material. Analyses of the samples with data for comparable samples from Lake Kivu quoted from Schmitz and Kufferath[2] are listed in Table 1.

Table 1. COMPOSITION OF DISSOLVED GASES IN VOLUME PER CENT

	Kivu*	Tanganyika†	Nyasa†
Depth (m)	400	c. 450 average of 3 samples	c. 400 average of 6 samples
ml. gas/l.	5	1	2·000
CH_4	21·7	0·2	0·2
N_2	n.d.	89	94
O_2	n.d.	trace	trace
A	n.d.	1·0	1·0
CO_2	77·3	10	5
H_2	n.d.	trace	trace
Rest	1	—	—

n.d. not determined.

* Depth of Lake Kivu, etc. *Treatise on Limnology* by G. E. Hutchinson (Oxford Univ. Press).

† *Ann. Rep. Geol Surveys Nyasaland and Tanganyika for 1960.*

The composition of the gas from Lakes Nyasa and Tanganyika is close to that of air from which oxygen has been removed. Organisms in the lakes could remove the oxygen from dissolved air and generate the methane and most of the carbon dioxide found in the samples. It was found that the proportion of nitrogen rises and that of carbon dioxide falls with increasing depth in Lake Nyasa.

The average volume of gas recovered per litre of water from Lake Nyasa was 5 ml. and that from Lake Tanganyika 1 ml. This difference may result from the stagnation of the lower waters of Lake Tanganyika and the occasional circulation of Lake Nyasa[4]. Circulation brings air-rich water to the deeper parts of the latter, while only small amounts of air reach the depths of the former. By contrast there are more than 2 l. of gas dissolved in every litre of water from a depth of 400 m in Lake Kivu.

The gas in Lake Kivu is so different from that in the other two lakes and there is so much more of it that it is reasonable to suspect that it originated in a different way. The three lakes are similar in climate and depth and could be expected to provide biologically similar environments. Only Lake Kivu is in an active volcanic area, and its gas content might be attributed to a volcanic origin. Schmitz and Kufferath rejected a purely volcanic origin for the Kivu gas, because gas from the neighbouring Virunga volcanoes contained no methane. They concluded that the dissolved gas originated through anaerobic fermentation of planktonic material with possible addition of carbon dioxide from volcanic sources. However, the difference between the volcanic and dissolved gases is not great if the absence of methane from the former results from atmospheric oxidation in the volcanoes. Had the gas originated through anaerobic fermentation some gas could have been expected in Lake Tanganyika. For these reasons it is suggested that the Lake Kivu dissolved gas is of volcanic origin.

This work was done while I was a member of the staff of the Atomic Energy Division at the Geological Survey of Great Britain. The assistance and co-operation of the directors and staffs of the Geological Surveys of Nyasaland and Tanganyika in collecting samples are gratefully acknowledged. The gas samples were analysed by N. J. D. Prosser of the Mass Spectrometry Group, Atomic Energy Research Establishment, Harwell.

KEVIN BURKE

Department of Geology,
University of the West Indies,
Mona,
Kingston,
Jamaica.

[1] Damas, H., *Exploration du parc national Albert*, **1**, 38 (1937).
[2] Schmitz, D. M., and Kufferath, J., *Bull. seances de l'Acad. Royale des Sci. Coloniales*, N. S., 326 (1955).
[3] Martin-Leake, H., *New Scientist*, **12**, 816 (1961).
[4] Beauchamp, R. S. A., *J. Ecol.*, **41**, 226 (1953).

IN my opinion the suggestion that the carbon dioxide in Lake Kivu is of juvenile origin, whereas the methane is biogenic, is unacceptable on the ground that the concentration of the latter within the neighbouring Lakes Tanganyika and Nyasa is some 5–6 orders of magnitude lower (see Table 1 of previous communication). The three following hypotheses of origin of the gases need more serious consideration.

(1) The carbon dioxide is juvenile, but the methane is an igneous contact distillation product of underlying carbonaceous sediments.

(2) All the gases originate from contact metamorphism of a bituminous limestone.

(3) The gases are juvenile, magmatic, as suggested by the author of the preceding communication.

The plausibility of hypotheses (1) and (2) could be tested through the examination of geological settings beneath the lake and the surrounding volcanoes, so far as this is practicable. A possible juvenile magmatic origin of the gases gains some support through a hitherto unpublished compilation of data of standard references regarding the H/C, O/H and H/C : O/H ranges of organic mineraloids. The very high H/C : O/H range of the presumably juvenile magmatic tucholites and allied substances is most significant (Table 1), being far above those of the substances of known or inferred biogenic origin.

Table 1. H/C, O/H and O/H:H/C RANGES OF THE MOST IMPORTANT ORGANIC MINERALOIDS

Organic mineraloid, or gas	H/C	O/H	O/H : H/C	Known or inferred (?) genesis
Petrol	1·4–2·0	0·005–0·07	0·0–0·08	Biogenic?
Natural gas	3·6–4·0	0·01 –0·4	0·0–0·1	Biogenic?
Fossil resins	1·2–1·7	0·01 –0·2	0·0–0·15	*Biogenic*
Asphalts	1·2–1·8	0·01 –0·2	0·0–0·16	Biogenic?
Asphaltites	*0·9–1·4*	0·005–0·2	0·0–0·2	Biogenic?
Anthracites	0·2–0·6	0·05 –0·15	0·1–0·3	*Biogenic*
Coals	*0·6–1·7*	0·08 –0·5	0·1–0·4	*Biogenic*
Tucholite and allied substances	0·1–0·8	*0·2 –2·0*	*0·6–5·0*	Juvenile?
Gas from Lake Kivu	*1·10*	*1·42*	*1·29*	?
C-containing molecules in fumarola gas	0·0–0·1?	>10?	>100?	Metamorphic or juvenile?

It is seen from Table 1 that the elemental composition of the gas mixture from Kivu has O/H and O/H : H/C well within the range of the tucholites (coincidences are in italics) and even the H/C value is not too far off. This means that the gas mixture in question may be a distillate of a tucholite-type juvenile magmatic phase, or, more likely, it may be the original gas mixture from which the latter organic mineraloid may condense under favourable conditions, such as the presence of radioactive substances, etc. The scanty data from the up-to-date literature indicates that the gases from fumarolas and hot springs are as a rule much richer in carbon dioxide and poorer in methane than those from Lake Kivu. This leads to a brief discussion of the hypothesis by Dr. Kevin Burke to the effect that the absence or relative scarcity of methane in the gases of the fumarolas of the neighbouring Virugna volcanoes in particular, and other volcanoes in general, could be explained through oxidation of it in the atmosphere. Some fumarolas produce mainly SO_2 whereas others produce SH_2, indicating in the latter case most reducing conditions right up to the land surface. It would be interesting to learn what redox potential is present in the gases of the Kivu volcanoes and, furthermore, how these data relate to the CH_4 percentage in fumarolic gases in general.

G. MUELLER*

Department of Geology,
University of Concepcion,
Chile.

* Nuffield Visiting Professor, Birkbeck College, University of London.

© 1963 Nature Publishing Group