Project Design Matrix (PDM-ver3)

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.	A) An operational direction in IRGM including the following contents. 1. Lake observation 1-1. Automatic buoy 1-2. Climatic station 1-3. CTD observation 1-4. YY method 1-5. CO2 flux on water surface 1-6. Multi-beam sonar 1-7. CO2 flux around the lakes 1-8. Boats including engine 2. Lake, spring, well, rain and river water sampling 2-1. Niskin sampler 2-2. MK method 2-3. Dissolved gas sampling 2-4. Treatment at the sampling site 2-5. Preparation of pure water (milli-Q)	A-1) Hard copy and electric file on web site A-2) Necessary reagents, standards, sampling tools, disposable materials (cleaning paper etc) and carrier gases etc in the lab	None

	3. Water analysis 3-A physical parameters 3-A1. Temperature 3-A2. Conductivity 3-A3. pH 3-A4. Discharge rate (if possible) 3-B Chemical parameters 3-B1. Dissolved CO_2 3-B2. Dissolved O_2 3-B3. Alkalinity 3-B4. Anions (major) 3-B5.Cations (major) 3-B6. Trace elements (relevant per sample) 3-C Isotope analyses 3-C1. D/H and $^{18}O/^{16}O$ ratios 4. Gas analysis 4-1. $^{13}C/^{12}C$ ratio of CO_2 5. Operational direction in IRGM for accreditation of analytical equipments (IC/Picarro/AAS etc) B) Proper use of each analytical and observational instrument C) Systematic storage of water	B) Notebooks for the record of use, showing dates, name of analyzer, supplier of sample + sample ID, amount paid for each parameter analyzed in the sample, the condition of instruments etc C) Shelves in the building of laboratory at Nkolbison for	

	and rock samples	storing well cataloged (GIS ref) water & rock samples	
	D) Communication among the project team members	D) Use of a groupware through internet	
	E) Funds-raised for the maintenance of analytical equipment.	E-1) Stand-by funds to be managed by the laboratory head for buying lab supplies as soon as need arises E-2) Acceptance of analytical request with charge	
Outputs			
1. The mechanism of limnic eruption is understood.	1. A) A scientific journal paper B) Report for local people C) Information on Web site		None
2. The CO_2recharge system beneath Lakes Nyos and Monoun is understood.	2. A) A scientific journal paper B) Information on Web site C) Awareness workshop for local people		
3. The hydrological regime around Lakes Nyos and Monoun is understood.	3. A) A scientific journal paper B) Outreach activities for local people		
4. The interaction between rock and CO_2-rich fluid is understood.	4. A scientific journal paper		
5. Lakes Nyos and Monoun are monitored.	5. A scientific journal paper		
6. The experimental system for removing CO_2-rich deep water to prevent gas rebuilding at Lake Monoun is set up.	6. A technical paper on the CO2 removal system		
7. Magmatism of Oku volcanic zone is understood.	7. (a) PhD thesis (b) Scientific journal papers		

8. Gochemical parameters of lakes along CVL other than Nyos and Monoun are understood. 9. The results of scientific monitoring are systematically shared with the Department of Civil Protection (DPC).		8. A scientific journal paper 9. A) Seminar with DPC B) Special session in CVL-9		
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 surface of Lakes Nyos, Lake Monoun.and Manenguba volcano 3-1 The flow path of groundwater around Lakes Nyos and Monoun is established	＜Indicators＞ 1-1 Computer simulation code 1-2 A)Bathymetric map of Lakes Nyos B) Bathymetric map of Lake Monoun 1-3 Recommendation to concerned authorities highlighting safety conditions 2-1. A) 3D distribution map of CO2 in Lake Nyos B) 3D distribution map of CO2 in Lake Monoun 2-2. A) CO2 flux map on the surface of Lake Nyos B) CO2 flux map on the surface of Lake Monoun C) CO2 flux map of ground surface within the caldera of Manenguba volcano 3-1. A) A detailed topographic map around Lake Nyos	<u>Japan</u> Personnel - Chief Advisor - Project Coordinator - Geochemistry - Volcanology - Petrology - Geology - Geography - Hydrology - Other fields that are mutually agreed up0n as necessary Equipment - Water and gas analysis - Monitoring equipment - sampling and observation - removing CO2-rich bottom water - Others mutually agreed upon as necessary for the implementation of the Project Training in Japan	<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

	B) Ground water flow map around Lake Nyos C) Ground water flow map around Lake Monoun	Activities in Cameroon	
3-2 The interaction between surface water and groundwater is understood.	3-2 A) A water quality map around Lake Nyos B) A water quality map around Lake Monoun		
3-3 The water balance in Nyos basin is estimated.	3-3 A Data base for climate and hydrological data for Lake Nyos		
3-4 Biogeochemical assessment on Lakes Nyos and Monoun watershed: Implication for CO2 and methane sequestration	3-4 Biochemical data on the lake water at Nyos and Monoun.		
4-1 Natural 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.	4-1 A) Photographs on mineral precipitation and dissolution B) Specimens of experiments		Pre-Conditions None
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.	5-1 A) Climatic station B) Automatic observation buoy		
5-2 Work rafts to collect water and gas samples are set up at Lakes Nyos and Monoun.	5-2 A) Work rafts on Lake Nyos B) A Work raft on Lake Monoun		

5-3 The amount of CO_2 remaining in the lakes will be measured through physical and chemical methods on a regular basis, at least, once a year.	5-3 A) A data base on the components in Lake Nyos B) A data base on the components in Lake Monoun		
6-1 An apparatus to pump CO_2-rich deep water is designed and tested at Lake Monoun to evaluate its capability, cost-performance and easiness of maintenance.	6-1 A test system for the removal of deep lake water in Lake Monoun		
7-1 Geological and petrochemical survey of rocks from Oku volcanic zone.	7-1 A petro-chemical data base for rocks of the Oku Volcanic Group		
7-2 Eruptive history of Nyos volcano are understood	7-2 Column diagram of the stratigraphic cross section around Nyos volcano		
7-3 Eruptive mechanism and hazard implications of Lake Barombi Mbo are understood	7-3 A volcanological data base for rocks at Lake Barombi Mbo		
8-1 The CO_2 flux around the lakes other than Nyos and Monoun along the CVL.	8-1 CO_2 flux maps at lakes other than Lakes Nyos and Monoun		

8-2 Basic survey are carried out at other lakes along the CVL. 8-3 The geochemical & climate database for the lakes along the CVL is established 9-1 The results of scientific monitoring are sent to DPC 9-2 Recommendations for disaster management are proposed based on scientific findings.	8-2 A geochemical data base on the lakes other than Nyos and Monoun along the CVL 8-3 Organized water samples taken at the lakes along CVL. 9-1 Annual report including data and interpretation. 9-2 Final project report		