news050926-4
**Deadly lakes may
explode again**
Pipes to avert disaster are
working, but not quickly
enough.
Andreas von Bubnoff



BBC NEWS WORLD EDITION

**Action needed on
deadly lakes**

By Richard Black
Environment Correspondent, BBC News
website
Tuesday, 27 September 2005, 11:37 GMT 12:37

**More work is needed urgently
to prevent potentially fatal
releases of gas from two lakes
in Cameroon, scientists say.**

ENN
ENVIRONMENTAL
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**Cameroon Dam Nears Collapse,
10,000 Lives at Risk**

August 19, 2005 — By Tansa Musa, Reuters
YAOUNDE — A natural dam holding back a lake in Cameroon is on the
verge of collapse, threatening to unleash a wall of water into neighbouring
Nigeria and sweep away 10,000 people in its path, a scientist warned on
Thursday.

*National Geographic, Smithsonian
Discovery Channel, Discover Magazine
The Learning Channel, PBS
BBC Film & Broadcasts, World Book
Scientific American, Voice of America*

NATIONALES
SOCIETY
Lake Nyos : UN Scientists Seek Safety Solutions
Government intensifies efforts to make resettlement areas safe for survivors.

On August 23rd, 1986, Cameroon
experienced a disaster of unprecedented
scale. A massive gas cloud, composed of
carbon dioxide, erupted from the
bottom of Lake Nyos, a 1,000-foot
deep lake. The gas cloud, which was
invisible and odorless, killed over
2,000 people and 35,000 head of
cattle. The disaster was the result of
a volcanic eruption that had been
ongoing for years. The gas cloud
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and the dam are expected to be
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Who's Affected?



Lake Monoun Region:

~3,000 people living or working near the lake.



Lake Nyos Region:

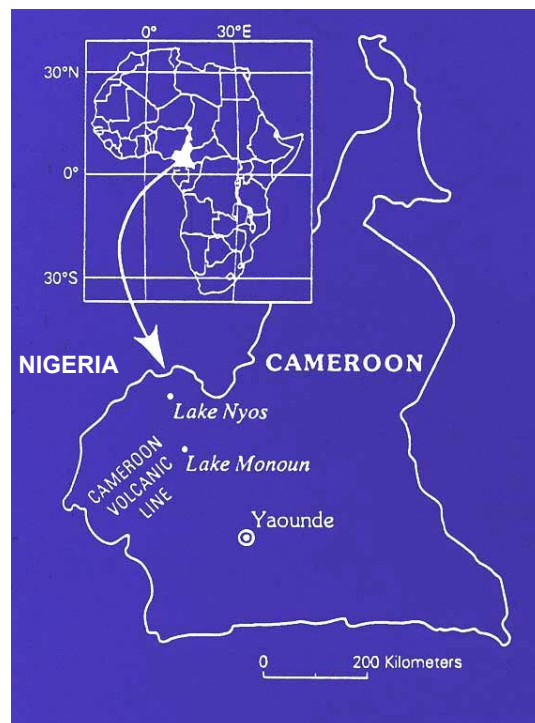
~5-10,000 people in the floodplain below the lake, including people living in Nigeria.



Introduction and Background

Only 3 lakes in the world are known to have high concentrations of gas:

Lakes **Nyos** and **Monoun** in Cameroon, and Lake **Kivu** in East Africa.





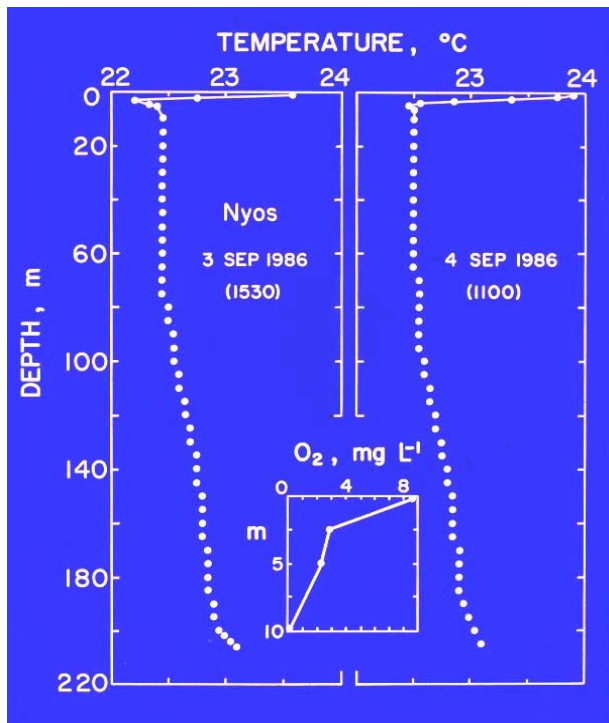
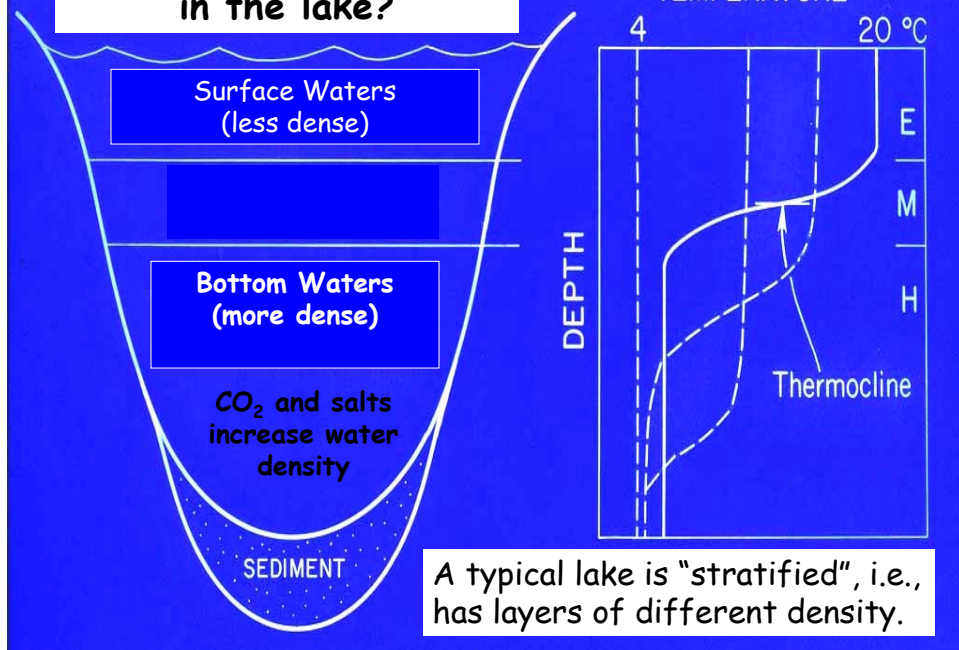
Lake Nyos in May 1985
before the disaster



Lake Nyos ~10 days after
the disaster in August 1986

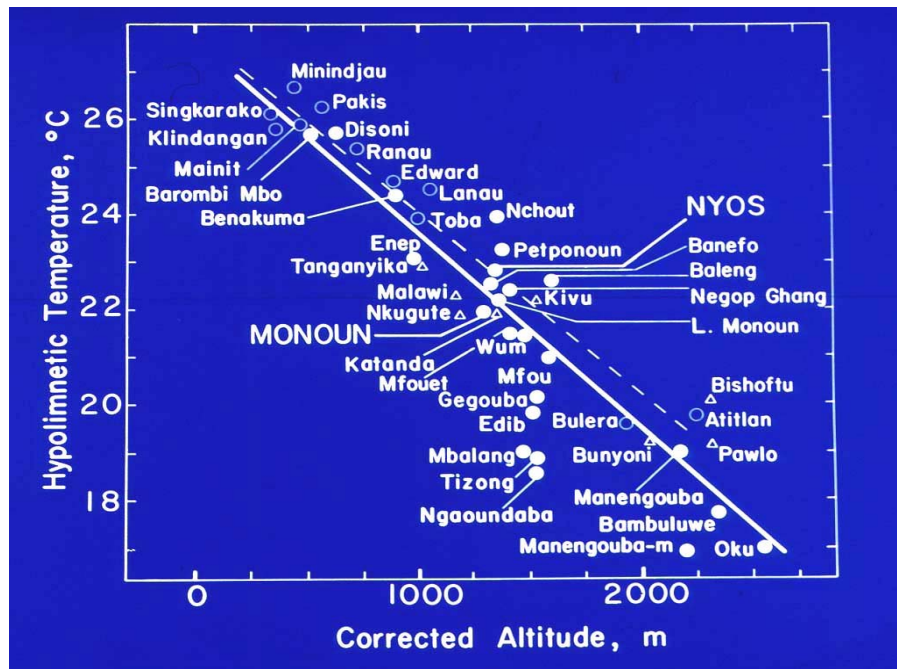


Why does the gas stay in the lake?

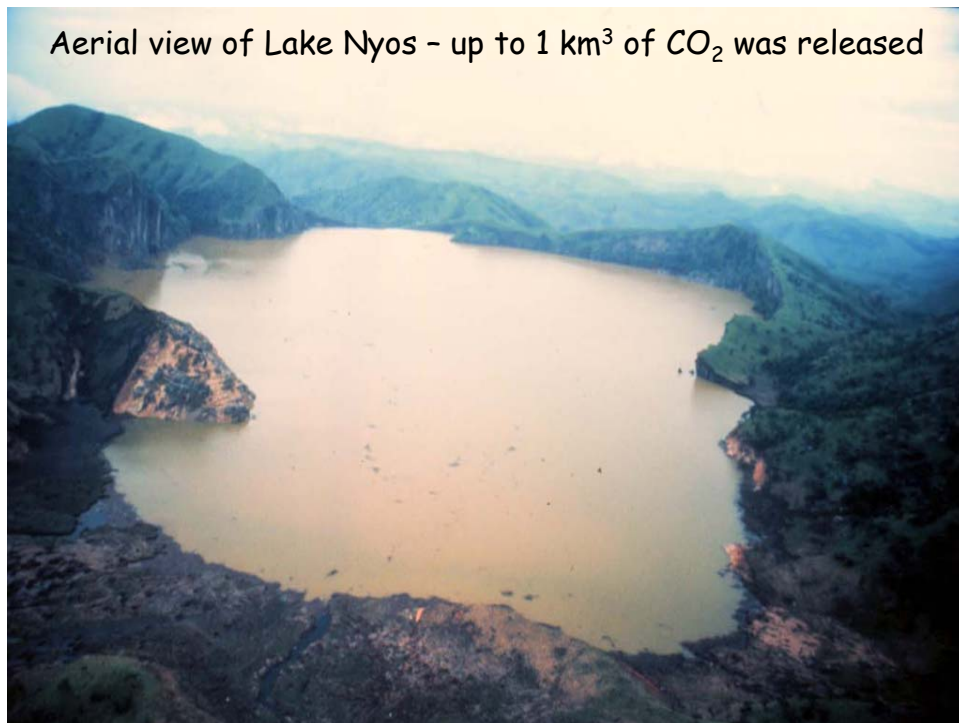


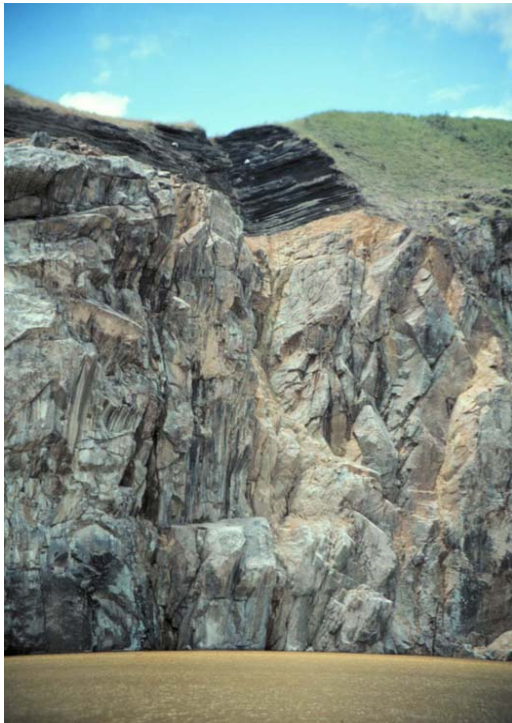
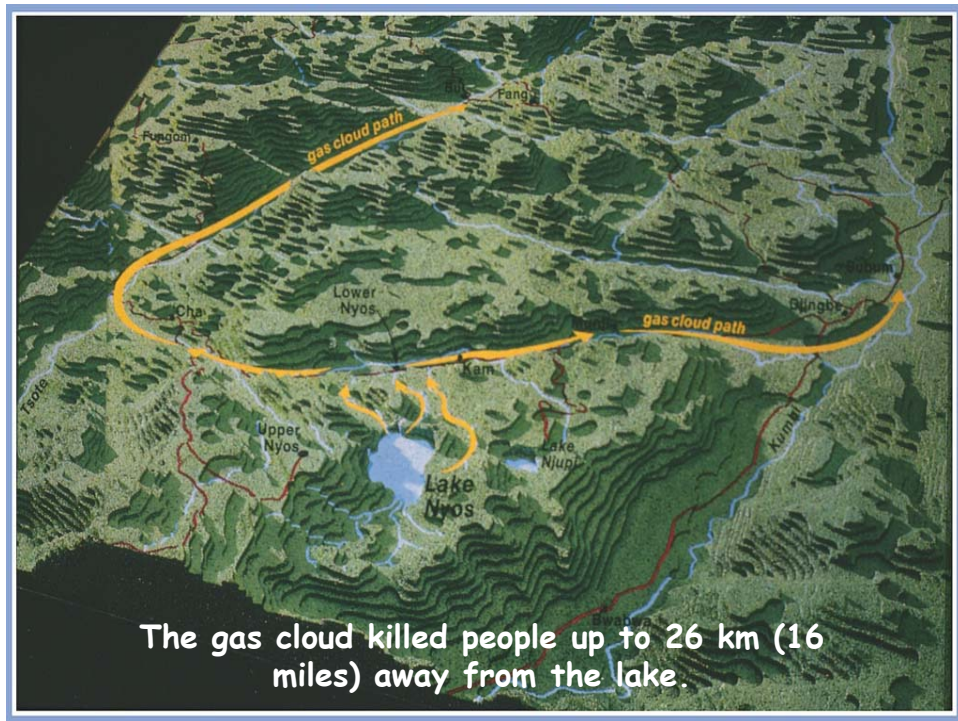
After the gas burst Lake Nyos had similar temperatures from top to bottom, indicating that mixing occurred during the gas release. The surface water warming was due to the sun.

Note also that the oxygen was gone by 10m depth.

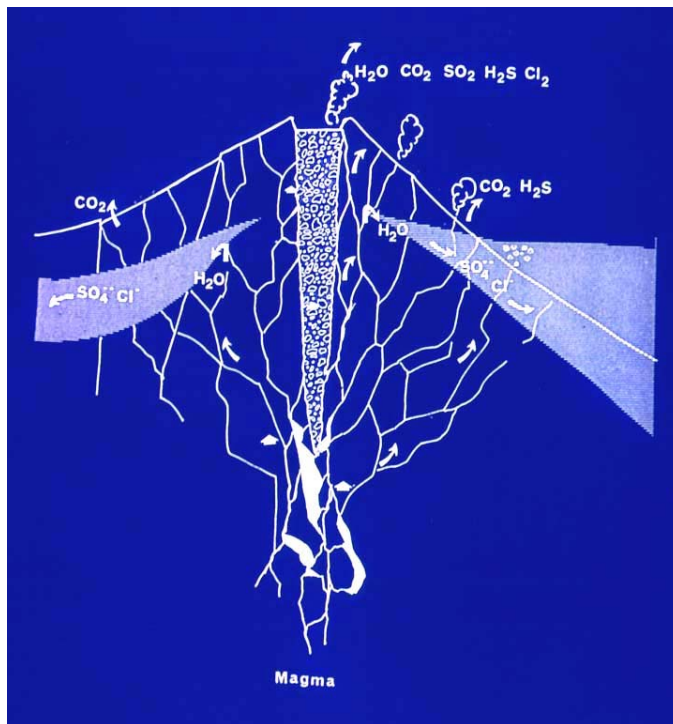


Lakes higher in elevation have colder bottom waters.





The gas-water fountain produced by the explosion reached over 100 m (300 feet) in height (and went over the rock promontory shown at left), and produced a surface wave 30 m (100 feet) high.



Most volcanoes produce large amounts of toxic sulfur gases, and heat.

Survivors reported smelling rotten eggs or gunpowder, and feeling warm.

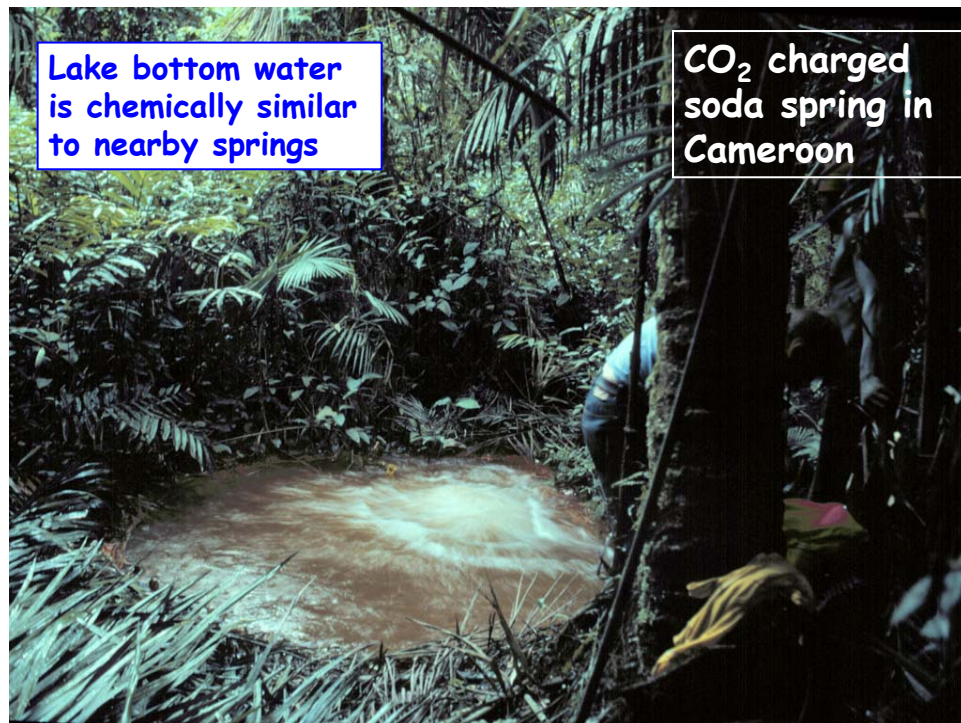
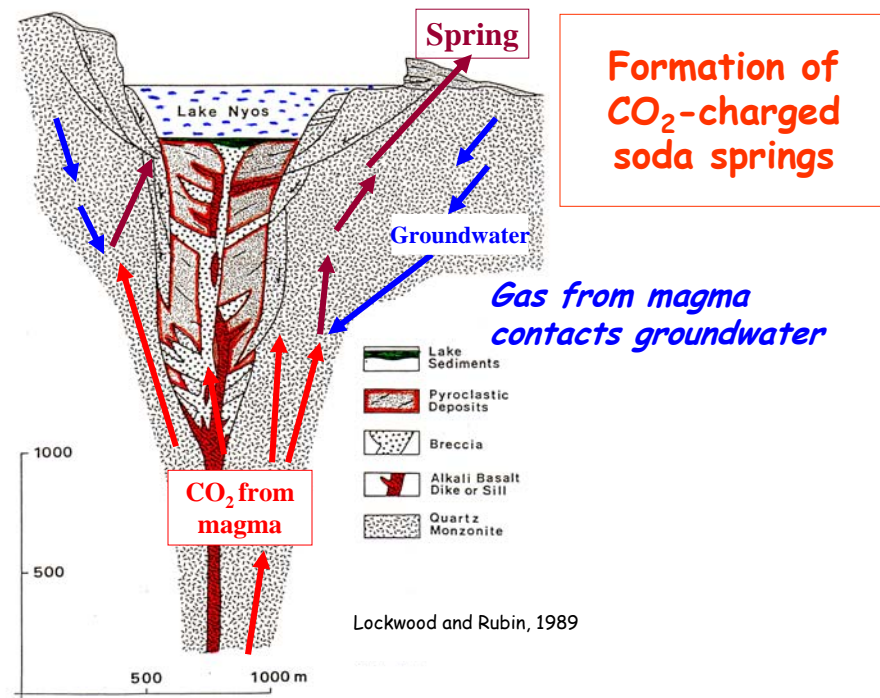
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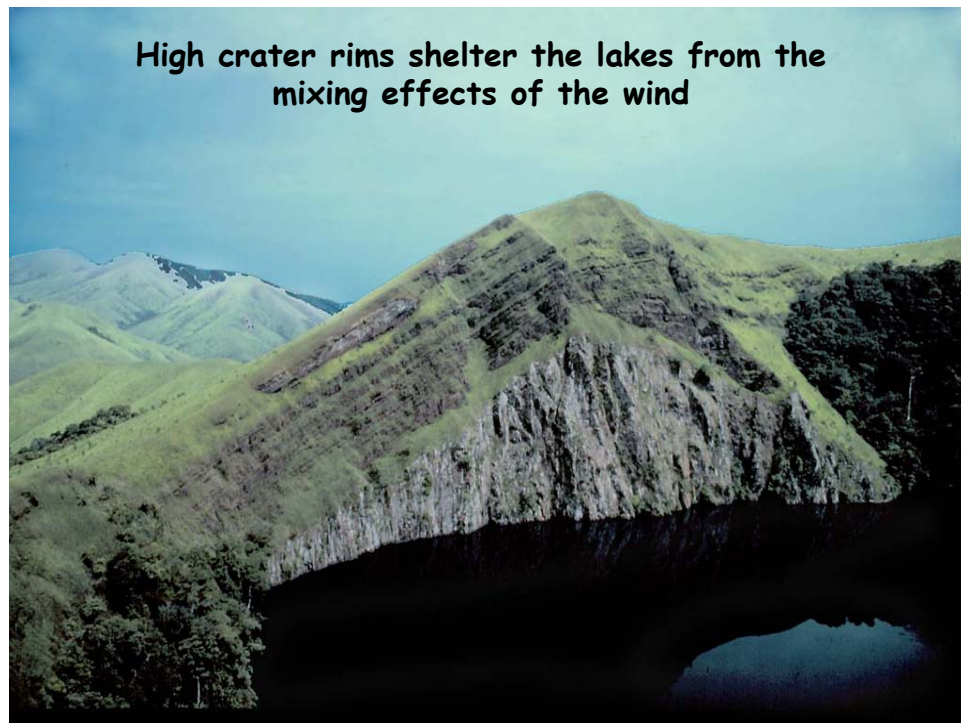
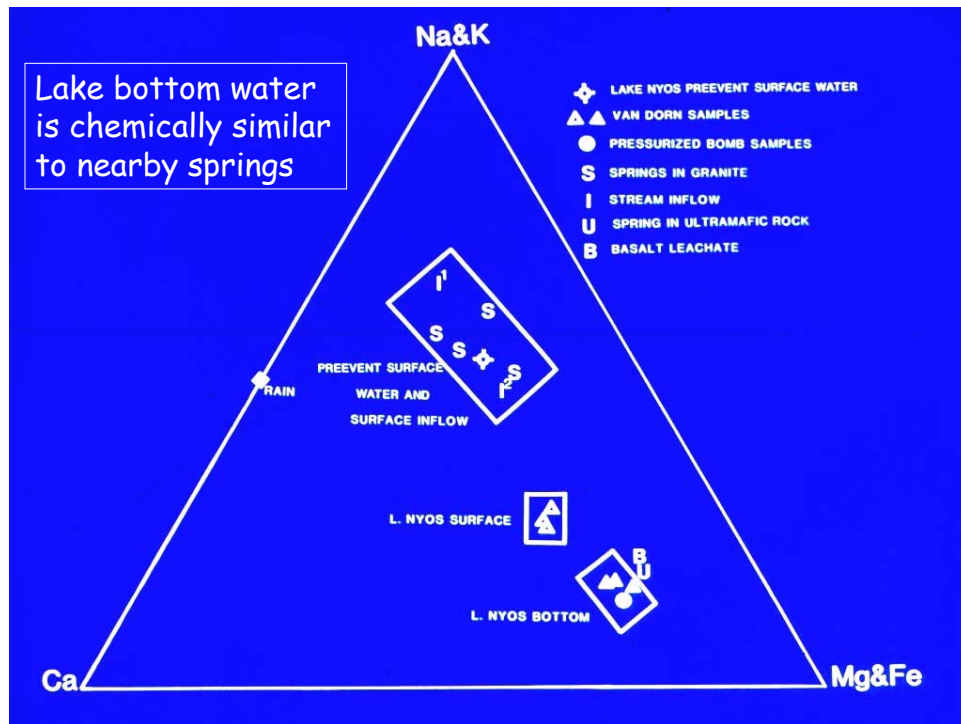
1. Volcanic (hot)
2. Biogenic
3. Magmatic (cool)*

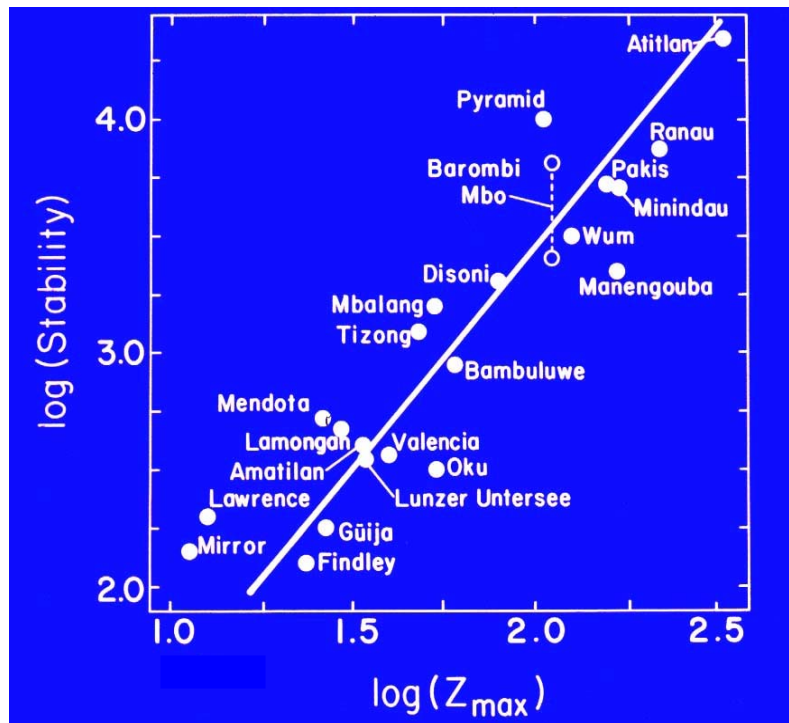


STORAGE:

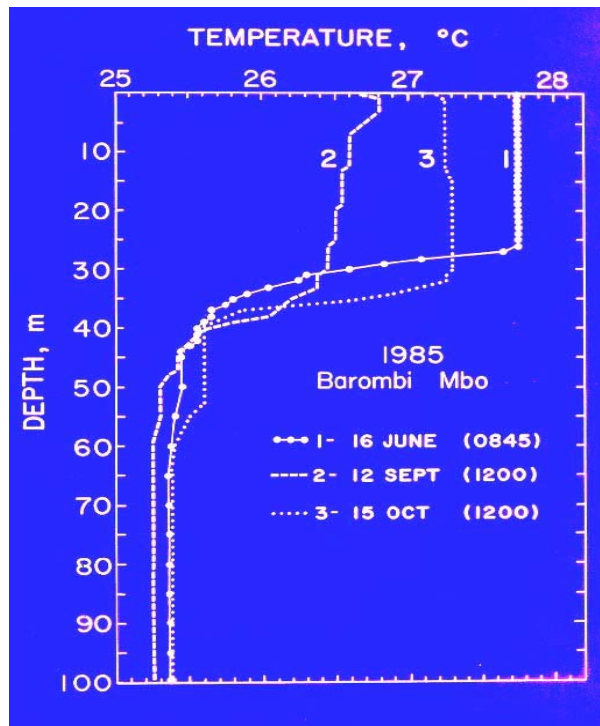
1. Fissures below the sediment
2. Bottom waters of the lake*



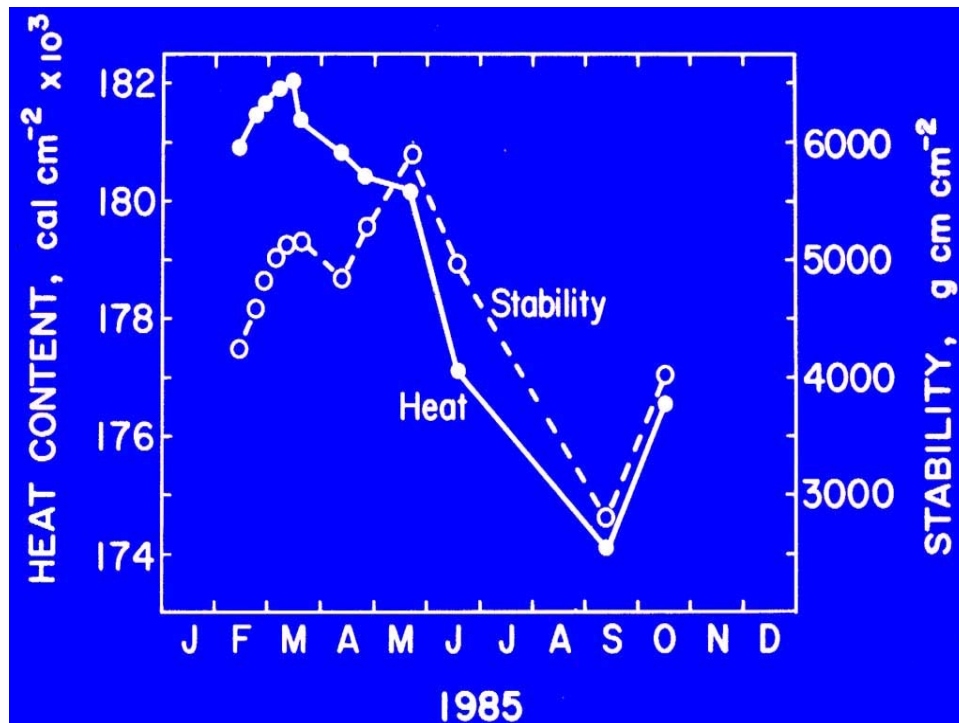




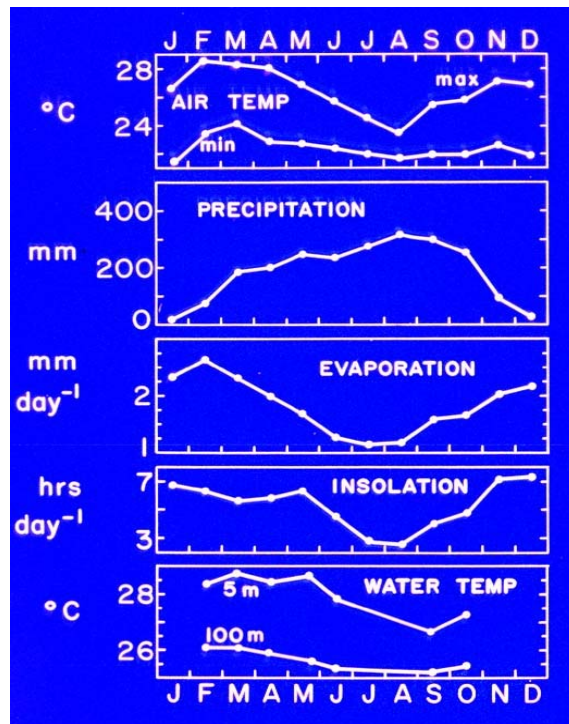
Deep lakes
have more
resistance
to mixing



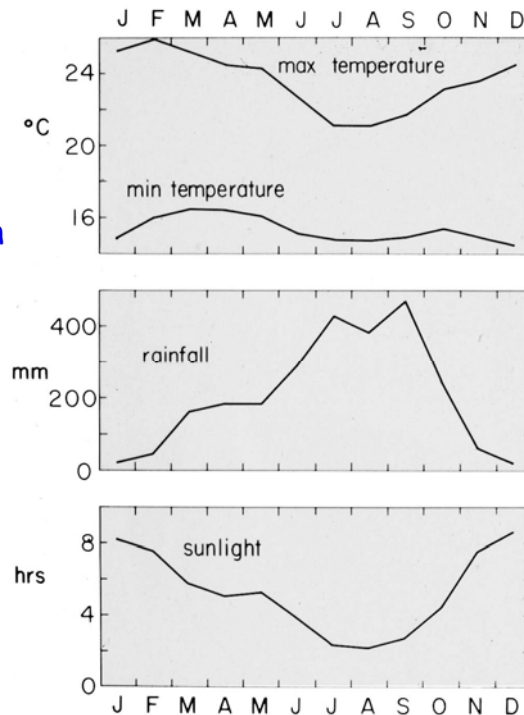
Mixing is greatest during the late summer monsoon season.



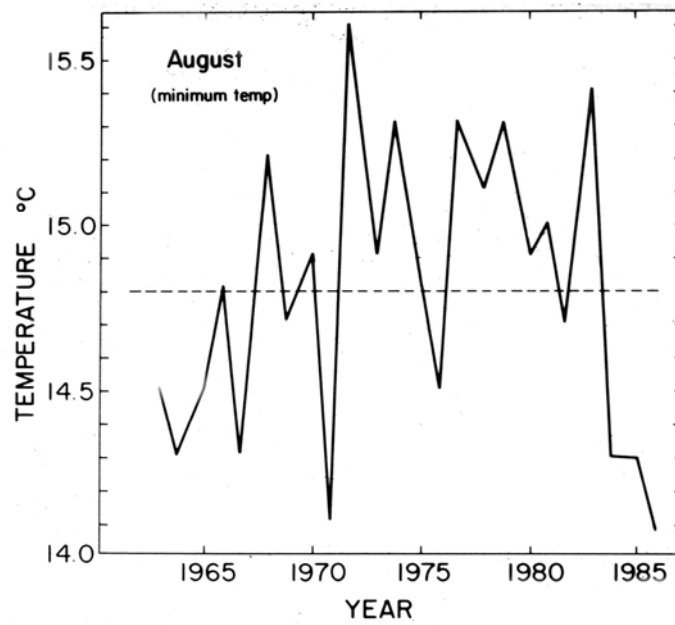
Climate near Barombi Mbo since 1968 is consistent with deepest mixing in August, the time of the events.



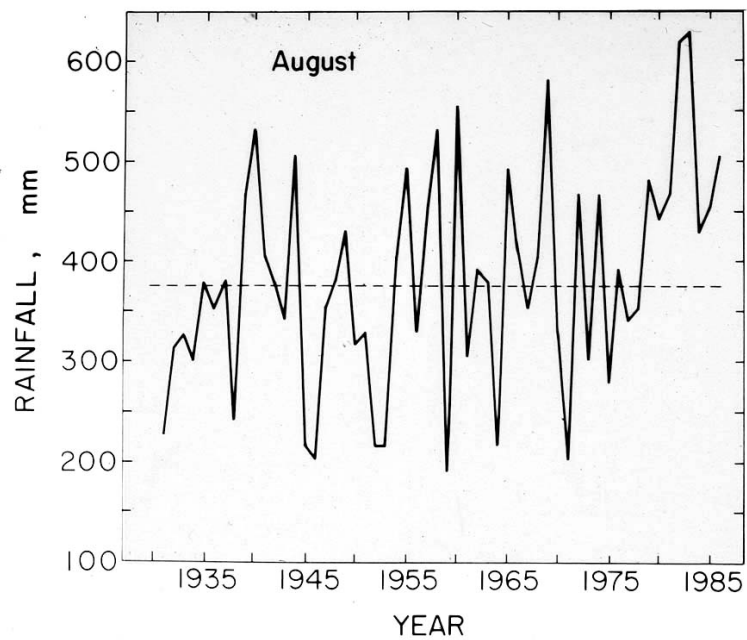
The climate near Lake Nyos is also consistent with deepest mixing in August.



Temperature was low in 1986, but, also in 1971



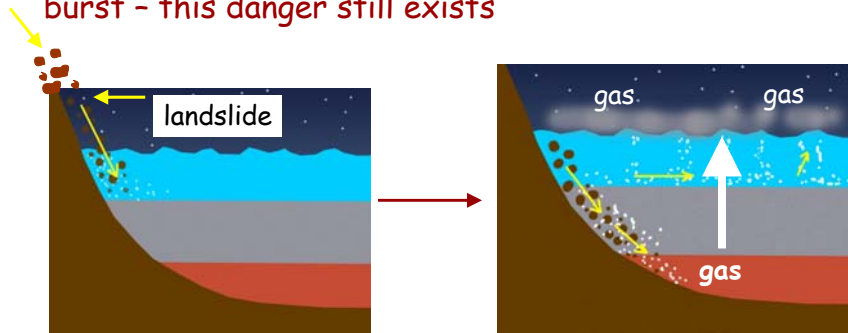
Rainfall was high in 1986, but not in 1971



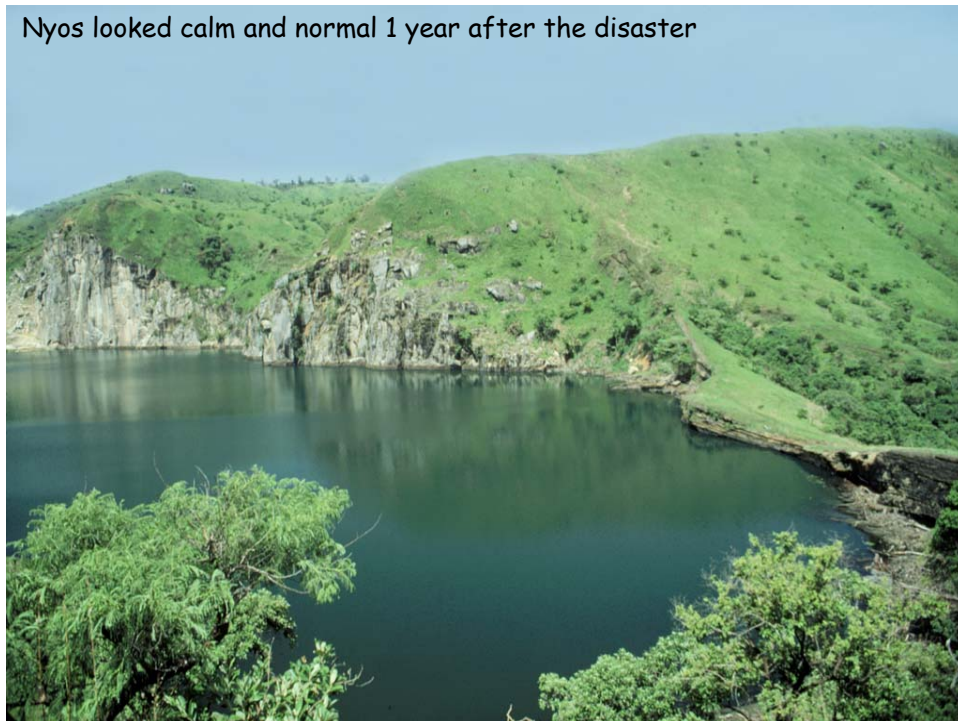
How does the gas get out of the lake?

Any movement of deeper water toward the surface could trigger a gas release if the lake is saturated - just like opening a bottle of soda or champagne.

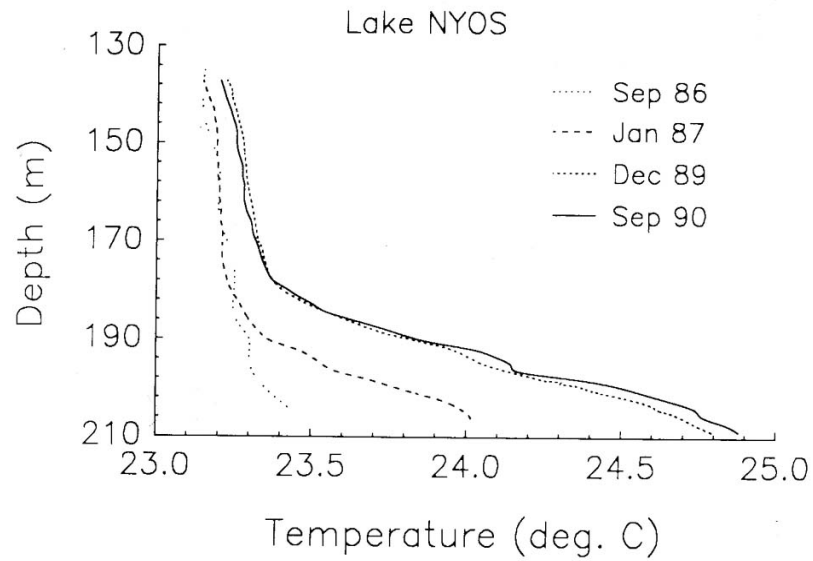
Most likely, a landslide into the lake triggered the gas burst - this danger still exists



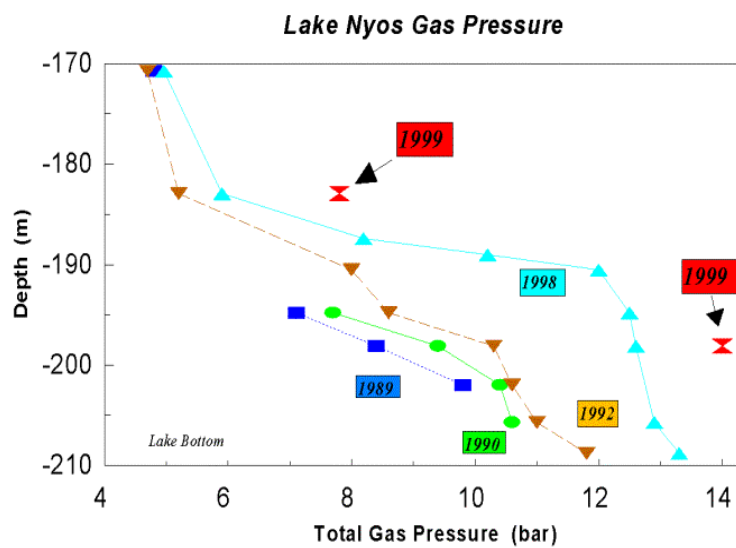
Nyos looked calm and normal 1 year after the disaster



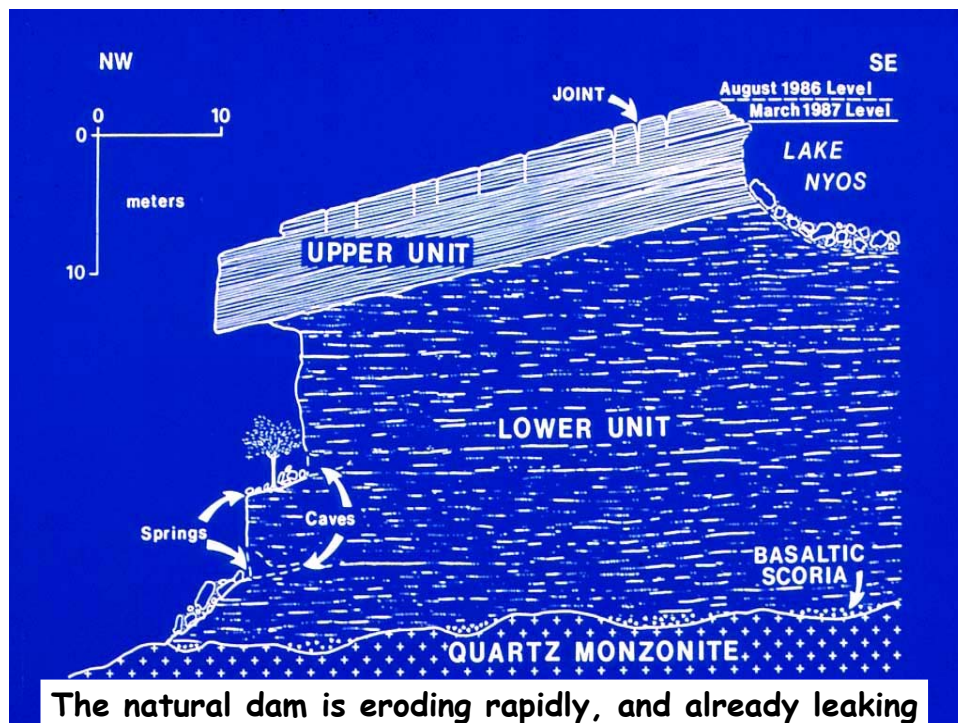
Deep-water temperatures continued to rise



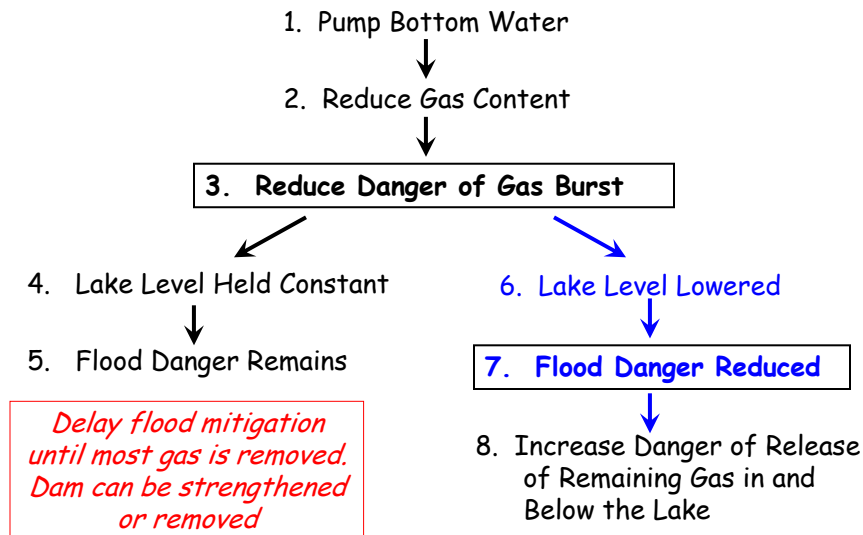
Gas Pressures continued to rise in the lakes



Failure of the weak natural dam at Lake Nyos will create a flood that would reach into Nigeria, 100s of km away.



Remediation for Lake Nyos Hazards Gas Bursts and Flooding



Lake Nyos-Monoun Degassing Program, NMDP



International Project - Cameroon, France, Japan, U.S.A.

Directed by an Inter-Ministerial Committee in Cameroon
Supported by OFDA/AID and foreign governments

Project includes:

1. Lake monitoring - ongoing since 1986
2. CO₂ warning stations - installed at both lakes in 2001
3. Construction of roads and buildings at both lakes
4. Degassing system - rafts, pipe, and instrumentation
 - * Pipe installation at Lake Nyos in January 2001
 - * Pipe installed in Lake Monoun in January 2003

CO₂ Warning Stations installed at both lakes.



Piping has reduced gas content by 12-14%

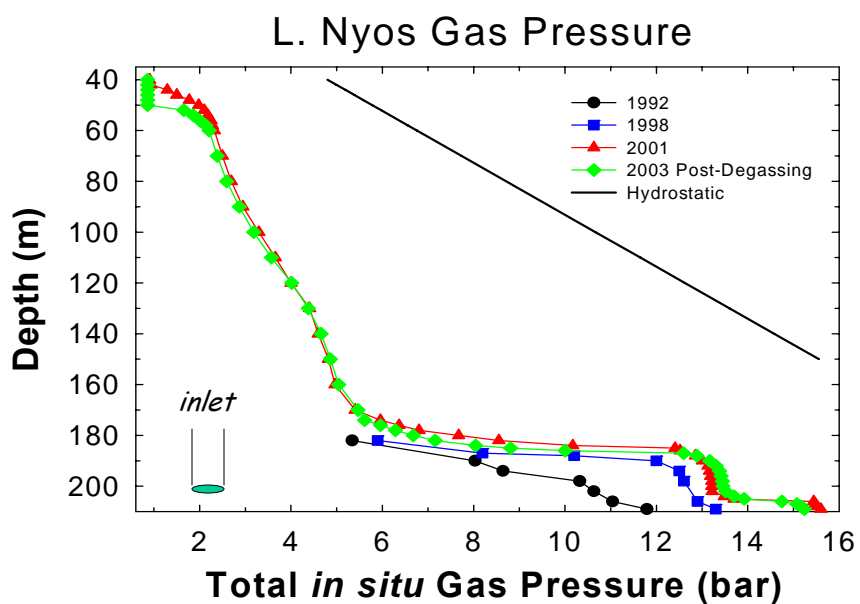
The degassing fountain at Lake Nyos is over 50 m (165 feet) high.

Once started, the degassing is spontaneous and self-sustaining.

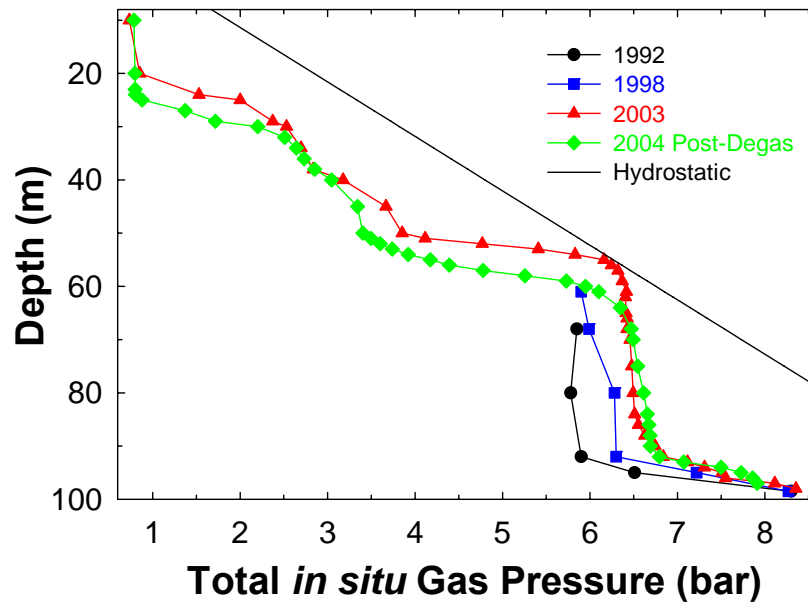
Energy *could* be extracted from the fountain, but there are no power transmission lines in this part of the country.



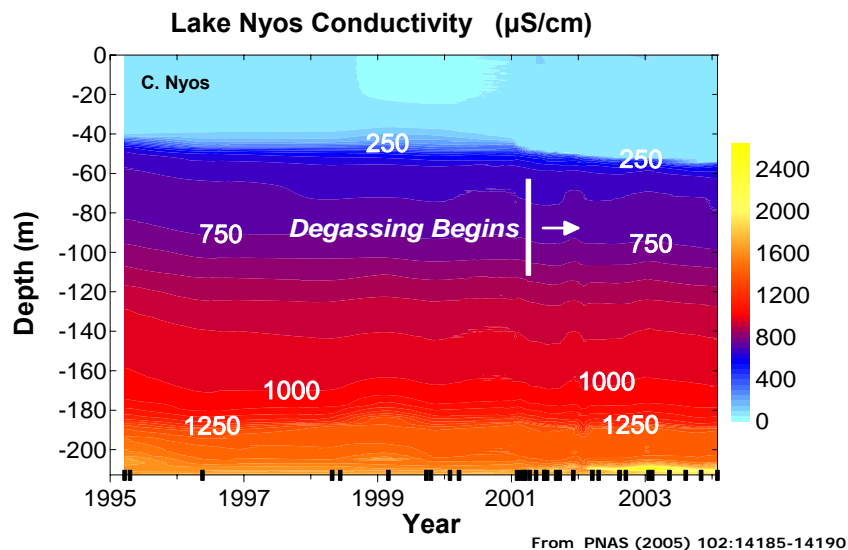
1. The degassing operation has reduced the gas content in the lakes.



L. Monoun Gas Pressure

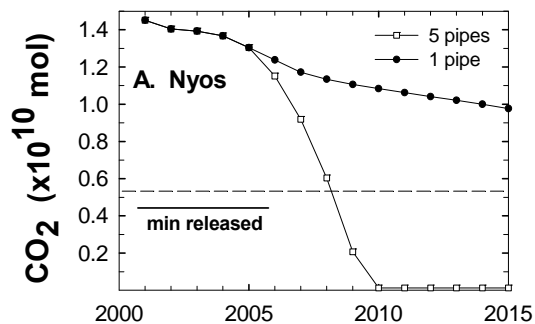
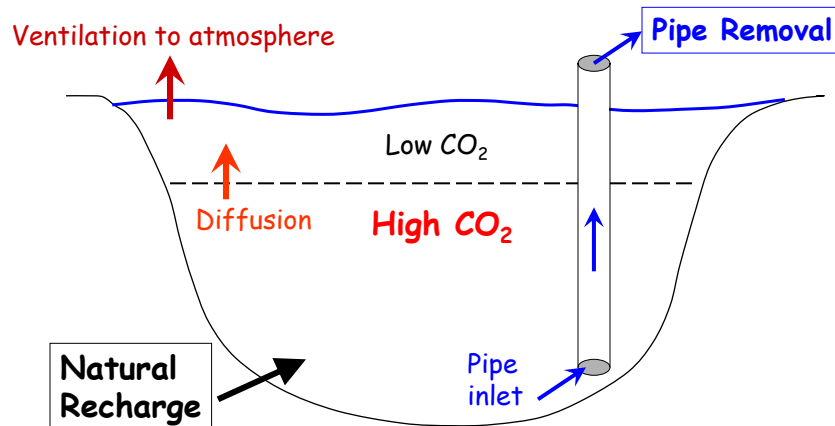


2. The degassing operation has not disrupted the layering in the lake - i.e., the degassing is proceeding in a controlled and safe way.



MODELING OF FUTURE STATUS IN THE LAKES:

$$\begin{aligned}
 [\text{CO}_2_{\text{Total}}] = & [\text{CO}_2_{\text{Initial}}] \\
 & + [\text{CO}_2_{\text{Natural Recharge}}] \\
 & - [\text{CO}_2_{\text{Pipe Removal}}] \\
 & - [\text{CO}_2_{\text{Diffusion + Ventilation to atmosphere}}]
 \end{aligned}$$



The Future of Degassing

In a relatively short time the current degassing operation with one pipe in each lake will become ineffective.

Modeling results indicate that more pipes added to each lake will increase the amount of gas removed, and decrease the time that local populations will be in danger.

The dashed lines indicate the amount of gas remaining at atmospheric pressure (0.9 bar), and the "min released" shows the amount of gas released in the 1986 disaster at Lake Nyos.

From PNAS (2005) 102:14185-14190

Politics of Scientific Debate

(Related to Natural Hazards, or Climate Change)

**Need to overcome the “comfort of inactivity” --
but HOW?**

1. Good Science
2. Understand alternate theories
3. Logic defeats hand-waving in the end
4. Explain principles to politicians and the solutions will become self-evident

(unless they stand to make money from one of the solutions...)

Take Home Message:

Science is only one part of the solution to any problem, but you still have to get the Science right.