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Trial of real-time measurement of dissolved CO_2 concentration in CO_2-rich volcanic crater lakes

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Volcanic CO_2 is supplied continuously into Lake Monoun and Lake Nyos (Cameroon Volcanic Lakes) in Cameroon, Africa. There, the erupted CO_2 killed approximately 1800 people in 1984 and 1986. After those events, many scientists and engineers took steps such as monitoring the lakes and controlled degassing to prevent the disasters. Those steps have been decreasing the CO_2 amount and it is less than 10% of maximum dissolved CO_2 in Lake Monoun, but still the 73% of the maximum is remained in Lake Nyos [1]. Moreover, supply paths are not revealed, there is the possibility that the supply amount might increase rapidly by the activation of volcanoes.

At present, the vertical profiles of CO_2 concentration are estimated from the correlation of measurements of electronic conductivity and pH and chemical analyses of collected lake water samples at each depths. This method, however, requires time and effort in collecting samples and chemical analyses, so the measurement has been done only once in a year. It is difficult to catch up with in the case of sudden and rapid intrusion of CO_2-rich water into lake using this method, therefore a new method which enables to measure dissolved CO_2 concentration in real time or frequently is required.

There is the method to measure dissolved CO_2 using membrane. After the liquid phase and gas phase are equilibrated, CO_2 concentration in gas phase is measured using IR absorbance. Because it is difficult to maintain such delicate equipments continuously in the field, an easy and fast measuring method is required. We concluded that sound velocity method using the change of the velocity by dissolved materials and/or the refined electronic conductivity method are more applicable. In former method, the sound velocity change is expected to be owing mainly to CO_2, major dissolved species in the lakes. On the other hand, in the latter method, the effect of other dissolved species, those concentrations are relatively low, is suggested as a cause of error [1]. Therefore the sound velocity method was tested in the beginning. Although there is the previous investigation on sound velocity method for ionic solutions [2], there are no data for CO_2 solution. We conducted the sound velocity change experiments for CO_2 solution.

Two piezo-electronic devices set in face-to-face with 16 cm distance were packed in PET-bottle with tap-water, and high pressure CO_2 gas was charged to produce carbonated water. The CO_2 concentration was 172 mmol/kg (0.5 times of that in Lake Nyos). Sound velocity of the water was measured by Time of Flight method. 2 MHz signal drove the one piezo device to generate sound waves and the arrival time of the waves received was monitored by another device connected to the oscilloscope. The sound velocities before and after CO_2-pressurize were measured. The result shows the sound velocity did not change within the precision of 10 m/s. To measure the sound velocity change of carbonated water more precisely, we developed a pressure tank which can contain a sound velocity profiler (Minos X, made by AML oceanographic) and high pressure CO_2 gas. The results using those devices will be shown.

The vertical profiles of temperature and sound velocity were measured using the profiler in Cameroon Volcanic Lakes in 2012 February to March. The results will be also shown.

[1]Kusakabe et al.(2008) Evolution of CO_2 in Lakes Monoun and Nyos, Cameroon, before and during controlled degassing, Geochemical Journal, 42, 93-118

[2]S. J. Kleis and L. A. Sanchez (1990) Dependance of Speed of Sound on Salinity and Temperature in Concentrated NaCl Solutions, Solar Energy, 4, 201-206

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