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Temporal variation (2011-2013) of the amount of CO2 dissolved in Lake Monoun, Cameroon

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Introduction

On 15th Aug 1984, the people living Lake Monoun, western Cameroon, heard a loud sound and experienced earth tremors. After the event, a deadly phenomenon occurred as 37 people were asphyxiated by gas that was discharged from the lake. Sigurdsson et al (1987) attributed the cause of the outburst of CO2 to landslide that plunged into the Lake's depth, which was CO2-charged. After a scientific consensus that proceeded from a similar phenomenon at Lake Nyos (100 km NW of Lake Monoun) in 1986, the explosive discharge of CO2 gas from lakes was named "limnic eruption". In 2001, the concentration of CO2 dissolved in Lake Monoun approached saturation at the depth of 50 m (Kusakabe et al., 2008), suggesting a possibility of recurrence of the limnic eruption if no preventive measures were taken. To prevent another limnic eruption, a degassing pipe was installed at Lake Monoun in 2003 (Halbwachs et al., 2004), and by 2009, the lake was almost free of dissolved CO2 and lost its natural gas self-lifting capability through the pipes. Recently we observed that concentration of CO2 has increased slightly in the bottom water. To avoid gas re-buildup in the lake, in 2013, we installed a solar energy driven system to artificially pump the CO2-rich water to the surface.

So far we have employed two methods (MK and CTD) to determine a reliable CO2 concentration profile in lakes.

The MK method (Kusakabe et al, 2000)

With this method, we determine CO2 concentration in lake water as follows. A disposable plastic syringe that contains 10 ml of 5M KOH solution is immersed in the lake at a given depth using an MK sampler. After that, we suck 30ml of lake water into the syringe to fix the total dissolved CO2 (CO2 dissolved gas, HCO3- and CO3–) as CO3–. Then a volumetric titration with standard HCl solution allows the determination of the total carbonate in the syringe. The results obtained so far indicate that the MK method is accurate and reliable. However, the method gives discrete data in terms of depth.

The CTD method

The CTD (Conductivity, Temperature, Depth) enables us to estimate the CO2 concentration as a smooth depth profile. The absolute value of CO2 concentration by the CTD method depends strongly on pH and conductivity values, thus the data from the CTD method need to be carefully examined compared to those from the MK method. We introduced an adjustable parameter k as defined by C-corr=k∗C, where C is the measured raw conductivity and C-corr is the corrected conductivity. Assuming an appropriate molar conductivity for HCO3-, the C-corr gives the total CO2 concentration under the assumption of chemical equilibrium among the dissolved carbon species (CO2aq, HCO3- and CO3–). We compared the total CO2 concentration by MK method and CTD method at the every depth where we have the values by MK method. The difference between the two methods was squared and the summation of squared values was calculated. The summation was minimized with changing the parameter k.

Results

As shown in Fig. 1, the thickness of bottom water with CO2 concentration higher than 20 mmol/L increased significantly in 2012 relative to 2011. This tendency continued in 2013, although CO2 concentration of the bottom water decreased slightly. The lake water shallower than 30m is affected by inflowing river water contains low concentration of total CO2. The total CO2 profile was integrated between -98m (near bottom) to -30m and estimate of the total amount of CO2 in the lake were 101, 118 and 119 Mmol in 2011, 2012 and 2013, respectively. Those values are much smaller than 600 Mmol, which was the amount of CO2 gas in lake just before the degassing pipe started functioning (Kusakabe et al., 2008). However, it should be noted the amount of dissolved CO2 is gradually increasing, so a regular monitoring of the lake is imperative.

Keywords: Lake Monoun, CO2, Limnic eruption, Cameroon, Magma

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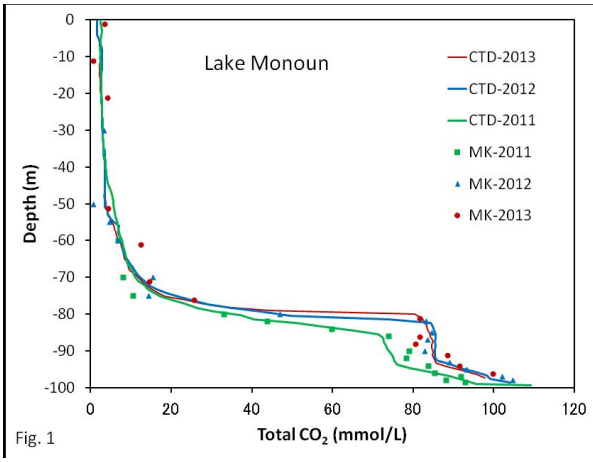

Fig. 1