Appendix 1

Joint Mid-Term Review Report

for

The Project on Magmatic Fluid Supply into Lakes Nyos and Monoun, and Mitigation of Natural Disasters through Capacity Building in Cameroon

Under

The Scheme of SATREPS

5 November, 2013

Joint Mid-Term Review Team

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Chapter 1 OUTLINE OF THE MID-TERM REVIEW

1.1. Background of the Mid-Term Review

On the basis of the request from the Government of Cameroon, Japan International Cooperation Agency (JICA) launched the five-year technical cooperation project (SATREPS: Science and technology Research Partnership for Sustainable Development) entitled “The Project on Magmatic Fluid Supply into Lakes Nyos and Monoun, and Mitigation of Natural Disasters through Capacity Building in Cameroon,” (herein after referred to as “the Project”) on April 2011, under the implementation structure consisting of Institute of Geological and Mining Research (IRGM) as a counterpart research institute from Cameroonian side, and University of Tokai as a representative of research institutes from Japanese side.

As two and half years have passed since the commencement of the Project, JICA has conducted the Mid-term Review to confirm challenges and direction of the Project for the betterment of the project activities in the remaining project period.

1.2. Objectives of the Mid-Term Review Study

The objectives of the Mid-Term Review are outlined as follows:

(1) to review actual inputs, activities and implementation process, the degree of achievements of outputs and the prospect of achieving the project purpose according to the Master Plan
(2) to assess the Project in terms of five evaluation criteria, namely relevance, effectiveness, efficiency, impact and sustainability, based on the JICA’s guideline for project evaluation
(3) to make common understanding of indicators for the Project Purpose and Outputs
(4) to make recommendations for the measures to be taken during the remaining project period in consultation with agencies concerned

1.3. Members of the Mid-Term Review Team

1.3.1. Japanese Team

Job title	Name / Position
Leader	Mr. Ejiri Yukihiko Senior Assistant Director, Global Environment Dept., JICA
Cooperation planning	Ms. DOI Yuriko JICA Officer, Global Environment Dept., JICA

Job title	Name / Position
Evaluation analysis	Ms. NAKAMURA Mitsuko Consultant, KOKUSAI KOGYO CO., LTD.
Advisor	Mr. SATO Masayuki Principle Researcher, Research Partnership for Sustainable Development Division, Japan Science and Technology Agency (JST)

1.3.2. Cameroonian Team

Job title	Name / Position
Leader	Mr. Nyoung Earnest Ministry of Economy, Planning and Regional Development (MINEPAT)
Member	Dr. Nnange Joseph Metuk Deputy Director, Institute of Geological and Mining Research (IRGM)

1.4. Schedule of the Mid-Term Review

The schedule of the mission is attached in Annex 2.

1.5. Methodology of the Mid-Term Review

The Project was reviewed jointly by the Cameroonian and Japanese Mid-Term evaluation team (herein after referred to as “the Team”) based on the Master Plan in the Record of Discussion (R/D) signed on 9 November 2010, with the statement of the Project Purpose, Outputs and Activities as the basic reference point for the review.

1.5.1. Procedure of the mid-term review

First, as a framework to collect and sort out relevant data and information, the evaluation grid which identified the specific review points and the data collection methods were prepared. To collect the data and information based on the evaluation grid, questionnaires were prepared and forwarded in advance to the counterparts and organizations concerned of the Project. During the review mission, the Team conducted interviews with counterparts and organizations concerned, and a representative from the Japanese Research Team (Chief Advisor), and observation of the provided equipment in use and the project sites. Findings and information from reports, interviews, questionnaire survey and site visits were collected and analyzed. The Team reviewed the Project in terms of the achievement level of the Project, the implementation process, and five evaluation criteria such as Relevance, Effectiveness, Efficiency,

Impact and Sustainability. Finally, the Team made the recommendations based on the result of the mid-term review.

1.5.2. Points for the mid-term review

Achievement level and Implementation Process of the Project

The achievement levels in terms of Inputs, Activities, Outputs, and Project Purpose were assessed in comparison with the Master Plan in the R/D and the actual progress of the Project. The implementation process of the Project was also confirmed from the various viewpoints such as monitoring and communication.

Evaluation Criteria

In addition to verification of achievement level and implementation process of the Project, the mid-term review assesses the Project from the following five evaluation criteria.

(1) Relevance: An overall assessment of whether the project purpose is in line with the policy of both sides and with partner country's needs.

(2) Effectiveness: A measure of whether the project purpose has been achieved. This is then a question to the degree to which the outputs contribute towards achieving the intended project purpose.

(3) Efficiency: A measure of the production of outputs of the Project in relation to the total resource inputs.

(4) Impact: The positive and negative changes, produced directly and indirectly as the result of the Project.

(5) Sustainability: An overall assessment of the extent to which the positive changes achieved by the Project can be expected to last after the completion of the project.

Chapter 2 OUTLINE OF THE PROJECT

The Project has been carried out since April 2011. The Master Plan in the R/D with the statement of the expected Project Purpose and Outputs written in the Master Plan are as follows. In the Master Plan, Outputs and Activities were listed by alphabetical headings (a, b,c,…), however, in this report, the headings are changed to numeric (1,2,3…), in order to apply for Project Design Matrix (PDM) later in the Project, as shown in Annex 1.

Project Purpose:

A framework is established where Cameroonian scientists can independently accomplish their own research on the issues related to the gas disasters at Lakes Nyos and Monoun, and utilize its outcomes for disaster management through scientific cooperation between Japan and Cameroon.

Outputs:

1. The mechanism of limnic eruption is understood.
2. The CO2 recharge system beneath Lakes Nyos and Monoun is understood.
3. The hydrological regime around Lakes Nyos and Monoun is understood.
4. The interaction between rock and CO2-rich fluid is understood.
5. Lakes Nyos and Monoun are monitored.
6. The experimental system for removing CO2-rich deep water to prevent gas rebuilding at Lake Monoun is set up.
7. The eruptive history around Lakes Nyos, Monoun and other volcanoes along CVL (Cameroon Volcanic Line) is understood.
8. The distribution of CO2 in Lakes along CVL other than Lakes Nyos and Monoun is understood.
9. The results of scientific monitoring are systematically shared with the Department of Civil Protection (DPC).

Chapter 3 ACHIEVEMENT AND IMPLEMENTATION PROCESS

The performances of the Project including inputs, activities and outputs, as well as the implementation processes were reviewed to assess the degree of achievements, the results of which described are below. Please note that the R/D of the Project was signed on 9 November 2010, and a launching seminar of the Project and preliminary field survey by Japanese experts were conducted on January 2011. However, all the numbers and figures below are the results from 1st of April 2011 to the end of September 2013, since the Project under the technical cooperation scheme was started from April 2011.

3.1. Inputs

3.1.1. Inputs from the Japanese side

(1) Dispatch of Japanese researchers

Since June 2011 until January 2013, total eight (8) Japanese researchers and two (2) American researchers have been dispatched to the Project. In addition, five (5) Cameroonian PhD students, who are currently studying at Japanese Universities as long-term trainees under the C/P training scheme, have been dispatched to the Project. Two (2) project coordinators have been dispatched by JICA. For details,

please refer to the Annex 4.

(2) Overseas Training/Workshop

To date, as seen in the Annex 5, five (5) persons have been dispatched for the PhD courses of Japanese University as long-term trainees. Totally six (6) persons underwent the training for instrumental technical analysis, and four (4) persons visited Japan in order to participate in the Workshop for Commission on Volcanic Lakes (CVL)-8.

(3) Provision of equipment

Machinery and equipments of approximately a total value equivalent to 247 million JPY (1,237 million CFA) have been provided for the Project activities. The list of these machinery and equipment are shown in Annex 6. Apart from the above machinery and equipment, approximately a total amount of 4 million JPY was provided to purchase consumables for field research and laboratory.

(5) Bearing of operational expenses

Approximately a total amount of 12,123,000 JPY has been provided for the necessary expenses to carry out project activities, by the JICA Cameroon Office. The details are as shown in Annex 7. It includes small office material (paper, stationary, etc.) for project coordinator, transportation fee, allowance for temporary work, travel expenses for business trip to Japan, etc.

Apart from the above expenses, Japanese Research Team also provided the operational expenses such as small material, fuel, maintenance of vehicle and allowance for temporary workers during field survey, and necessary expenses for meetings other than JCC.

3.1.2. Inputs from the Cameroonian Side

(1) Assignment of Counterpart Personnel

Project Supervisor (Secretary General of MINRESI) and Project Manager (Director of IRGM) have been assigned as listed in the R/D. Although there is no official letter on assignment of counterpart, so far fifteen (15) personnel have been recognized as counterpart personnel at the time of Mid-term Review. A list of the counterpart personnel is found in Annex 8.

(2) Provision of facilities

The necessary office spaces with furniture, electricity, facilities for communication and public utilities, and meeting rooms for Japanese Researchers; necessary spaces for installation of the provided

machinery and equipment for the laboratory; and necessary space and facilities for storage of equipment with antitheft security at the site near Lake Nyos and Lake Monoun were provided for the Project. An office space for Japanese Project Coordinator were provided since April 2013 in the building at Nkolbison.

(3) Local Operation Expenses

The Cameroonian side has allocated 850 million CFA as a counterpart fund for the Project, for a five year period from 2011 to 2016. A total amount of 316 million CFA has been disbursed as budget for 2011 on November, 2011. A total amount of 307 million CFA has been spent until the end of June 2013. The expenses include computers, data storage system and software, enhancement of buildings, vehicles for field survey, field allowances, fuel, seminars and colloquia, communication (optical fiber, etc.), and custom duties and various activities (JCC, CPM). The enhancement of buildings include rehabilitation of the Nkolbison laboratory, drilling of the bore hole, acquisition of internet and purchase of the back-up power generator.

3.2. Achievement of the Project

3.2.1. Outputs

Output 1. "The mechanism of limnic eruption is understood."

Currently, activities in order to achieve Output 1 have been progressed as planned, as seen below.

- Activity 1-1 and 1-3 (computer simulation on limnic eruption), the detailed parameters that incorporated observation data of the real CO2 density distribution in existing primary physical model closely were analyzed and two-dimensional simulation about the inflow process of CO2 bubbles in the water was developed. A critical condition about the volume of CO2 supply from the bottom of a lake where a lake explosion was possible, and CO2 density distribution in the lake. The conditions such as scales at time before a lake explosion starting were clarified. It was indicated that Lake Nyos has been in a stable state against two-fold diffusion convection phenomenon.
- Activity 1-2 (acoustic survey of the detailed topography of the bottom in Lakes Nyos and Monoun in order to locate the recharging point of CO2 enriched fluid), trainings in Japan for the operation of Multi-beam sonar were conducted to IRGM researcher and Cameroonian PhD students in 2011 and 2012.
- The following research paper has been currently in press:
- Minoru Kusakabe, "Evolution of CO2 content in Lakes Nyos and Monoun, and sub-lacustrine CO2-recharge system at Lake Nyos as envisaged from C/3He ratios and noble gas signatures," Volcanic Lakes (D. Rouwet, B. Christenson, F. Tassi, J. Vandemeulebrouck, eds),

Springer-Heidelberg, 2014

- Based on the above research activities, tne following research paper is in preparation:
- Kozono, T., Ohba, T., Kusakabe, M., Yoshida, Y., and Suzuki, Y.J., "Conditions for limnic eruption of Lake Nyos, Cameroon: Numerical analysis of 1-D plume model"
- Due to a characteristic of research methodology of computer simulation for Activity 1-1 and 1-3, technical transferring from Japanese researchers to Cameroonian researchers has not been fully carried out at the time of Mid-term Review. However, an application soft based on GUI has been developed, and the results of two-dimensional simulation have been data-based for future technology transferring.
- The levels of progress of activities for achieving Output 1, generally perceived by Japanese Research Team, vary among the activity. The level of progress by Activity 1-1 and 1-3 are 50%; on the other hand, Activity 1-2 is 60%.
- In the latter half of the project period, technical transferring is expected to be progressed through searching a practical way of building capacity of Cameroonian researchers, as much as possible. Then Output 1 is likely to be fully achieved in terms of capacity building of Cameroonian researchers.

Output 2. "CO2 recharge system in Lake Nyos and Lake Monoun."

Output 2 is being progressed as seen below.

- Regarding Activity 2-1 (3D survey for distribution of dissolved CO2 in the lakes), examination of practicability of measuring the sound velocity of lake water, and laboratory experimentation for estimating level of dissolved CO2 concentration were conducted.
- As a result of the above activities, the effectiveness of the sound velocity measurement of lake water has been proved, and a potable device for measuring the underwater sound velocity, which can be easily maintained in a remote place like Lake Nyos where maintenance of scientific instrument is difficult in the field, has been developed.
- Through the field survey, the method of using the above mentioned sound velocity measurement, and its significance were shared with Cameroonian researchers as technical information.
- Regarding Activity 2-2 (measuring of the CO2 flux from soil and the CO2 concentration in surrounding atmosphere), CO2 concentrations in surrounding atmosphere in Lake Nyos and Lake Monoun have been measured.
- Based on the above research activities, the following research papers are in preparation:
- K. Saiki, M. Sanemasa, K. Kaneko, T. Ohba, M. Kusakabe, G. Tanyileke, J. V. Hell, "Vertical profile of dissolved CO2 concentration in Cameroonian volcanic lakes estimated from sound

velocity of lake water”

- M. Sanemasa, K. Saiki, K. Kaneko, T. Ohba, M. Kusakabe, G. Tanyileke, J. V. Hell, “A new method for the estimation of dissolved CO2 concentration of volcanic lakes using the sound velocity of lake water”
- The levels of progress of activities for achieving Output 2, generally perceived by Japanese Research Team, are different from activities to activities. The level of progress by Activity 2-1 is 75 %; Activity 2-1- is 40%.

Output 3. “The hydrological regime around Lakes Nyos and Monoun is understood.”

Output 3 is being progressed as seen below.

- Regarding Activity 3-1 (estimation of the flow path of groundwater around Lake Nyos and Monoun by application of GIS), the detailed topographical map of Lake Nyos and surrounding area was made from satellite images.
- For Activity 3-2 (assessment of the interaction between surface water and ground water), the field surveys was conducted by Japanese and Cameroonian researchers for water sampling from lake, river, spring and other water resources near Lake Nyos and hydrological analysis was conducted on laboratory in 2011.
- Through the above research activities, technical instructions regarding water sampling methods and hydrological data analysis by application of GIS were provided by Japanese researchers.
- Two (2) PhD students have been accepted in April (Brice Tchakam Kamtchueng) and in October (Tiodjio Edwige Rosine) in 2012 at Toyama University as long-term trainees under the C/P training scheme in Japan.
- Water sampling campaigns and on-site analysis were conducted twice by the above PhD students under the supervision of Japanese and Cameroonian researchers in 2013.
- Based on the above research activities, research papers by PhD students and Cameroonian researchers are in preparation.
- Regarding Activity 3-3 (estimation of the water balance in Nyos), water samples collected from various water resources by Activity 3-2 were categorized into groups by chemical structure and isotope analysis in Japan.
- The levels of progress of activities for achieving Output 3, generally perceived by Japanese Research Team, are different from activities to activities, but relatively high. The level of progress by Activity 3-1 and 3-3 are 70 %; Activity 3-2 is 90%.

Output 4. “The interaction between rock and CO2-rich fluid is understood.”

Output 4 is being progressed as seen below.

- Experimental study for monitoring of precipitation rate of siderite was conducted in Lake Nyos.
- Correlation between the above results and water quality was analyzed at laboratory in Japan.
- By using a newly developed device, water sampling without losing dissolved CO2 from the bottom of Lake Nyos was successful.
- The above new sampling method and traditional sampling method were compared in terms of effectiveness for measuring level of dissolved CO2 concentration.
- Based on the above research activities, the following research papers are in preparation:
- Ueda, Akira, Ozawa, Akiko, Yoshida, Yutaka, Kusakabe, Minoru, Ohba, Takeshi , Tanyileke, Greg and Hell, J.Victor, "A new geochemical sampler for CO2 analyses of lake water and for monitoring of siderite precipitation in Lake Nyos"
- The level of progress of activities for achieving Output 4, generally perceived by Japanese Research Team, is 95%.

Output 5. "Lakes Nyos and Monoun are monitored."

Output 5 is being progressed as seen below.

- Regarding Activity 5-1 and 5-2, two rafts for the climate station and stationary observation of the lake were built in Lake Nyos (June 2012) and Monoun, (January 2013), and equipment of the climate station were successfully set up on the new rafts in both lakes. As a result, measurements of the conductivity, temperature, total gas pressure of the lake water and climate parameters have been started by the climate station.
- Regarding Activity 5-3, a periodical monitoring (once a year) has been continued by Japanese and Cameroonian researchers.
- As a result it was indicated that CO2 content in Lake Nyos has been decreasing gradually so as to lose its gas self-lift capability in the near future. CO2 content in Lake Monoun decreased to minimum, but supply of magmatic CO2 still continues, resulting a slight increase in CO2 content in the lake.It gives a strong justification for the necessity that deep water of Lake Monoun should be pumped out.
- Through the above monitoring activity, technical methods such as MK sampling, YY method and pH method have been transferred to Cameroonian researchers. Thus, it is likely that Cameroonian researchers are able to conduct monitoring by themselves.
- Two (2) PhD students have been accepted at University of Tokai as long-term trainees under the C/P training scheme in Japan.
- Analytical machinery and equipment have been provided to the laboratory at Nkolbison, such as

Ion Chromatograph, Laser Isotope Analyzer (PICARRO), Ultrapure Water Equipment (Milli-Q), and CTD measurement.

- In order to master the operation and maintenance of the above provided machinery and equipment, One Cameroonian researcher and three (3) laboratory technicians were invited to the short-term training in Japan.
- As indicated above, human resources with technical knowledge and equipment necessary for the monitoring of lake water are ready; however, mainly due to various shortcomings of laboratory infrastructure, such as water, communication and electricity, and also the lost accident of CTD measurement, monitoring and analytical activity have not been conducted by Cameroonian researchers at the time of Mid-term Review.
- The levels of progress of activities for achieving Output 5, generally perceived by Japanese Research Team, are different from activities to activities. The level of progress by Activity 5-1 is 50%, Activity 5-2 is almost 100 %; and Activity 5-3 is 70%.
- In the latter half of the project period, it expected that Cameroonian side starts and mainstreams monitoring and analytical activities, as a routine work. Then Output 5 is likely to be fully achieved before the completion of the Project.

Output 6. "The experimental system for removing CO2-rich deep water to prevent gas rebuilding at Lake Monoun is set up."

Output 6 is being progressed as seen below.

- The experimental system based on the situation of Lake Monoun has been designed and produced in Japan.
- The level of progress of activities for achieving Output 4, generally perceived by Japanese Research Team, is 70%.

Output 7. "The eruptive history around Lakes Nyos, Monoun and other volcanoes along CVL (Cameroon Volcanic Line) is understood."

Output 7 is being progressed as seen below.

- Regarding Activity 7-1, more than 100 samples of eruptive rocks have been collected and analyzed in Japan.
- Based on the above research activities, a research patter by Japanese researcher is in preparation
- Based on the above research activities, the following research paper was published by Cameroonian researchers.
- Aka, F.T. and Yokoyama, T, "Current status of the debate about the age of Lake Nyos dam

(Cameroon) and its bearing on potential flood hazards", Natural Hazards 65, 875-885, 2013

- One PhD student (Asobo Nkengmatia Elvis A.) has been accepted on April 2012 at Tokyo Institute of Technology as long-term trainees under the C/P training scheme in Japan.
- Regarding Activity 7-2, since the field survey was postponed by the Japanese Researcher, the activity has not progressed as planned.
- The levels of progress of activities for achieving Output 8, generally perceived by Japanese Research Team, are different from activities to activities. The level of progress by Activity 7-1 is 40%, regardless started in 2012, and Activity 7-2 is 50 %.

Output 8. "The distribution of CO2 in Lakes along CVL other than Lakes Nyos and Monoun is understood."

Output 8 is being progressed as seen below.

- Regarding Activity 8-2, due to security reason of the target research area, a field survey planned by Japanese researchers on March 2013 was canceled, and only Cameroonian researchers conducted the surveys.
- A field survey of CO2 distribution surged from soils of flank of Mt. Manenguba, has been conducted by Cameroonian researcher.
- Water sample was collected from the surface and bottom of Lake Barombi-Mbo by Cameroonian researchers.
- The levels of progress of activities for achieving Output 8, generally perceived by Japanese Research Team, are different from activities to activities. The level of progress by Activity 8-1 is 0%, Activity 8-2 is 75 %, and Activity 8-3 is 50%.

Output 9. "The results of scientific monitoring are systematically shared with the Department of Civil Protection (DPC)."

- Output 9 is not being achieved at the time of Mid-term Review, since no activities have taken place.

3.2.2. Achievement of the Project Purpose

"A framework is established where Cameroonian scientists can independently accomplish their own research on the issues related to the gas disasters at Lakes Nyos and Monoun, and utilize its outcomes for disaster management through scientific cooperation between Japan and Cameroon."

Indicators for the Project Purpose were not set in the Master Plan in the signed R/D. Overall progress of the research activities as summarized in the above section, is considered appropriate in general as of the time of the Mid-term Review.

The Project Purpose of the Project consists of (i)“the establishment of the framework where Cameroonian scientists can independently accomplish their own research on the issues related to the gas disasters at Lakes Nyos and Monoun,” which mainly focused on personal and institutional capacity building, and (ii) “ the establishment of the framework where Cameroonian scientists can utilize its outcomes for disaster management,” which mainly focused on scientific contribution to the society.

In terms of capacity building, researchers and technicians are the target of the Project, and it has been generally observed that their individual capacity through collaborating research activities and training in Japan is strengthened. As for institutional capacity building in terms of the laboratory attached to IRGM, the capacity of laboratory work is also strengthened by allocating the inputs such as the equipment and training from Japanese side, and enhancement of the infrastructure of the laboratory from Cameroonian side. However, the Team observes that institutional management, which should support and maintain the framework for Cameroonian scientists to accomplish research activities, has a room to improve in the Project.

In terms of scientific contribution towards the society, the Project has not produced concrete outcomes from research activities; therefore, it is early to discuss here the achievement. However, The project should start to establish the framework to transfer the scientific information or the proposal based on scientific standpoint to the government or authorities responsible for prevention and management of natural disaster. Therefore, it is necessary to accelerate the activity of Output 9, which is a key activity to attain this part of Project Purpose. Furthermore, it is also necessary to clarify the responsibility of IRGM towards natural disaster management and reduction as a research institute, because it is assumed that the utilization of research outcomes would be out of control for IRGM.

3.2.3. Implementation Process

(1) Planning of implementation of activities

For project implementation, a tentative Plan of Operation (PO) for the Project was attached in M/M signed on 19 August 2010; however, there is no official version of PO in the Project. Although each

Japanese and Cameroonian sides has a flowchart describing research subject, summary of research activities and fiscal year, which is based on the mentioned tentative PO, the numbers and order of research subjects of each flowchart are different, and each project activities and objectives are not fully presented. Lack of specific PO did not create crucial problems in the overall implementation of the Project; however, as mentioned later, it is likely to effect on smooth implementation of the Project especially in terms of administration, and understanding about the objectives of activities, outcomes, and the Project in total.

It is also difficult to verify if the activities were implemented as planned due to the above reason, however, from the research plans of Japanese researchers and activity reports of both sides, most activities were implemented as planned at annual JCC meeting, except activity 7-2 and all the activities under Output 8, as mentioned at the section “3.2.2 Output”.

(2) Decision making and monitoring mechanism

The JCC, which is the decision-making authority and monitoring mechanism of the Project, has so far been held 2 times to review the progress of Project activities. Although the attendants of the 2nd JCC were not confirmed due to lack of the minutes of meeting, as a result of the interview survey, all the stakeholders, such as MINEPAT, DPC/MINATD, representatives of local authorities, and MINESIP participated, and reported to the Team that they could monitor the progress of the activities.

However, almost all the interviewed personnel including the Project Supervisor and representative personnel from MINEPAT, suggested that Cameroonian side should hold internal meeting among the project members to discuss issues aroused during implementation of the Project, and if necessary Cameroonian stakeholders join the internal meeting to support for problem solving.

At the researcher’s level, representatives from both Japanese and Cameroonian sides have internal meetings before the field mission (approximately twice a year) in order to decide operation of the activities and monitor the progress. In terms of operation and monitoring of activities, although both representatives reported that the above mentioned meeting was adequate, most of Cameroonian personnel involved to the Project activities reported that it has not been adequate because detailed information such as schedule, participants, contents and objectives of the field mission and training in Japan were not shared enough before the Project started and even before each field mission and training started, and progress within the total research activities was unknown .

In addition, it was found from the interview survey that it was possible to understand the objectives and contents of field survey at the site, however, the feedback such as the results of analysis and progress of research activities by Japanese researchers have not been carried out timely.

Therefore, it is concluded that monitoring of the Project activities is done when the Japanese researchers conduct the field survey by the representatives, but the monitoring of each activities between Japanese researchers and Cameroonian researchers is not done, and there is no effective internal monitoring mechanism.

Chapter 4 EVALUATION BY FIVE CRITERIA

4.1. Relevance

The relevance of the Project evaluated as **high** based on the following confirmations.

1) With the regard to the consistence of the Project Purpose with the Cameroonian policies, and Japan's aid policies that were confirmed at the Ex-ante Evaluation of the Project in October 2010, there wasn't any alternation to undermine the relevance of the Project. Therefore, the consistencies are being maintained at the time of the Mid-term Review.

2) For the protection of the Lake Nyos area, the construction of degassing pipes was completed in 2011, and the reinforcement of natural dam and rehabilitation of social infrastructure for resettlement of displaced people is currently carried on. In addition to the degassing and the reinforced dam, the sustainable observation and monitoring system is demanded by the government in order to declare the security of the Lake Nyos area.

3) In the Lake Monoun area, supported by the French Embassy, the Natural Disaster Management and Civil Protection (GRINO) project, the capacity building to improve on disaster prevention and the management of emergencies around Lake Monoun has been carried out. In Lake Monoun, the gas-releasing by pipes was finished, and the security has been already declared by the government, however, it is observed that CO2 supply from the bottom of the lake continues. While the government is searching the adequate solutions to recurrent emergencies to avoid heavy losses as in the past, the continuous observation and monitoring as in Lake Nyos, and experimental research for measures to prevent accumulation of the CO2 in the Project has a great significance.

4) IRGM is a key organization taking a role of proposing the means from the scientific standpoint to the disaster prevention measures by the government. Utilizing the upgraded laboratory by the Project, and strengthening the capacity of the Cameroonian researchers through collaborating research activities with Japanese researchers, the project purpose is likely to be achieved. However, at the time of Mid-term Review, the number of the researchers and technicians in IRGM, who are targets of capacity building by the Project, were limited. Therefore, if more researchers and technicians were transferred the technology and knowledge by the Project in the latter half of the Project, the relevance of the Project will be remained as high.

4.2. Effectiveness

The effectiveness of the Project is assessed **between low and middle** through the following examinations:

1) Indicators, which will be used to verify the achievement of the Project Purpose at the time of terminal evaluation, were not set in the Master Plan included in the signed R/D. It is necessary to discuss and agree on indicators by foreseeing the goal to be reached two years ahead. However, the achievements of the Project Purpose at present are as follows.

2) At present, the project is making a steady progress of research activities at each Output level. In most of the Outputs, the research papers in preparation are clarified, which are the indicators to verify the Outputs, and some research papers were already published in the scientific journals or on review. Therefore, it is widely indicated that the Project has a good potential to achieve the goal of research activities by the end of the project period, March 2016.

3) Regarding the laboratory it belongs to the Hydrological Research Center of IRGM. The basic analytical equipments were provided and trainings of researchers and technicians in Japan were conducted, and the infrastructure of the laboratory was enhanced, so that the capability of the laboratory is far more developed in terms of capacity building.

4) However, in terms of “a framework” where Cameroonian scientists can independently accomplish their own research”, which the Project Purpose presents, there are few activities that the Cameroonian researchers at the time of Mid-term Evaluation.

5) In addition, related to the above situation, due to the various issues regarding the laboratory (the

details are presented in the section of Efficiency), the provided equipments was functioning at the time of Mid-term Review, however the Team also found that most of the provided equipment have had one or another problem, therefore have been un-functioning for several months.

5) In addition, Output 9, where the results of from Output 1 to Output 8 are to be synthesized to achieve the Project Purpose, has so far made rather limited progress.

4.3. Efficiency

The efficiency of the Project is assessed **low** on the following observations:

A number of activities have been carried out and the outputs are being produced as mostly planned. The Team observed that overall satisfaction towards inputs such as human resources, trainings and provided the equipment is high. However, due to the issues regarding with utilization of the provided equipment and long-term trainees in Japan, the Team concluded that the efficiency of the Project at the time of Mid-term Review is assessed low. If the situation below is improved, the efficiency would be also increased by the termination of the Project.

Human recourses (The Japanese Researchers)

The C/Ps, especially those who are working in the field survey, confirmed that they learned a lot of methods such as MK methods and YY methods. In terms of the period of the Japanese researchers, half of the response indicated it as adequate; the other half response indicated it as not sufficient, and strongly recommended longer dispatching period than now, so as to enhance the level of mastering how to operate analytical equipments and receive practical advice for day to day analytical activities.

Overseas Training

Six (6) participants in the training course held in Japan were interviewed during the mid-term review. Five (5) of them, selected from the researchers and technicians, participated to the operation and maintenance course of analytical equipment in Japan, and gained the operational instructions and maintenance knowledge through lecture and demonstration of the same analytical equipments provided by the Project. In addition, it was reported that the participants, especially technicians of the laboratory, have learnt a great significance of curating samples through the observation of various laboratories in Japan. They have highly valued the training, and it was confirmed that the courses have provided practical knowledge which have been applied in their context in the laboratory after the training.

One research officer participated to the training course on operating multi-beam sonar in Japan two times, in order to learn and practice its operation in an intensive manner from assembling the machinery, setting on the boat, data sampling to data analysis. The equipment is not delivered to Cameroon, the gained knowledge and skills from the training have not been utilized yet.

Although five long-term trainees in the Project, who are currently studying at the Japanese universities were not interviewed during the study mission, it was reported that all the trainees have been making progress on their own research activities. However, apart from one long-term trainee who maintain a position of research assistant in IRGM, the other trainees are not guaranteed to be able to or intended to involve with the Project, join the IRGM, or, moreover, become the scientists in Cameroon in the future after the training. It is true that their research activities during the PhD courses are contributing to produce the outputs of the Project, but there is a possibility that it will not contribute to achieve the Project Purpose eventually. Thus, the efficiency and effectiveness of this input can not be judged at the time of Mid-term Review.

Equipment

Under the technical guidance from the Japanese experts, all the equipment listed in the Annex 6 was provided, and installed at the laboratory and the observation sites as planned. The provided equipment can be considered as adequate in general. At the time of Mid-term Review, all the equipments were functioning; however, due to a number of shortcomings including unstable supply of electricity, irregular supply of clean water, unavailability of high speed internet system, lack of a server for data storage, the equipments were not properly functioning for long time. Thus, the utilization of the equipments C/Ps emphasizes the importance of the technical guidance provided with the introduction of new equipment; such arrangement done by the Project maximizes the benefit of the provided equipment.

Cost

For implementation of the Project, MINEPAT has prepared a counterpart fund as a Cameroonian side of budget for the Project, which amount is 850 million CFA for five years. However, the budget of 2011 was disbursed in November 2011, seven months later after the Project started. The delay of the budget hindered the smooth operation of research activities, as the activities were progressed as much as efficiently. It should be noted that the counterpart fund for 2012 and 2013 should be disbursed as soon as possible to implement project activities in the latter half of the Project. In order to receive the budget, it is necessary for IRGM to request the disbursement of the counterpart fund in far advance than usual timing, taking consideration of the possibility of delaying by other factors.

4.4. Impact

It is assessed that the Project would bring about **high and positive** impacts, in view of the following aspects.

1) Positive impacts such as security declaration by the Government in Lake Nyos area can be expected once the Project achieves its purpose and the application of research results to local authorities and national government policies starts to utilize.
2) It is expected that the Project utilizes a seminar or sensitization workshop, for increasing social impact of the Project, such as the workshops held at the surrounding cities of Lakes Nyos and Monoun during the Mid-term Review mission
3) In 2016, it is planned to hold an international workshop, namely ”Workshop for CVL-9” in Cameroon, which the Cameroonian researchers has been accepted as a host researchers during the visit for Workshop for CVL-8. It is expected that this workshop can be also a driving forth to utilize the result of research activities in the Project, thus social impact of the Project would be also increased.
4) If the provided analytical machinery and equipment in laboratory are maintained and utilized for research activities by universities and other Cameroonian scientists, the presence of laboratory will have positive impact on not only Cameroonian science society, but also those of neighboring African countries.

4.5. Sustainability

The sustainability of the Project is assessed as **middle,** because the Team could expect sustainability in some aspects, but some other aspects need further reinforcement, as described in the following.

(1) Policy and institutional sustainability

In the Lake Nyos area, the Project is implemented in line with the National Program for the Security and Rehabilitation of Lake Nyos. Since the gas-releasing by pipes and reinforcement of natural dam are not completed, it is assumed that the policy support from the above national program to the Project would continue for the coming years. Similarly, the Government is implementing the Natural Disaster Management and Civil Projection project in the Lake Monoun area, which aims to improve on disaster prevention and management of emergencies, the project is also taking same directions of the Project. As to institutional aspects, IRGM is obligated to transfer scientific standpoint of views to DPC. The periodical monitoring activities of the Project has been carried out in line with their mandates, thus institutional sustainability is also assessed high.

(2) Organizational and financial sustainability

It has generally been observed that human resource allocated by the Government for the Hydrological Research Center (CRH), where most counterpart of the Project belong to, is adequate, comparing to other sections of IRGM, but financial resource for the research activities has been limited. Although IRGM is currently receiving the counterpart fund to implement the Project activities, financial resource after the Project would be much less scale than the counterpart funds. The Project aims to establish a framework where Cameroonian scientists can independently accomplish their own research. In order to enable researchers of IRGM accomplish their own research based on the enhanced scientific knowledge and technology by the Project, financial resources for the scientists need to be secured. In addition, high running and maintenance cost of the provided equipment in the laboratory should be bored by IRGM after the Project. Taking account of the financial shortage in the past to procure consumables for analytical equipment, such as argon gas, it is necessary for IRGM and its researchers to utilize and maintain the provided machinery and equipment in the laboratory to produce a good quality of data and research papers, so as to show a good presence of laboratory to the Government and other scientists and search budget or financial resources to maintain the laboratory. The team observes that financial sustainability has not been secured so far thus, it is concluded as middle.

(3) Technical sustainability

A series of scientific technologies and technical information in order to pursue several research subjects (i.e. understanding of mechanism of limnic eruption, CO2 recharging system, hydrological regime, interaction between rock and CO2, and eruptive history around Lakes Nyos and Monoun) as well as monitoring lake water, have been transferred to the C/Ps though the collaborating field survey in Cameroon and short-term and long-term trainings in Japan.

From a technical point of view, it has been observed that the Project aims to (i) enable IRGM researchers and technicians to implement monitoring and data analysis activities at Lakes Nyos and Monoun independently and (ii) also enable young researchers to pursue own research related to the gas disasters at Lakes Nyos and Monoun independently. Currently one senior researcher, four research officers, one research assistant, and three technicians in CRH have acquired considerable knowledge of monitoring and data analysis activities by the Project and some of them reached the level that they can continue monitoring and data analysis activities even while the Japanese researchers are absent. One research assistant, who is currently a PhD student of Japanese university, is pursuing own research activity in Cameroon and Japan. It should be also noted that one senior researcher has already submitted a research proposal related to the Project activities. Thus, it can be said that researchers and technicians involved to

the Project have been acquiring appropriate knowledge and skills. In addition, although it is too early to say, if the other four PhD students who are the long-term trainees of the Project are able to join the IRGM in the future, and if the transferred technology and the provide equipment are further gainfully utilized the sustainability in terms of technical aspect will be further affirmed.

Chapter 5 CONCLUSIONS

5.1. Results of Mid-Term Review

Up until the time of mid-term review, it is reasonable to recognize that the Project has mostly been implemented as planned. Judging from the view point of five evaluation criteria, relevance is regarded as ensured. Efficiency, effectiveness and sustainability of the Project, however, remain facing challenges since they are dependent to large extent on whether the recommendations presented below are seriously taken by the parties concerned. Provided that such recommendations are followed, the prospect to achieve the Project Purpose at the time of completion would be high.

5.2. Recommendations and Actions to be taken

<u>For the Project</u>

1) Indicators, which will be used to verify the achievement of the Project Purpose at the time of terminal evaluation, were not set in the Master Plan included in the signed R/D. It is necessary to discuss and agree on indicators by foreseeing the goal to be reached two years ahead.

2) The Mid-term review revealed that lack of internal meetings within the Project hinders the smooth execution of project activities. And eventually the output. Thus, the Team recommended that the .Project should have regular internal meetings with all project members including project managers, researchers, technicians, and administrative staff, for the purpose of information sharing, discussion, decision making, problem solving and monitoring and feed-back.

3) The Team recommended, in addition to the above point, communication and networking not only between the representatives of both sides, but also between Japanese and Cameroonian researchers should be enhanced by using an effective way such as internet or email.

4) The Team recommended that it is necessary to utilize the provided equipment in the laboratory so as to increase the efficiency of the Project.

5) The Team recommended that regarding Output1, the development application soft based on GUI and

the database of two-dimensional simulation should be transferred to the Cameroonian researchers, and more capacity buidling would be done in the latter half of the Project.

6) The Team recommended that the Project accelerate the activities of Output 9 in the later half of the Project, since no activities have taken place so far.

For IRGM

- The team recommended that the IRGM should consider seriously the employment of the long-term trainees after the training in Japan, so as to affirm the sustainability of the Project.

For the MINEPAT

- The counterpart fund for the Project should be secured by MINEPAT in time.

DRAFT

Project Design Matrix (PDM0)

Project Name: The Project on Magmatic Fluid Supply into Lakes Nyos and Monoun, and Mitigation of Natural Disasters through Capacity Building in Cameroon
Area: Cameroon Period: April 2011 – March 2016 Counterparts: institution / organization IRGM Date: 21 October 2013

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Overall Goal None			
Project Purpose A framework is established where Cameroonian scientists can independently accomplish their own research on the issues related to the gas disasters at Lakes Nyos and Monoun, and utilize its outcomes for disaster management through scientific cooperation between Japan and Cameroon.			None
Outputs 1. The mechanism of limnic eruption is understood. 2. The CO_2recharge system beneath Lakes Nyos and Monoun is understood. 3. The hydrological regime around Lakes Nyos and Monoun is understood. 4. The interaction between rock and CO_2-rich fluid is understood. 5. Lakes Nyos and Monoun are monitored. 6. The experimental system for removing CO_2-rich deep water to prevent gas rebuilding at Lake Monoun is set up. 7. The eruptive history around Lakes Nyos, Monoun and other volcanoes along CVL (Cameroon Volcanic Line) is understood. 8. The distribution of CO_2 in Lakes along CVL other than Lakes Nyos and Monoun is understood. 9. The results of scientific monitoring are systematically			None

shared with the Department of Civil Protection (DPC).

Activities		Inputs		
1-1 The conditions under which limnic eruption can occur are constrained through computer-simulation. 1-2 Acoustic survey of the detailed topography of the bottom in Lakes Nyos and Monoun is made to locate the recharging point of CO2 enriched fluid. 1-3 The conditions under which limnic eruption can occur are estimated, and utilized to judge the safety of the lakes. 2-1 3D distribution of CO2 in the lakes is investigated, which can be used to locate the recharging point of CO2 enriched fluids. 2-2 The CO2 flux from soil and the CO2 concentration in surrounding atmosphere are measured at Lakes Nyos and Monoun. 3-1 The flow path of groundwater around Lakes Nyos and Monoun is estimated through remote sensing (satellite images) and hydro-geochemical approaches. 3-2 The interaction between surface water and groundwater is understood. 3-3 The water balance in Nyos basin is estimated. 4-1 Laboratory experiments on the interaction between rock and CO2-rich fluid are carried out to understand geochemical and mineralogical processes in a sub-lacustrine CO2-supply system. 5-1 Automatic observation systems to monitor the lake water and climatic parameters are installed in Lakes Nyos and Monoun and the data are transmitted to IRGM via	＜Indicators＞	<u>Japan</u> Personnel - Chief Advisor - Project Coordinator - Geochemistry - Vocanology - Petrology - Geology - Geography - Hydrology - Other fields that are mutually agreed up0n as necessary Equipment - Water and gas analysis - Monitoring equipment - sampling and observation - removing C2-rich bottom water - Others mutually greed upon as necessary for the implementation of the Project Training in Japan Activities in Cameroon	<u>Cameroon</u> Personnel - Project Supervisor - Project Manager - Counterpart personnel Facility - Office space, furniture, facilities for communication and public utilities, and meeting rooms necessary for JICA Experts to undertake project activities - Space and appropriate facilities for the installation and storage of equipment with antitheft security at IRGM, Lake Nyos and Lake Monoun - Other facilities mutually agreed upon as necessary Local Cost	None

satellite. 5-2 Work rafts to collect water and gas samples are set up at Lakes Nyos and Monoun. 5-3 The amount of CO2 remaining in the lakes will be measured through physical and chemical methods on a regular basis, at least, once a year. 6-1 An apparatus to pump CO2-rich deep water is designed and tested at Lake Monoun to evaluate its capability, cost-performance and easiness of maintenance. 7-1 Detailed geological and petrochemical survey of volcanoes is carried out at the volcanic lakes distributed along the CVL. 7-2 Geological maps of the Nyos and Monoun areas are produced. 8-1 The CO2 flux from soil and the CO2 concentration in surrounding atmosphere are measured at other lakes along the CVL. 8-2 Basic survey and preliminary monitoring are carried out at other lakes along the CVL, such as Manengouba (Bangem), Wum and Barombi Mbo (Kumba) located near urban centers. 8-3 The geochemical database for the lakes along the CVL is established. 9-1 The results of scientific monitoring are sent to DPC for annual report. 9-2 Recommendations for disaster management are proposed based on scientific findings.				Pre-Conditions None

Annex 2: Schedule of Review Mission

	Date	Activities	
		JICA Officials Japanese Experts	Consultant Ms. NAKAMURA
1	10/19 Sat		Arriving at Yaounde (19:20)
2	10/20 Sun		Interview with Project coordinator
3	10/21 Mon		Meeting with JICA Office 1st Kick off Meeting at IRGM HQ
4	10/22 Tue		Interview with Counterparts at IGRM
5	10/23 Wed		Interview with Counterparts at Nkolbison Office, IRGM Observations of laboratory and machinery
6	10/24 Thu		MINESUP Interview with IGRM Executives and administrative staff
7	10/25 Fri		MINEPAT, MIMRESI DPC, EU
8	10/26 Sat		Report Preparation
9	10/27 Sun		Report Preparation
10	10/28 Mon	Arriving at Yaounde (20:05)	Report Preparation
11	10/29 Tue	Courtesy on JICA and EoJ	Report Preparation
		JICA internal meeting, project meeting with JICA officials Project meeting with evaluation members at Nkolbison Office, IRGM	
12	10/30 Wed	Courtesy on MINRESI	Interview with Counterparts at IGRM
		2nd Kick-off meeting with Japanese Officials and Experts at MINRESI	
13	10/31 Thu	(Move to Bamenda)	
14	11/1 Fri	Observation of site at Lake Nyos (Move to Bamenda)	
15	11/2 Sat	Workshop at Wum (Move to Bamenda)	
16	11/3 Sun	Observation of site at Lake Monoun Project Meeting	
17	11/4 Mon	Workshop at Kouptamo (Move to Yaounde)	
18	11/5 Tue	Joint Coordinate Committee at MINRESI, Signing of M/M	
19	11/6 Wed	Report to Embassy of Japan	
20	11/7 Thu	Report to JICA Office, JICA internal meeting Leaving Yaounde (23:25)	
21	11/8 Fri	Paris -	
22	11/9 Sat	- Japan	

Annex 3: List of Interviewees

Organization	Name	Title
DPC	Mr. Tchuente Gilbert	Deputy Director
EU	Ms. Yvonne Fabienne Titti	Charge de Programmes
MINESUP	Prof. Wilfred GABSA	Director of Coordination of Academic Activities
MINEPAT	Mr. M. Nyong Ernest	Head of Cartography Unit
MINRESI	Dr. Ebelle Etame Rebecca M	General Secretary
	Dr. Dongmo Thomas	Director
IRGM	Dr. Aka Festus Tongwa	Senior Researcher
	Dr. Fantong Wilson Yetoh	Researcher
	Dr. Fouepe Takounjou Alain Léopold	Researcher
	Dr. Ako Andrew Ako	Researcher
	Dr. Ntchantcho Romaric	Researcher
	Mr. Djomou Bopda Serge L.	Assistant Researcher
	Dr. TANYILEKE Gregory	Researcher/Chief of SATREPS Project
	Dr. Ntonga Jean Claude	Chief of CRH
	Ms. Massussi née Ateba Bessa Henriette	Researcher/Chief of LAGE
	Mr. Tawedi Robert	Senior Technician of LAGE
	Mr. Nlozoa Justin	Technician of LAGE
	Mr. Libongo Mbilongo Jean Christel	Technician of LAGE
	Mr. Simo Motsebo Joseph (SAF/CRH)	Accountant of CRH
Japan Embassy	Mr.Tsutomu ARAI	Ambassador
	Mr. Hiroko KONNO	Attachee
JICA Cameroon Office	Mr. Yujiro YABE	Representative
	Mr. Mitsuko KUWAHATA	Program Coordinator

Annex 4 List of the dispatched Japanese experts

Japanese Fiscal Year 2011
Japanese Researcher

	Expert Name	Expertise	Duration	Man-Month
1	Takeshi OHBA	Chief Advisor	June 8, 2011 - June 13, 2011	0.13
			Dec. 6, 2011 - Dec. 12, 2011	0.23
			Feb. 29, 2012 - Mar. 22, 2012	0.76
2	Minoru KUSAKABE	Monitoring of Lake Water	June 8, 2011 - June 13, 2011	0.13
			Dec. 6, 2011 - Dec. 13, 2011	0.26
			Feb. 29, 2012 - Mar. 22, 2012	0.76
3	Akira UEDA	Rock-Water Interaction	June 8, 2011 - June 13, 2011	0.13
			Dec. 6, 2011 - Dec. 20, 2011	0.50
4	Yutaka YOSHIDA	Removal of CO_2 Dissolved in Deep Lake Water	Dec. 6, 2011 - Dec. 21, 2011	0.53
			Feb. 29, 2012 - Mar. 22, 2012	0.76
5	Katsuro ANAZAWA	Flow of Groundwater	Dec. 6, 2011 - Dec. 20, 2011	0.50
6	Kazuto SAIKI	CO_2 distribution in lake water	Feb. 29, 2012 - Mar. 22, 2012	0.76
7	Katsuya KANEKO	CO_2 distribution in lake water	Feb. 29, 2012 - Mar. 22, 2012	0.76
8	Youichi YOSHIDA	Project Coordinator	Apr. 21, 2011 - Mar. 31, 2012	12.00
Total				18.21

Japanese Fiscal year 2012
Japanese Researcher

	Expert Name	Expertise	Duration	Man-Month
1	Takeshi OHBA	Chief Advisor	May 29, 2012 - June 4, 2012	0.23
			Mar, 5, 2013 - Mar. 26, 2013	0.63
2	Minoru KUSAKABE	Monitoring of Lake Water	May 12, 2012 - June 15, 2012	1.16
			Jan. 14, 2013 - Jan. 25, 2013	0.40
			Mar. 4, 2013 - Mar. 22, 2013	0.63
3	Yutaka YOSHIDA	Removal of CO_2 Dissolved in Deep Lake Water	May 28, 2012 - June. 15, 2012	0.63
			Jan. 14, 2013 - Jan. 25, 2013	0.40
			Mar. 4, 2013 - Mar. 22, 2013	0.60
4	Tetsuya YOKOYAMA	Petrology of Volcanic Rock	Nov. 20, 2012 - Dec. 5, 2012	0.53
5	Katsuro ANAZAWA	Flow of Groundwater	Jan. 13, 2013 - Jan. 25, 2013	0.43
6	Youichi YOSHIDA	Project Coordinator	Apr. 1, 2012 - Mar. 31, 2013	12.00
Total				17.64

Other Researchers

	Expert Name	Expertise	Duration	Man-Month
1	Geoge Kling	Installation of Climate Station	May 28, 2012 - June. 15, 2012	0.63
			Jan. 14, 2013 - Jan. 25, 2013	0.40
2	William Evans	Installation of Climate Station	May 28, 2012 - June. 15, 2012	0.63
			Jan. 14, 2013 - Jan. 25, 2013	0.40
Total				2.06

Japanese Fiscal year 2013
Japanese Researcher

	Expert Name	Expertise	Duration	Man-Month
1	Youichi YOSHIDA	Project Coordinator	Apr. 1, 2013 - Apr. 25, 2013	0.83
2	Aya INABA	Project Coordinator	May 7, 2013- Sep 31, 2013	4.90
Total				5.73

Grand Total	43.64

Annex 5: List of the trainees in Japan

Japanese Fiscal Year 2011

Scheme	Term	Name	Job title	Duration	Training Course/Theme	Training Organization
Business Trip	Short-term	Dr. Alain Fouepe	Researcher	6 Sep 2011 - 18 Sep 2011	Multibeam sonar	Tokai University
C/P Training	Long-term	Mr. Issa	Researcher	Oct 2011 - Sept 2014	PhD Limnology	Tokai University

Japanese Fiscal Year 2012

Scheme	Term	Name	Job title	Duration	Training Course/Theme	Training Organization
C/P Training	Long-term	Mr. Chako Tchamabe Boris	-	April 2012 - Mar 2015	PhD Volcanology	Tokai University
		Mr.Tchakam Kamtchueng Brice	-	April 2012 - Mar 2015	PhD Hydrogeology	Toyama University
		Mr.Tiodjio Edwige	-	Oct 2012 - Sep 2015	PhD Hydrogeology	Toyama University
		Mr. Asobo Nkengmatia Elvis A.	-	Oct 2012 - Sep 2015	PhD Volcanology	Tokyo Institute of Technology

Japanese Fiscal Year 2013

Scheme	Term	Name	Job title	Duration	Training Course/Theme	Training Organization
Business Trip	Short-term	Dr. Alain Fouepe	Researcher	6 Sep 2013 - 22 Sep 2013	Multibeam sonar	Tokai University
		Dr. Sigha Nkamdjou	Researcher	16 July 2013 - 10 Aug 2013	IAVCEI general assembly/ Workshop for CVL-8	Tokai University
		Dr. Tanyileke Gregory	Researcher	16 July 2013 - 10 Aug 2013	IAVCEI general assembly/ Workshop for CVL-8	Tokai University
		Dr. Festus Aka	Researcher	16 July 2013 - 10 Aug 2013	IAVCEI general assembly/ Workshop for CVL-8	Tokai University
C/P Training	Long-term	Dr. Wilson Fantong	Researcher	9 April 2013 - 25 April 2013	Instrumental chemical analysis	Tokai University
		Mr. Djomou Bopda Serges Laurent	Technician	9 April 2013 - 25 April 2013	Instrumental chemical analysis	Tokai University
		Mr. Nlozoa Justin	Technician	9 April 2013 - 25 April 2013	Instrumental chemical analysis	Tokai University
		Mr. Tawedi Robert Elvis	Technician	9 April 2013 - 25 April 2013	Instrumental chemical analysis	Tokai University
		Mr. Libongo Mbilongo Jean Christel	Technician	9 April 2013 - 25 April 2013	Instrumental chemical analysis	Tokai University

Annex 6 List of the Provided Machinery and Equipment

Japanese Fiscal Year 2011

No.	Machinery & Equipment	Condition	Qt.	Total Value (JPY)	Total Value (USD)
1	Ion Chromatograph (ICS-1100) + Computer and Software	Good	1	5,550,000	-
2	Analyzer for Isotope H2O (PICARRO L2120-i) + Computer and So	Good	1	11,410,000	-
3	Ultrapure Water Equipment (Milli-Q Direct 8)	Good	1	2,615,000	-
4	pH Meter (Orion 5-Star Plus)	Good	1	425,000	-
5	FRP Boat	Good	2	1,071,000	-
6	Rubber Boat	Good	1	494,000	-
7	Raft for Lakeside Investigation (Big) 3.2m x 3.2m Custom-made	Good	1	5,000,000	-
8	Raft for Lakeside Investigation (Small) 2.5m x 2.5m Custom-made	Good	1	3,000,000	-
9	Flux Meter Soil CO2 Gas Flow Equipment	Good	2	4,990,000	-
10	CTD Measuring device (OCEAN SEVEN 316 Plus)	−*1	1	3,400,000	-
11	Multi-beam Sonar	Good	1	42,000,000	-
13	2 Stroke Engine for Small Boat Inflatable	Good	2	507,000	-
14	2 Stroke Engine for Small FRP Inflatable	Good	2	579,000	-
15	MK Method Water Recipient	Good	1	579,000	-
16	Raft for Climate Station	Good	1	3,530,000	-
17	Sunshade for Raft	Good	1	3,860,000	-
18	Methodological Equipments for Climate Station	Good	1	-	$11,500
Total				89,010,000	$11,500

*1 CTD Measuring device has been lost in the lake by the accident during the field survey.

Japanese Fiscal Year 2012

No.	Machinery & Equipment		Qt.	Value (JPY)	Value (USD)
1	Raft for Climate Station	Good	1	3,530,000	-
2	Sunshade for Raft	Good	1	3,860,000	-
3	Methodological Equipments for Climate Station	Good	1	-	$11,500
4	CO2 Isotope Analyzer	-	1	6,200,000	-
Total				103,790,000	$11,500

Japanese Fiscal Year 2013

No.	Machinery & Equipment		Qt.	Value (JPY)	Value (USD)
1	Atomic absorption analyzer	-	1	9,492,000	-
2	Deep water CO2 removal system	-	1	7,900,000	-
3	Polarization microscope	-	1	483,000	-
4	Automatic observation buoy	-	1	33,400,000	-
5	Rubber Boat	-	1	1,005,900	-
Total				52,280,900	-

Ground Total (JPY)	247,325,470

* 1USD = JPY 97.59

Ground Total (CFA)	1,236,627,350

* 1JPY = 5 CFA

Annex 7: Operational Cost

Japanese Side

(Unit: Thousand)

	FY2011	FY2012	FY2013*[2]	Total
Local Operational Cost *[1](CFA)	18,170	23,513	18,933	60,616
Local Operational Cost (JPY)	3,634	4,703	3,787	12,123

*[1] Local operational cost means the amount of expenditure that the Project Coordinator disbursed from the JICA Cameroon Office.

*[2] Japanese fiscal year starts from April to March. Local operational cost in FY 2013 is summed from April to the end of September.

Cameroonian Side

(Unit: Thousand)

	FY2011*[2]	FY2012	FY2013*[3]	Total
Expenditure*[1] (CFA)	7,645	232,811	66,544	307,000
Expenditure (JPY)	1,529	46,562	13,309	61,400

*[1] Expenditure means the amount of expenditure that the Cameroonian side disbursed from the Counterpart Fund.

*[2] Cameroonian fiscal year starts from January to December. Expenditure of FY2011 is summed from January since the Kick-off ceremony and preliminary survey by Japanese Researchers were conducted in January before the Project started.

*[3] Expenditure in FY 2013 is summed from January to the end of July.

Annex 8: List of Counterparts

No.	Name	Title	Department/Section	Title
1	Hell Joseph Victor	PhD	IRDM	Director
2	Sigha Luc Nkamdjou	PhD	Senior Researcher/Chief of Research, IRGM	Senior Researcher/Chief of Science Research
3	Tanyileke Gregory	PhD	Hydrology Research Center (CRH), IRGM	Senior Researcher
4	Aka Festus Tongwa	PhD	Hydrology Research Center (CRH), IRGM	Senior Researcher
5	Fantong Y. Wilson	PhD	Hydrology Research Center (CRH), IRGM	Researcher
6	Ako Andrew	PhD	Hydrology Research Center (CRH), IRGM	Researcher
7	Ntchantcho Romaric	PhD	Hydrology Research Center (CRH), IRGM	Researcher
8	Fouepe Alain	PhD	Hydrology Research Center (CRH), IRGM	Researcher
9	Issa	Msc	Hydrology Research Center (CRH), IRGM	Researcher
10	Djomo Serge	Msc	Hydrology Research Center (CRH), IRGM	Assistant Researcher
11	Massoussi Henriette	Msc	Hydrology Research Center (CRH), IRGM	Assistant Researcher/ Chief of Laboratory
12	Simo M	-	Hydrology Research Center (CRH), IRGM	Accountant
13	Tawedi Robert Elvis	Bsc	Geochemical Laboratory Analysis Water (LAGE), CRH, IRGM	Senior Technician
14	Nlozoa Justin	BSc	Geochemical Laboratory Analysis Water (LAGE), CRH, IRGM	Technician
15	Libongo Mbilongo Jean Christel	-	Geochemical Laboratory Analysis Water (LAGE), CRH, IRGM	Technician

Annex 9: The Revised List of Counterpart Personnel

Affiliation	Name	Monitoring of Lakes Nyos and Monoun	Interaction between rock and CO2-rich fluid	Mechanism of limnic eruption	Hydrological regime around Lakes Nyos and Monoun	CO2 recharge system beneath Lakes Nyos and Monoun	Eruptive history around Lakes Nyos, Monoun and other volcanoes along CVL (Cameroon Volcanic Line)
	Note	Incluidng persons who are not grouped in other themes.	Mineralization including biological process	Computer simulation of limnic eruption		Multi-beam sonar usage	"Chemical evolution of magma" is included.
Tokai Univ	Takeshi OHBA	○				○	
Tokai Univ	Seigo OOKI	○					
Tokai Univ	Takashi OOSUMI	○					
Yoshida Office	Yutaka YOSHIDA	○					
Tokyo Ins Tech	Akihiko TERADA	○					
Aso Vol Muse	Miyuki YOSHIKAWA	○					
Univ of Toyama	Akira UEDA		○				
Univ of Toyama	Minoru KUSAKABE		○	○			
Univ of Toyama	Shougo NAKAMURA		○				
Univ of Toyama	Daisuke TANAKA		○				
Tohoku Univ	Tomofumi KOZONO			○			
Univ of Tokyo	Mie ICHIHARA			○			
Univ of Tokyo	Yusuke SUZUKI			○			
Univ of Tokyo	Katsuro ANAZAWA				○		
Univ of Tokyo	Toshihiko SUGAI				○		
Univ of Tokyo	Ryoichi IMASU				○		
Osaka Univ	Kazuto SAIKI					○	
Kyoto Univ	Katsuya KANEKO					○	
Kumamoto Univ	Yasuo MIYABUCHI						○
Kagoshima Univ	Tetuo KOBAYASHI						○
Tokyo Ins Tech	Tetsuya YOKOYAMA						○
IRGM	Hell Joseph Victor	○					
IRGM	Sigha N Luc	○					
IRGM	Tanyileke Gregory	○	○				
IRGM	Ntonga Jean Claude				○		
IRGM	Fantong Wilson		○		○		
IRGM	Ako Andrew	○					
IRGM	Ntchantcho Romaric			○			
IRGM	Fouepe Alain				○	○	
IRGM	Issa	○			○	○	
IRGM	Djomou Serges	○				○	
IRGM	Massoussi Henriette	○					

Affiliation	Name	Monitoring of Lakes Nyos and Monoun	Interaction between rock and CO2-rich fluid	Mechanism of limnic eruption	Hydrological regime around Lakes Nyos and Monoun	CO2 recharge system beneath Lakes Nyos and Monoun	Eruptive history around Lakes Nyos, Monoun and other volcanoes along CVL (Cameroon Volcanic Line)
	Note	Incluidng persons who are not grouped in other themes.	Mineralization including biological process	Computer simulation of limnic eruption		Multi-beam sonar usage	"Chemical evolution of magma" is included.
IRGM	Simo Motsebo	○					
IRGM	Nlozoa Justin	○					
IRGM	MBilongo Jean Christel	○					
IRGM	Ayissi Mevengue						
IRGM	Abega Raphael						
IRGM	Tawedi Robert	○			○		
IRGM	Mohammad Belo				○		
IRGM	Bassogog Zachee				○		
IRGM	Aka Festus Tongwa						○
IRGM	Boniface Kankeu						○
IRGM	Teitchou Isidore						○
IRGM	Eyong John						○
IRGM	Nche Linus						○
IRGM	Yannah Mero						○
IRGM	Mimba Ernestine						○
IRGM	Nguemhe Fils						○
USGA	Evans William C	○		○			
Univ Michigan	Kling George W	○		○			

ANNEX 10: Performance of the Project Activities

Output 1 The mechanism of limnic eruption is understood.	
Activity	Performance
1-1 The conditions under which limnic eruption can occur are constrained through computer-simulation.	• The detailed parameters that incorporated observation data of the real CO2 density distribution in existing primary physical model closely were analyzed • Two-dimensional simulation about the inflow process of CO2 bubbles in the water was developed. • A critical condition about the volume of CO2 supply from the bottom of a lake where a lake explosion was possible, and CO2 density distribution in the lake.
1-2 Acoustic survey of the detailed topography of the bottom in Lakes Nyos and Monoun is made to locate the recharging point of CO2 enriched fluid.	• Trainings in Japan for the operation of Multi-beam sonar were conducted to IRGM researcher and Cameroonian PhD students in 2011 and 2012.
1-3 The conditions under which limnic eruption can occur are estimated, and utilized to judge the safety of the lakes.	• The conditions such as scales at time before a lake explosion starting were clarified. It was indicated that Lake Nyos has been in a stable state against two-fold diffusion convection phenomenon. • The following research paper has been currently in press: • Minoru Kusakabe, "Evolution of CO2 content in Lakes Nyos and Monoun, and sub-lacustrine CO2-recharge system at Lake Nyos as envisaged from C/3He ratios and noble gas signatures," Volcanic Lakes (D. Rouwet, B. Christenson, F. Tassi, J. Vandemeulebrouck, eds), Springer-Heidelberg, 2014 • Based on the above research activities, following research paper, is in preparation • Kozono, T., Ohba, T., Kusakabe, M., Yoshida, Y., and Suzuki, Y.J., "Conditions for limnic eruption of Lake Nyos, Cameroon: Numerical analysis of 1-D plume model"
Output 2 The CO2 recharge system beneath Lakes Nyos and Monoun is understood.	
2-1 3D distribution of CO2 in the lakes is investigated, which can be used to locate the recharging point of CO2 enriched fluids.	• Examination of practicability of measuring the sound velocity of lake water, and laboratory experimentation for estimating level of dissolved CO2 concentration were conducted. • As a result of the above activities, the effectiveness of the sound velocity measurement of lake water has been proved, and a potable device for measuring the underwater sound velocity, which can be easily maintained in a remote place like Lake Nyos where maintenance of scientific instrument is difficult in the field, has been developed.
2-2 The CO2 flux from soil and the CO2 concentration in surrounding atmosphere are measured at Lakes Nyos and Monoun.	• CO2 concentrations in surrounding atmosphere in Lake Nyos and Lake Monoun have been measured. • Based on the above research activities, following research papers are in preparation • K. Saiki, M. Sanemasa, K. Kaneko, T. Ohba, M. Kusakabe, G. Tanyileke, J. V. Hell, "Vertical profile of dissolved CO2 concentration in Cameroonian volcanic lakes estimated from sound velocity of lake water"

	• M. Sanemasa, K. Saiki, K. Kaneko, T. Ohba, M. Kusakabe, G. Tanyileke, J. V. Hell, "A new method for the estimation of dissolved CO2 concentration of volcanic lakes using the sound velocity of lake water"
Output 3 The hydrological regime around Lakes Nyos and Monoun is understood.	
3-1 The flow path of groundwater around Lakes Nyos and Monoun is estimated through remote sensing (satellite images) and hydro-geochemical approaches.	• The detailed topographical map of Lake Nyos and surrounding area was made from satellite images.
3-2 The interaction between surface water and groundwater is understood.	• The field surveys was conducted by Japanese and Cameroonian researchers for water sampling from lake, river, spring and other water resources near Lake Nyos and hydrological analysis was conducted on laboratory in 2011. • Through the above research activities, technical instructions regarding water sampling methods and hydrological data analysis by application of GIS were provided by Japanese researchers. • Two PhD students have been accepted on April (Brice Tchakam Kamtchueng) and on October (Tiodjio Edwige Rosine) in 2012 at Toyama University as long-term trainees under the C/P training scheme in Japan. • Water sampling campaigns and on-site analysis were conducted twice by the above PhD students under the supervision of Japanese and Cameroonian researchers in 2013. • Based on the above research activities, research papers by PhD students and Cameroonian researchers are in preparation
3-3 The water balance in Nyos basin is estimated.	• Water samples collected from various water resources by Activity 3-2 were categorized into groups by chemical structure and isotope analysis in Japan.
Output 4 The interaction between rock and CO2-rich fluid is understood.	
4-1 Laboratory experiments on the interaction between rock and CO2-rich fluid are carried out to understand geochemical and mineralogical processes in a sub-lacustrine CO2-supply system.	• Experimental study for monitoring of precipitation rate of siderite was conducted in Lake Nyos. • Correlation between the above results and water quality was analyzed at laboratory in Japan. • By using a newly developed device, water sampling without losing dissolved CO2 from the bottom of Lake Nyos was succeed. • The above new sampling method and traditional sampling method were compared in terms of effectiveness for measuring level of dissolved CO2 concentration. • Based on the above research activities, following research papers are in preparation • Ueda, Akira, Ozawa, Akiko, Yoshida, Yutaka, Kusakabe, Minoru, Ohba, Takeshi , Tanyileke, Greg and Hell, J.Victor, "A new geochemical sampler for CO2 analyses of lake water and for monitoring of siderite precipitation in Lake Nyos"

Output 5 Lakes Nyos and Monoun are monitored.	
5-1 Automatic observation systems to monitor the lake water and climatic parameters are installed in Lakes Nyos and Monoun and the data are transmitted to IRGM via satellite. 5-2 Work rafts to collect water and gas samples are set up at Lakes Nyos and Monoun.	• Two rafts for the climate station and stationary observation of the lake were built in Lake Nyos (June 2012) and Monoun, (January 2013), and equipment of the climate station were successfully set up on the new rafts in both lakes. As a result, measurements of the conductivity, temperature, total gas pressure of the lake water and climate parameters have been started by the climate station.
5-3 The amount of CO2 remaining in the lakes will be measured through physical and chemical methods on a regular basis, at least, once a year.	• A periodical monitoring (once a year) has been continued by Japanese and Cameroonian researchers. • As a result it was indicated that CO2 content in Lake Nyos has been decreasing gradually so as to lose its gas self-lift capability in the near future. CO2 content in Lake Monoun decreased to minimum, but supply of magmatic CO2 still continues, resulting a slight increase in CO2 content in the lake.It gives a strong justification for the necessity that deep water of Lake Monoun should be pumped out. Through the above monitoring activity, technical methods such as MK sampling, YY method and pH method have been transferred to Cameroonian researchers. • Two PhD students have been accepted at University of Tokai as long-term trainees under the C/P training scheme in Japan. • Analytical machinery and equipment have been provided to the laboratory at Nkolbison, such as Ion Chromatograph, Laser Isotope Analyzer (PICARRO), Ultrapure Water Equipment (Milli-Q), and CTD measurement. • In order to master the operation and maintenance of the above provided machinery and equipment, 1 Cameroonian researcher and 3 laboratory technicians were invited to the short-term training in Japan. • Through the above monitoring activity, technical methods such as MK sampling, YY method and pH method have been transferred to Cameroonian researchers. Thus, it is likely that Cameroonian researchers are able to conduct monitoring by themselves.
Output 6 The experimental system for removing CO2-rich deep water to prevent gas rebuilding at Lake Monoun is set up.	
6-1 An apparatus to pump CO2-rich deep water is designed and tested at Lake Monoun to evaluate its capability, cost-performance and easiness of maintenance.	• The experimental system based on the situation of Lake Monoun has been designed and produced in Japan. • The level of progress of activities for achieving Output 4, generally perceived by Japanese Research Team, is 70%.

Output 7 The eruptive history around Lakes Nyos, Monoun and other volcanoes along CVL (Cameroon Volcanic Line) is understood.	
7-1 Detailed geological and petrochemical survey of volcanoes is carried out at the volcanic lakes distributed along the CVL.	• More than 100 samples of eruptive rocks have been collected and analyzed in Japan. • Based on the above research activities, a research patter by Japanese researcher is in preparation • Based on the above research activities, the following research paper was published by Cameroonian researchers. • Aka, F.T. and Yokoyama, T, "Current status of the debate about the age of Lake Nyos dam (Cameroon) and its bearing on potential flood hazards", Natural Hazards 65, 875-885, 2013 • One PhD student (Asobo Nkengmatia Elvis A.) has been accepted on April 2012 at Tokyo Institute of Technology as long-term trainees under the C/P training scheme in Japan.
7-2 Geological maps of the Nyos and Monoun areas are produced.	• No Activity
Output 8 The distribution of CO2 in Lakes along CVL other than Lakes Nyos and Monoun is understood.	
8-1 The CO2 flux from soil and the CO2 concentration in surrounding atmosphere are measured at other lakes along the CVL.	• Due to security reason of the target research area, a field survey planned by Japanese researchers on March 2013 was canceled, and only Cameroonian researchers have conducted surveys.
8-2 Basic survey and preliminary monitoring are carried out at other lakes along the CVL, such as Manengouba (Bangem), Wum and Barombi Mbo (Kumba) located near urban centers.	• A field survey of CO2 distribution surged from soils of flank of Mt. Manenguba, has been conducted by Cameroonian researcher. • Water sample was collected from the surface and bottom of Lake Barombi-Mbo by Cameroonian researchers.
8-3 The geochemical database for the lakes along the CVL is established.	• No Activity
Output 9 The results of scientific monitoring are systematically shared with the Department of Civil Protection (DPC).	
9-1 The results of scientific monitoring are sent to DPC for annual report.	• No Activity
9-2 9-2 Recommendations for disaster management are proposed based on scientific findings.	• No Activity