Mission Report

The January 2011 Field Work at Lakes Nyos and Monoun,

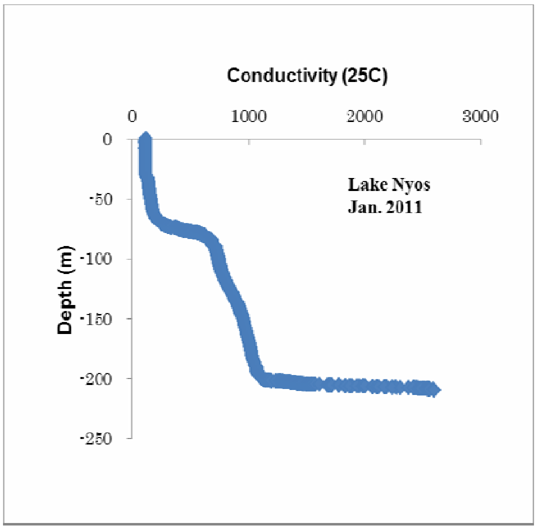
Prepared by Japan-Cameroon Joint Team, February 2011

A field survey was carried out during 11th and 19th January 2011 under the SATREPS project "MAGMATIC FLUID SUPPLY INTO LAKES NYOS AND MONOUN, AND MITIGATION OF NATURAL DISASTERS THROUGH CAPACITY BUILDING IN CAMEROON". The survey team consisted of 9 scientists, namely, M. Kusakabe, Y. Yoshida, A. Ueda, K. Anazawa, K. Kaneko, Y. Miyabuchi (Japan), Issa, Aka, F.T., and Fantong W.Y. (Cameroon). They visited Lake Nyos for the period from 12th to 15th, and Lake Monoun from 16th to 19th January 2011. The team was divided into 3 groups; limnology (MK, YY and Issa), hydrology (AU, KA and FWY), and volcanology (KK, YM and AFT). After the field work, the launching seminar for SATREPS was organized by IRGM on 21st January 2011 at Hotel Hilton, Yaounde. This summarizes the activities taken by the team.

Limnology Group (M. Kusakabe, Y. Yoshida and Issa)

CTD measurement

Since degassing of Lakes Nyos and Monoun is going on, and since a supply of magmatic CO_2 from beneath the lake bottom is continuing, it is imperative to monitor the lakes' chemical structures from time to time. Following the regular monitoring program of the lakes, we made CTD casts, measurement of CO_2 profiles, and collection of water and gas samples for determination of chemical and isotopic compositions. Figure 1 shows the conductivity profile at Lake Nyos measured on 13th January 2011 (a) and at Lake Monoun measured on 17th January 2011 (b). At Lake Nyos the electric conductivity profile shows a sharp increase toward the bottom below 190 m, and the whole profile subsided slightly compared with the 2009 profile. At Lake Monoun the conductivity profile also subsided slightly but the general pattern remains the same compared with the 2009 profile. These conductivity profiles indicate that degassing at the lakes has progressed steadily but slowly.



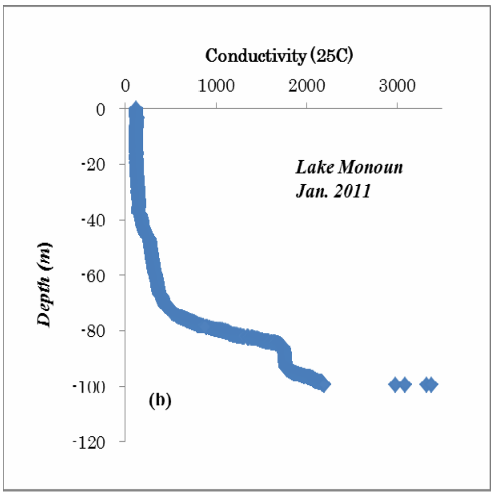


Fig. 1 Conductivity profile at Lake Nyos (a) and at Lake Monoun (b) in January

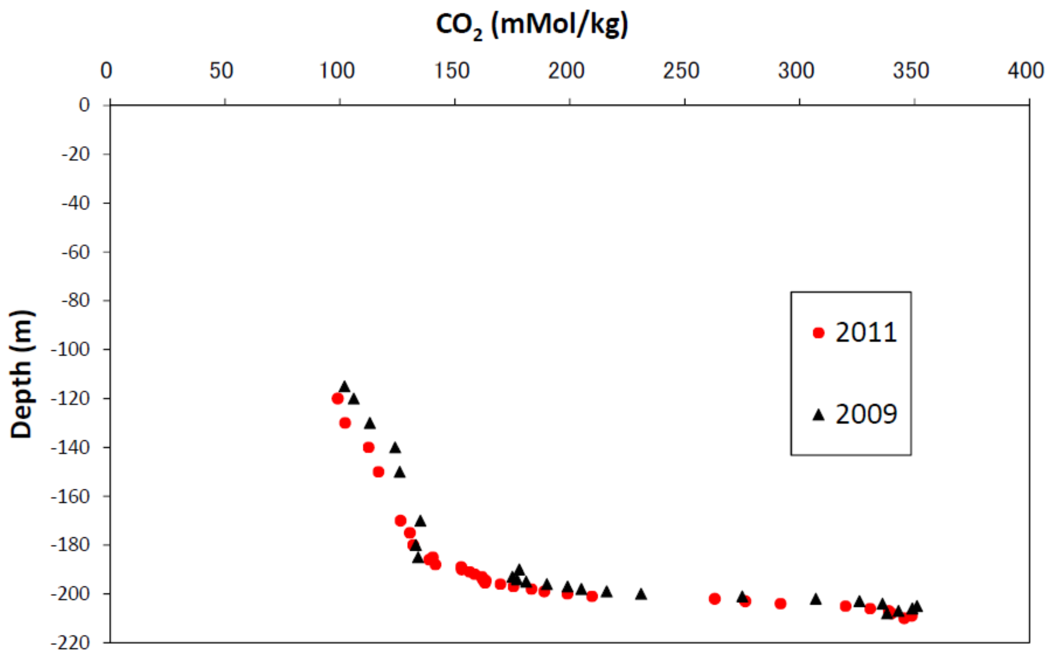


Fig. 2. The latest CO_2 profiles below 110 m depth at Lake Nyos.

The CO_2 profile was measured at Lake Nyos using the method described by Yoshida et al. (2010) as shown in Fig. 2. Since gas self-lifting ceased at the depth of 110 m, CO_2 concentrations were measured between the depths of 120 m to 210 m. Gas samples for noble gas analysis were collected at the same time. As shown in Fig. 2, the shape of the CO_2 profiles in 2009 and 2011 is similar. But the 2011 profile is slightly below the 2009 profile, which is consistent with the conductivity profile (Fig. 1a). At Lake Monoun even the deepest water (-99m) did not gas self-lift, so we gave up the CO_2 measurement and gas sampling at Lake Monoun.

Hydrology Group (A. UEDA, K. ANAZAWA, and Y.W. FANTONG)

Given the roles of water in circulating carbon dioxide and supporting domestic activities in and around Lakes Nyos and Monoun, the SATREPS hydrology group has objectives to investigate:

(1) CO_2-groundwater-surface water system around the lakes and

(2) gas-water-rock interaction.

An initial survey to meet the aforementioned objectives was conducted from the 10th to the 19th of January 2011.

Method of study

Desk study involved the acquisition of relevant data and information (e.g. topographic maps, aerial photographs etc). On the field, a total of 20 samples from different water bodies (3 Lake water, 2 well water, 1 stream, 3 boreholes, and 10 springs) were collected (Fig. 3) into 100 ml plastic bottles. During sampling on-site measurements of electric conductivity (EC), water temperature, pH, oxidation-reduction potential (ORP), Fe^{2+} and alkalinity were done, and GPS position noted. The water samples were properly preserved for subsequent analyses of major ions, stable environmental

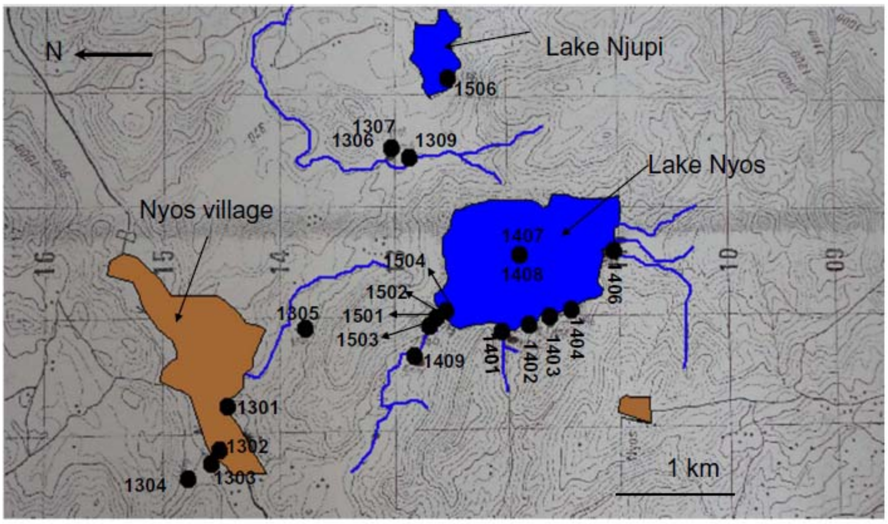


Figure 3. Sample collection sites

isotopes, and trace elements. Fresh and altered equivalent of rock exposures were sampled using a geologic hammer for subsequent XRD, XRF, and microscopic analyses.

<u>*Preliminary Results and interpretations*</u>

The observed EC ranged from 27-264 µS/cm, pH ranged from 5.35-8.11, ORP ranged from -120 to 202 mV, and Fe^{2+} ranged from less than 0.5 ppm to >10 ppm. From the field parameters observed the following preliminary conclusions were inferred:

-The deep lake Nyos water may be influencing only one spring (sample No. 1306/1307) on the eastern slope

-The spring seeping from the dam is influenced by shallow lake water that may be mixed with deeper groundwater

-On a general note there is a tendency of mixing of rain and surface water that resulted in some of the observed springs.

<u>*Future plan*</u>

-The hydrology team did not carry out water sampling around Lake Monoun, and plans to do so as from the next mission in November 2011

-Analyses of the rock and water samples shall guide the team to plan for a more comprehensive future work.

Volcanology Group (Y. Miyabuchi, K. Kaneko and Aka, F.T.)

<u>*Preliminary field examination of volcanic geology around Lakes Nyos and Monoun*</u>

We performed fieldwork at Lake Nyos on 13-15 January and at Lake Monoun on 17-18 January to clarify eruptive histories of the two maar volcanoes. A reconnaissance survey in and around the lakes was also made for the future CO_2 measurement.

Eruptive history

At Lake Nyos, deposits related to the formation of Lake Nyos are divided into three units in an ascending order: pyroclastic-flow deposits, scoria-fall deposits and pyroclastic-surge deposits. Basal pyroclastic-flow deposits were observed at the base of the eastern lakeshore wall and downstream side of the dam. The deposits were poorly sorted and divided into the lower, fine-grained unit and the upper, clast-rich unit. Scoria-fall deposits at the eastern lakeshore were found partially densely welded. Pyroclastic-surge deposits occur at the northern to eastern lakeshores. The surge deposits were well-stratified and the thickest of all the deposits. The sequence of the deposits suggested that a series of eruptive events that formed Lake Nyos started with a pyroclastic-flow eruption followed by a Strombolian activity that produced scoria-fall deposits, and finally by explosive eruptions that discharged multiple pyroclastic surges.

There are several cinder cones around Lake Monoun. We examined a tephra section located near the top of the largest cinder cone at the south of the lake. The section is composed mostly of pyroclastic surge deposits. The surge deposits were well-stratified and contained abundant clasts up to 40 cm across. The deposits were underlain by a scoria-fall deposit. The scoria was well vesiculated with a maximum size of approximately 50 cm. We believe that the cinder cone is composed of an alternating bed of pyroclastic-surge deposits and scoria-fall deposits. The tephra sequence indicates that the eruption that formed Lake Monoun was dominated by explosive events which produced pyroclastic surges and were associated with Strombolian activities. Unfortunately, we could not find any charcoal sample for determination of the detailed eruption age.

From the above observation, we believe that the volcanic eruptions that led to the formation of Lakes Nyos and Monoun were accompanied not only by explosive activity (surge producing eruption) but also by Strombolian activity.

We collected several rock samples during the fieldwork. We will conduct chemical analyses and microscope observation to estimate petrological characteristics of the two maar volcanoes.

Reconnaissance survey in and around the lakes

Since we will perform an automated survey of CO_2 distribution in the lakes during SATREPS, a preliminary survey of the local geography and infrastructures was made. At Lake Nyos, we obtained detailed positioning data of the lake shore and of some obstacles on the lake using a GPS and a boat. The GPS tracks were obtained at the distance of about 5 m from the lake shore. There are two structures on the lake; one is a degassing pipe that was fixed near the center of the lake and another an observation raft that was tentatively set for lake work. At the lake shore, there are four points where steel wires were anchored to fix the degassing pipe. No cell phones and internet were usable, but electricity was available through a generator.

We made a similar survey at Lake Monoun; acquisition of GPS tracks of the lake shore and positioning of obstacles for our future work. The GPS tracks were obtained at the distance of about 5 m from the lake shore. There were five fixed structures in the eastern basin of the lake including three degassing pipes and an abandoned climate station on a raft and the instrumental raft. There are seven anchoring points for steel wires that fix the structures at the eastern lake shore. At the western half of the lake, many fishing nets were deployed, which will be a big obstacle for our planned CO_2 measurement. At Lake Monoun, hippopotamus and crocodiles may be problematic for our survey. Cell phones can be used at a limited area but internet cannot. Electricity was available through a generator.

Information collected during the reconnaissance will be useful for our next survey.