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Letter

# Lake Bambuluwé (Cameroon): building-up the same scenario as Lake Nyos?

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Sir,

A great number of lakes from Cameroon are crater-lakes. In the recent past, some of them suddenly emitted great quantities of gas, mostly $CO_2$:

– On the 15th August 1984, 37 humans were killed by the Lake Monoun gas burst,

– On the 21st August 1986, the same phenomena appeared at Lake Nyos, killing about 1700 people.

Local trades and legends let us to think that many other lakes of this part of Africa showed an extreme and random behaviour. This is the case for Lake Bambuluwé which is assumed to be the source of female fertility. In the corresponding legends of this lake, events in relation with menstrual cycles (Shanklin, 1989) may represent some periods with red colored lake waters. Such a colour pattern has already been observed at Lake Monoun and Lake Nyos just after the accidents.

The bottom waters of these lakes are anoxics and show high values of ferrous ions (Sigurdsson et al., 1987). The $CO_2$ emission leads to the mixing and the upwelling of a part of these bottom waters, and at the surface the oxydation of $Fe^{2+}$ leads to the red colouring.

In February 1987, as part of a Cameroon paleoclimatic and paleoenvironmental program (Maley et al., 1990), we sampled sediment cores from the bottom of 5 lakes, respectively from South to North: Ossa, Barombi-Mbo, Bambuluwé, Oku and Nyos (Fig. 1).

The measurement of the $^{210}Pb$ profile along each core allows the determination of the sedimentation rate (about one century period) for three of these lakes. Concerning Lake Nyos, the observed anomalies in the natural and artificial radio-isotope profiles of the cores (Piboule et al., 1990), led to the following conclusions:

(1) The sediment had been mixed for several meters in depth (constant values of $^{137}Cs$ and $^{210}Pb$ for all the core length).

(2) There was an increase of $^{210}Pb$ due to an additional flux of Radon through the sediment (radioactive imbalance between $^{210}Pb$ and $^{226}Ra$).

(3) The radon emission took place at least two years before the accident (secular radioactive equilibrium between $^{210}Pb$ and $^{210}Po$).

Concerning Lake Bambuluwé, located about 10 km south of Bamenda, we have also observ-

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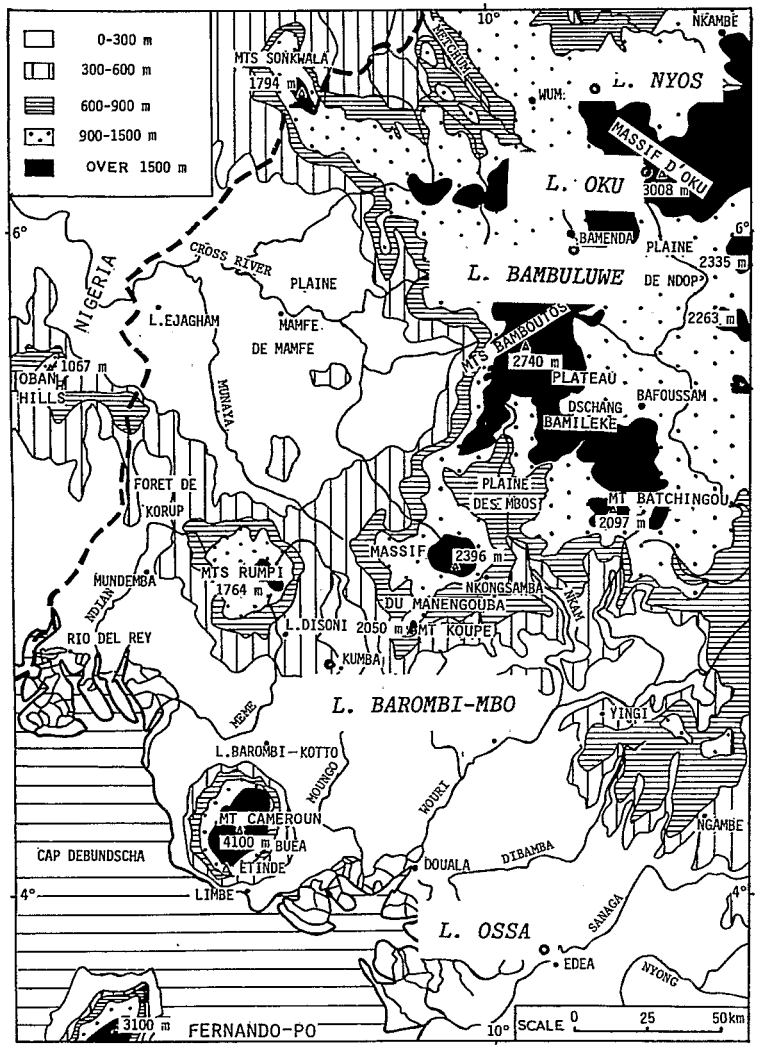


Fig. 1. West-Cameroon: map with position of lakes studied.

ed and indicated in a short paper (Pourchet et al., 1988) $^{210}$Pb profile anomalies. These measurements are given here.

The $^{210}$Pb measurements (Fig. 2) exhibit, between the surface and 4.7 g cm$^{-2}$ depth cumulative weight, corresponding to the 15 upper cm, a 369-Bq kg$^{-1}$ constant value of radioactivity. As for Lake Nyos, this activity is unusually very strong.

Below 5.5 g cm$^{-2}$ cumulative weight, another constant value of about 100 Bq kg$^{-1}$ corresponds to the supported $^{210}$Pb by the long-



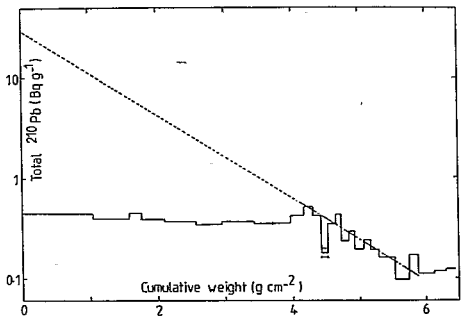


Fig. 2. Total $^{210}$Pb in Bambuluwé lake sediments versus depth (expressed in cumulative weight of dry sediment).

lived parents present in the sediment ($^{238}$U family). The activity of this fraction is respectively 53 and 96 Bq kg$^{-1}$ for Nyos and Ossa lake sediments.

Between those 2 constant levels (4.7 and 5.5 g cm$^{-2}$) the decrease shows a regular pattern in the same way as a normal decrease of $^{210}$Pb activity. A preliminary interpretation of the whole set of $^{210}$Pb measurements of this lake could let us think that we are faced with a simple profile, but with an uppermost part which had been previously and erronnously mixed during drilling or sampling. However, this interpretation is unlikely. In fact, the extrapolation up to the origin depth surface of the decreasing part of the curve (between 4.7 and 5.5 g cm$^{-2}$), supposed not to be mixed, leads to a surface activity of about 3000 Bq kg$^{-1}$, 5 times the current value of the other Cameroon surface sediment lakes. We here suggest it corresponds, as for lake Nyos, to an unusual flux of Radon through the sediment. The mixing of the uppermost part of the core must have been triggered by a $CO_2$ release.

As in Nyos, the bubbles observed in the core during its recovery from the bottom of the lake indicate that their contents were very close to the gas saturation at the sampling depth (58 m at Lake Bambuluwé). Unfortunately we have not analysed this gas. The core observation at its removal from the bottom leads to the conclusion that the bubble pattern at the precise sample time may be responsible of the mixing, but for only 2.0 g cm$^{-2}$ or less. The mixing of the sediment between 2.0 and 4.7 g cm$^{-2}$ corresponds to former degassing. Two other locations of this same lake were sampled in 1985: the two small cores were free of gas bubbles (Maley et al., 1990). Did the gas accumulated in the sediment between those two dates (1985 and 1987)? It is not presently possible to confirm this because in different locations of one lake (Barombi-Mbo) areas with gas-bubbles have been observed at different depths.

Concerning Lake Bambuluwé, all our $^{210}$Pb determinations have been conducted by alpha spectrometry of $^{210}$Po making use of Hasanen method (1977). We clearly indicated elsewhere (Piboule et al., 1990) the limits of this method which makes the hypothesis of radioactive equilibrium between $^{210}$Pb and $^{210}$Po and which fails to give an indication of the relative contributions of the different members of the $^{238}$U family.

In spite of these extra comments in sampling measurements strategies, it clearly appears possible that Lake Bambuluwé follows the same pattern as Lake Nyos, that is an increase of radon flux through the lake sediments. Will this flux, as in Nyos, lead to a large $CO_2$ release? Our presently available measurements do not allow us to confirm this absolutely. It should be very valuable to complete these first determinations and to verify by a new sampling if a modification of the sediment column took place since 1987.

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# Letter

Dear Sir,

Thanks to a scientific correspondence (Nature, Vol. 334, 25 August 1988), we have been able to rapidly inform the scientific community about our radiochemical measurements conducted on sediment samples from Lake Bambuluwe.

In a letter to the Journal of Volcanology and Geothermal Research (this issue) we gave all details about these measurements. In both correspondences, we pointed out, with great care, the excess of $^{210}Pb$ in the sediments of this lake, and the analogy with the measurements of Lake Nyos sediments, already published (J. Volcanol. Geotherm. Res., 42: 397–400).

In order to explain the Nyos accident, the scientific community proposed two hypotheses: a limnological and a volcanological one.

In his letter to the editor, Dr S.J. Freeth prevails the former hypothesis. In that case, the potential risks of Lake Bambuluwe are small. But if the volcanological hypothesis is true, the risks may be quite different: in that case, the quantity of $CO_2$ possibly released in the atmosphere does not depend only on the volume of the lake water. Concerning our team, we are not able to say what hypothesis is right. However, the radiochemical measurements give rise to some answers or reflexions which must be taken into account by the different scientific communities.

In February 1989, thanks to a contract with the Ministry of Environment (Délégation aux Risques Majeurs), the ORSTOM and the Cameroon authorities we conducted a second campaign of sediment sampling of a large number of Cameroon lakes, including Lake Bambuluwe.

The radiochemical measurements are actually in progress and the results will be submitted for publication, when completed. However, the first results presently available demonstrate:

(1) The $^{210}Pb$ anomaly, already determined in the previous 1987 sediment core, is confirmed two years later.

(2) This anomaly did not evolve since that time: it still concerns the 15 first centimeters of sediment.

(3) We are in presence of unsupported $^{210}Pb$ (by long-lived parents from the $^{238}U$ family), much like in Nyos sediments.

(4) During field work, we were able to check that the origin of the excess $^{210}Pb$ cannot "correspond to the recently built access road around the lake" as suggested by Dr G.W. Kling (Nature, Vol. 337, 19 january 1989). Anyway, the materials removed from the road construction had no access to the lake.

(5) The sediment cores sampled in 1989 showed small gas concentrations, mainly methane.

These first indications may suggest that at the precise time of the Lake Nyos accident, a stronger volcanic activity prevailed in the area and induced an excess of radon.

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