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Chemical structure of Lakes Nyos and Monoun, Cameroon

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The explosive discharge of CO2 gas (limnic eruption) in the mid 1980s at Lakes Nyos and Monoun in Cameroon killed about 1800 people around the lakes. The driving force of the limnic eruptions was the CO2 gas dissolved in the lake water. A good knowledge of lake water chemistry and an elucidation of lake stratification are therefore important ingredients in preventing future limnic eruptions.

Water was collected at Lakes Nyos and Monoun in 2011 and 2012. Dissolved total-CO2 (CO2aq + HCO3-) concentration was determined by volumetric titration. The temperature, pH and dissolved O2 of lakes was measured in situ by use of CTD.

With the temperature and chemistry, Lake Nyos was roughly divided into 3 layers. In the first layer, shallower than -10m, the temperature reaches 25C due to solar radiation, while the temperature of the second layer (-10 to -70m) lies between 21.5 and 22C. In the third layer, deeper than -70m, the temperature increases gradually with depth, reaching 25C close to the bottom (-210m). Except for near surface water, dissolved species (total-CO2, Cl-, Br-, SO4–, Na+, K+ and Mg2+) show depth-concentration profiles that parallel those of temperature, except Fe and Mn, which were low in the first layer, and increased abruptly from -80m. The concentration of dissolved O2 was higher than 2 mg/L in the first and second layers, and less than 0.3 mg/L in the third layer, showing the anoxic environment.

In Lake Monoun, the first layer shallower than -10m was heated to 25C by solar radiation. The temperature of second layer (-10 to -50m) was uniform (19.5 to 20C). In the third layer (-50 to -80m), the temperature increases gradually towards the bottom. In the fourth layer (-80 to -90m) the temperature was uniform (22C). In the fifth layer, deeper than -90m, the temperature increases gradually towards the bottom of the lake at -100m. Like for Lake Nyos, depth-concentration profiles of chemical species in Lake Monoun parallel those of temperature. The dissolved O2 concentration was higher than 1 mg/L in the first layer and less than 0.2 mg/L in the layers deeper than -10m.

The CO3– concentration can be thermochemically estimated based on the total-CO2 and pH. The estimated concentration was multiplied with Fe concentration to make the product, Q (a_Fe∗a_ CO3), which was compared with K, the solubility product of FeCO3. The water of Lake Nyos was estimated to be under-saturated in terms of FeCO3 in the first and second layers but oversaturated in the third layer. In Lake Monoun, the water deeper than -30m was oversaturated thoroughly. In Lake Nyos, the deep water has been lifted up to surface by the degassing pipes and Fe(OH)3 precipitate was generated, making the color of lake red after April 2011. The Fe(OH)3 precipitate sinks to third layer then dissolved to be Fe2+ ion due the anoxic condition. The increased Fe2+ ion meets with the high carbonate ion, resulting in the condition of oversaturation in terms of FeCO3

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