Crater lake monitoring by sound speed and turbidity measurement of lake water

*Kazuto Saiki[1], Keisuke Johroku[1], Katsuya Kaneko[2], Takeshi Ohba[3]

1.Graduate School of Science, Osaka University, 2.Graduate School of Human and Environmental Studies, Kyoto University, 3.School of Science, Tokai University

Crater lakes are generally part of the volcanic hydrothermal system. Because the chemical compositions of lake water reflect the activity of the volcano, the monitoring of active crater lakes is important to understand the local hydrothermal system and prevent disaster.
Through the study of Lakes Nyos and Monoun in Cameroon, we developed a convenient method of CO_2 monitoring using sound speed of lake water. Furthermore, we found stratification with dense suspended solid particles by turbidity measurement with an under-water camera. This stratification had not been detected by chemical analysis of sampled water. We are elaborating a plan for crater lake monitoring using these new methods. In our presentation, we introduce these new methods and the future plan.
Concerning the CO_2 measurement, we expected that $CO_{2\ (aq)}$ could change the sound speed of dissolved water even though CO_2 is a nonpolar molecule, and confirmed it through laboratory experiments [1]. We used a parameter Fwhich is the difference between the observed sound speed in the lake and the sound speed in pure water at the same temperature and pressure. Through sound speed, depth profile measurements at Lakes Nyos and Monoun with an underwater data logger equipped with a sound speed sensor, we found that the value of Δv has good linear correlation with total CO_2 concentration which mainly consists of HCO_3^- and $CO_{2(aq)}$ [2].
At Lakes Nyos and Monoun, we measured the turbidity depth profile of lake water using an underwater camera. At Lake Nyos there is a chemocline layer in which CO_2 concentration rapidly increases with depth. We found that the turbidity increases in only upper part of chemocline layer, and rapidly decreases at the middle of the layer. Using this result, we made a new Fe ion transport model with precipitates around the chemocline layer.
Using these methods, we are now planning crater lake monitoring project in Japan. Our target will be Lake Ikeda (Kagoshima, 233m deep) and Lake Unagi-ike (Kagoshima, 57m deep), where convection of lake water may stop because of the increase of mean atmospheric temperature. And there is a possibility that volcanic gas compositions started to accumulate in bottom of the lake because geothermal activity around the lake is high. In addition to these lakes, Lake Towada (Aomori & Akita, 327m deep), Lake Mashu (Hokkaido, 211m deep), Lake Toya (Hokkaido, 180m deep), and Lake Kuttara (Hokkaido, 148m deep) will be our second priority targets where we may detect a sign of volcanic activity because there are eruptions within these 5000 years.
References:
[1]Sanemasa et al.(2015) *Geochemistry and Geophysics of Active Volcanic Lakes*
[2]Saiki et al.(2016) *Geochemistry and Geophysics of Active Volcanic Lakes*

Keywords: crater lake, carbon dioxide, turbidity

