UNION GEODESIQUE ET GEOPHYSIQUE INTERNATIONALE
INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

2009-2010 GRANT PROGRAMME

Project title:

Monitoring Taal volcano unrest in Philippines with joint Electromagnetic and multi-disciplinary educational EMSEV-PHIVOLCS program

FINAL REPORT
December 2010

EMSEV Inter- Association (ElectroMagnetic Studies of Earthquakes and Volcanoes)
http://www.emsev-iugg.org/emsev/

Jacques Zlotnicki, Chairperson
CNRS-France
(UMR6524-Clermont-Ferrand Observatory, France)
Email: Jacques.zlotnicki@wanadoo.fr

Yoichi Sasai, IAVCEI Liaison member
Tokyo Metropolitan Government
The Disaster Prevention Division
Email: yosasai@zag.att.ne.jp

Toshiyasu Nagao, EMSEV Secretary
Tokai University, Shimizu
Earthquake Prediction Research Center
Email: nagao@scc.u-tokai.ac.jp

Renato Solidium, PHIVOLCS Director
Philippines Institute of Volcanology and Seismology
PHIVOLCS
Email: renato_solidum@yahoo.com

Malcolm Johnston, EMSEV vice-Chair, IASPEI Liaison
U.S. Geological Survey, Menlo Park, USA
Earthquake and Volcano Hazards
Email: mal@usgs.gov

Introduction

Following an international workshop held in Manila in January 2003 for 'Initiating seismic and volcanic electromagnetic monitoring in Asian countries' the Inter-Association Working Group EMSEV has developed a scientific cooperation in the electromagnetic field and other geophysical methods with the Philippines Institute of Volcanology and Seismology (http://www.phivolcs.dost.gov.ph/). Priority was given to Taal volcano which may involve large eruptions with pyroclastic flows, base surges and violent phreatic explosions. The volcano has always shown signs of sporadic activity since the last period of activity (1965-1977) during which about 200 people were killed. In 1991, 1992, 2000-2004, 2006, and 2010 major seismic crises were recorded inducing occasionally felt earthquakes, opening of fissures, cyclic ground surface uplifts, increase in ground and water temperatures, bubbling in the acidic inner crater lake, and surface activity. Based on local authorities and PHIVOLCS researches, about 10,000 inhabitants should be concerned by a mild activity within a radius of only 7 km while more than 650,000 people should be affected in case of a violent eruption as that in 1749.

To respond and mitigate to this high level volcanic risk, EMSEV and PHIVOLCS have joined their best efforts for (1) understanding the interactions between the magma feeding system and the hydrothermal system buffered by both the hot acidic inner Crater Lake (MCL) and the cold outer Taal Lake(TL), the geological discontinuities along which heat and soil degassing prevail, (2) evaluating scenarios of activities, (3) monitoring the volcanic activity, and (4) constituting an electromagnetic scientific community at PHIVOLCS.

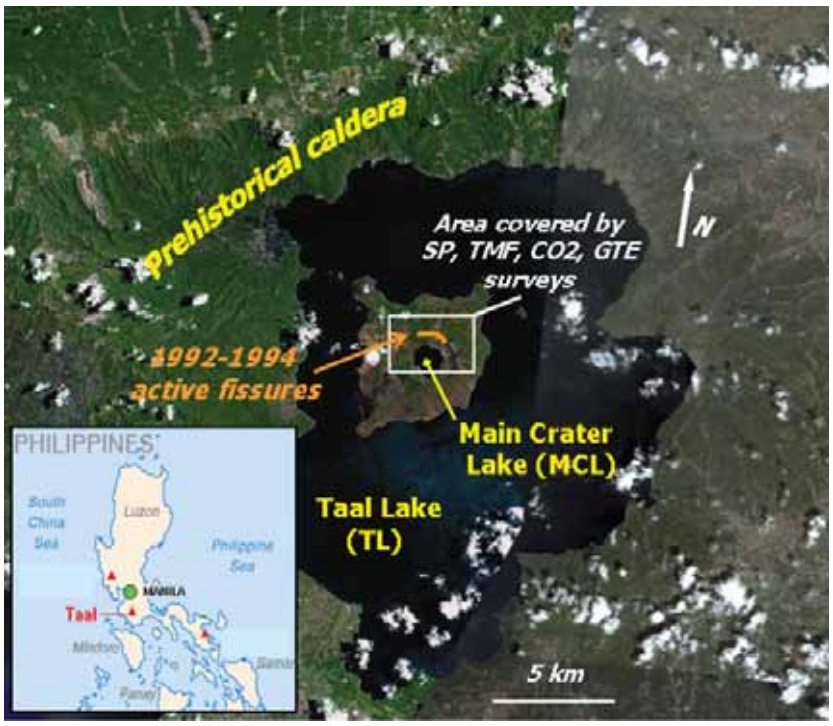

Figure 1: Topographic map of Taal volcano. White rectangle is the main area where EM and other geophysical field studies have been performed.

Time line of the cooperation

- **2003**

International EMSEV-PHIVOLCS workshop in Manila held in January 2003 on 'Initiating seismic and volcanic electromagnetic monitoring in Asian countries'

Formation an international electromagnetic (EM) EMSEV team based on Japanese and French counterparts.

- **2004**

Memorandum of agreement signed by PHIVOLCS and EMSEV on 'The understanding of the geotectonics, seismicity and volcanism of the southern Luzon region'

- **2005**

PHIVOLCS designs an initial EM team. First joint field campaign on Taal.

Magnetic (TMF), self-potential (SP), ground temperature (GT) and soil degassing surveys (CO_2) are performed.

A first continuous multi-parametric station located across the active fissures opened during the 1991-92 seismic activities is set. Data are recorded locally.

- **2006**

Two joint field campaigns are led. During the first January campaign, felt earthquakes incite people living on the volcanic Island to spontaneously evacuate for a few days.

A network of magnetic benchmarks is achieved on which the total magnetic field is regularly measured.

- **2007**

Two tasks were simultaneously performed during the two multiparty field works. One is to extend the electromagnetic, soil degassing and temperature surveys on the ground through the two identified geothermal fields. The second task is to build a new continuous multi-parametric station located inside the crater above the second geothermal field.

A real telemetry system was implemented between the two multi-parametric stations and the local Taal observatory. Data can be visualized and analyzed by PHIVOLCS.

Two continuous stations recording the total magnetic field were installed in the immediate vicinity of the two multi-parametric stations. Data which are recorded locally are collected every month by PHIVOLCS members.
One cross section of 13 audio-magnetotelluric soundings along a North-South direction highlights the rooting and the interconnection of the two geothermal fields.
During field work, particular attention is made to educate EM-PHIVOLCS team to the methods which are applied. EM-PHIVOLCS team is advised on best techniques to make measurements .
Reports were written, and meetings were held at PHIVOLCS headquarter.

- **2008**

Two years IUGG grant is obtained. It greatly allows the cooperation to speed up research.
A memorandum of agreement was made on the use of geomagnetic data from Muntinlupa magnetic observatory in the Philippines. It was signed by the National Mapping and Resources Information Authority (Philippines), the Ocean Hemisphere Research Center, the Earthquake Research Institute (University of Tokyo) the Japan Agency for Marine-Earth Science and Technology, PHIVOLCS, and EMSEV. This memorandum allows EMSEV and PHIVOLCS to use Muntinlupa magnetic data as remote reference.
Magnetic and bathymetry surveys of the inner Crater Lake were performed during the two joint 2008 campaigns.
Water level and temperature of the Crater Lake are now recorded thanks to a combined sensor located in the middle of the Crater Lake.
Reports were, and meetings at PHIVOLCS were held.

- **2009**

Meetings at PHIVOLCS, and two common field work efforts were organized.
Detail and large scale magnetic, self-potential, soil degassing and ground temperature surveys are done.
Because of the relative quietness of the surface activity of the Crater Lake, water temperatures (WTE) at the bottom of the Lake were measured. Detail bathymetry was updated.
An outstanding effort was made by both parties to install a more reliable internet connection between the computer recording multi-parametric data at the local observatory and PHIVOLCS headquarter, and the French server. Automatic transfers were set, and data can now be visualized and processed routinely on the Virtual ElectroMagnetic Laboratory (VEML; http://virtual-electromagnetic-laboratory.com/).

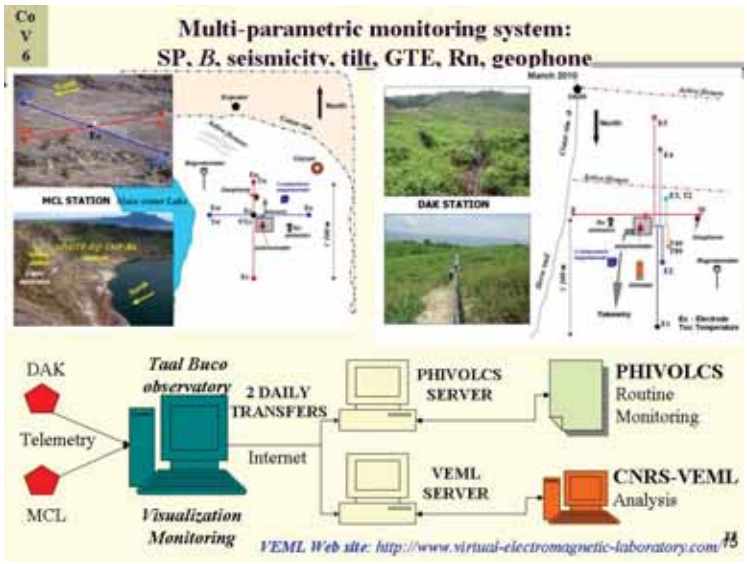

Figure 2: At MCL station, self-potential, ground temperature and gradient, seismic noise, components of the magnetic field, seismicity, , and Rn emission are recorded. At DAK station, in addition to the same parameters, two components of the tilt are also recorded (2010). 2 seconds

sampled data are radio-transmitted in real time.

♦ **2010**

Thanks to IUGG grant, PHIVOLCS and French Embassy supports, a second international workshop was held at PHIVOLCS. Title is 'Monitoring active volcanoes by electromagnetic and other geophysical methods; Application to Asian volcanoes'. About 60 participants attended the meeting (http://www.emsev-iugg.org/emsev/).

A new memorandum of agreement was signed between PHIVOLCS and EMSEV for the period 2010-2014.

Following the meeting, a large field campaign was organized:

- Resistivity, Very Low Frequency soundings are performed along the tracks followed by SP, ground temperature and soil degassing surveys (Greek participation).
- A borehole tiltmeter is installed at the northern multi-parametric station (DAK, USGS participation).
- Magnetic surveys were measured along the magnetic network of benchmarks, and new SP profiles allow building a complete map describing the extent of the hydrothermal field including the two geothermal fields.

In October and November 2010, a new step in the cooperation was achieved:

- Three magnetotelluric stations are installed under the framework of a JICA support (Japan).
- A new EMSEV multi-parametric station was build on the northwestern edge of the crater rim, at the limit of the northern geothermal field. Data recorded on site will be telemetered in real time in 2011.

From mid-April to the end of July, Taal volcano exhibited an abrupt and strong seismic crisis. PHIVOLCS raised the alert level from 1 to 2 temporarily and included a possible plan to partially evacuate the volcanic Island. Thanks to the real-time multi-parametric network, EMSEV was able to regularly process data and to inform PHIVOLCS about the observed signals and the interpretation. Two reports were sent to PHIVOLCS during this period. This several months of activity were useful for all the participants who rapidly communicate data, evaluation of the activity and so forth.

♦ **2011 prospective**

Two main field campaigns should be done during the year.

- Magnetotelluric soundings should be performed on the volcanic Island in order to study the deep structure,
- A fourth EMSEV multi-parametric station should be installed on the volcano. The objectives of this new station are multiple. First, parameters similar to those at the other stations (SP, temperature, gradient of temperature, seismic noise …) will be recorded, and, second, a current system which will allow dipole-dipole resistivity soundings on the basis of the multi-parametric network will be implemented.
- Depending on the budgets that each foreign EM team will get, theoretical and applied studies and stages will be proposed to PHIVOLCS EM team members.

Main results and achievements

Combined SP, GT, WTE, soil degassing and TMF surveys indicate that the northern part of the volcano is undergoing strong thermal transfers and degassing. The activity takes place along E-W fissures that could be linked to the root of the northern border of the Crater (MC) at a depth of some hundreds of metres, and also connected to a thermal source near the MCL shore line. This thermal source location could be the initial spot of the next eruptive activity. In such a case, strong activity could induce a collapse of a part of the northern MC rim into the MCL, due to mechanical weakening by the active 1992-1994 fissures. To the south, this system appears to be bounded by a NW-SE fault suspected from the NW-SE alignment of negative SP and WT anomalies in the MC. Seismic activity and dike injection may be taking place along this alignment. Changes in SP, TMF

and GT are measured by means of repeat profiles, suggesting that potentially hazardous phreatic/and gas eruptions may be associated with future seismic unrest in these geothermal areas.
The two geothermal fields are linked at several hundreds meters depth and the hydrothermal/volcanic fluids are prevailing in the northern part of the crater. Bathymetry and bottom water temperature of MCL clearly show that a bulge of 5 to 10 m high is present and is cut by active hot springs located along a N.NW-S.SE direction.
Resistivity soundings outline that hydrothermal fluids have mineralized and altered the northern rim of the crater which make it unconsolidated.
When one considers the background seismicity on the volcano, it is clear that seismic crises appear abruptly and are accompanied by rapid ground deformation as observed on many similar volcanoes. High levels of activity can be quickly reached. Therefore, real time monitoring and data analysis systems are a necessity for anticipating the level of hazard expected.
Earthquakes during the April-July 2010 crisis have again re-activated the 1991-94 fissures, which might unconsolidate the northern outer rim of the crater. Many data indicate that the region beneath the northern Crater Lake is still active. During this crisis, the near-surface activity in MCL is apparent, and one may consider that the general hydrothermal activity will again be similar to that observed in 2007 or before. Taking into consideration all the available data, it seems that is new crisis is serious although the details of the deep activity and its potential are not clear. Magmatic intrusion, together with hydrostatic overpressure, could be reactivating the region below the northern part of the volcano. Under this hypothesis, any depressurization, resulting from faulting triggered by teleseismic or local earthquakes, landsliding, etc, could destabilize the system and lead to a phreatic explosion on the volcano.
Four real time multi-parametric EMSEV stations will be operating in 2011. They allow continuous monitoring of the volcanic activity and greatly contribute to improved understanding of the on-going activity. The program adds further value to the seismic networks, geophysical and geochemical surveys operated by PHIVOLCS. PHIVOLCS already integrate some of our results in the information planning to Local authorities and inhabitants.
Several PHIVOLCS members are now aware of EM methods and they would go further in the next years in the study of the EM field. Some of the methodologies developed during the cooperation may already be integrated in the monitoring of other volcanoes in the Philippines.

PHIVOLCS and International EMSEV consortium and evolution

♦ PHIVOLCS team

From the beginning of the cooperation PHIVOLCS (Director R. Solidum) made a huge effort to mobilize active researchers, engineers and technicians in the EMSEV-PHIVOLCS cooperation. The Institute has always largely contributed to providing adequate numbers of personnal in the field in order to complete joint field campaigns. PHIVOLCS has also financially supported the contribution of PHIVOLCS members on the field.

About 8 to 10 PHIVOLCS members may be regularly involved in the cooperation. Most of them are coming from the Volcanological section (directed by J. Sincioco). Two groups were constituted and each of them has focused his interest in the 'Magnetic field monitoring' (J.M. Gordon, Jr, P. Alanis, Freddy)or in the 'Electric field monitoring' (E. Villarcorte, L. Bong, P. Reniva). During each field visit, a representative (J.P. Sabit) of the volcanological section accompanies PHIVOLCS members on the field. The local support is given by Taal observatory (A. Loza Loic, L.A. C. Banes).

♦ EMSEV team and other contributions

EMSEV team has largely increased during the past years.

- Initially the cooperation was supported by two teams mainly belonging to the Earthquake Prediction Research Centre (T. Nagao, M. Harada located at Tokai University, Shimizu) and Tokyo Metropolitan City (Y. Sasai) in Japan, and to the French National Research Centre in France (J. Zlotnicki, F. Fauquet, and P. Yvetot positioned at the Observatory of Physics of

Globe, Clermont-Fd). About 6 researchers and engineers, experts in the EM field, were involved.

From these countries other research teams joint the cooperation, bringing their own expertise: For instance the Aso observatory for total field magnetometers, and J.P. Toutain from the Laboratoire de Mécanismes de Transfert en Géologie for geochemical studies and soil degassing.

- Later on, F. Sortino from the Istituto Nazionale per la Vulcanologia of Palermo (INGV, Italy) contributed to heat fluxes and CO_2 degassing measurements, while A. Bernard from the Laboratoire de Géochimie et Minéralogie (Université Libre de Bruxelles, Belgium) focuses on Thermal Aster imagery of Taal Crater Lake.

- In 2010, G. Vargemezis from the Aristotle University of Thessaloniki entered the scientific consortium and manages the resistivity soundings on the volcano with J.R. Puertollano, R.C. Pigtain from PHIVOLCS. US Geological Survey greatly enlarges the monitoring of the volcano by setting a borehole tiltmeter at a first multi-parametric station (DAK). Now, M.J.S. Johnston is deeply involved in the monitoring of the volcano as the French and Japanese teams.

- Satellite observations progressively enlarge the multi-disciplinarity of the EMSEV consortium. EM observations by DEMETER are active til the end of the experiment. MOPITT observations are done by R.P. Singh working at Chapman University (USA). V. Tramutoli and N. Pergola from Department of Engineering and Physics of The Environment (DIFA, University of Basilicata) are presently setting a time domain analysis of robust satellite techniques (RST) for near real-time monitoring of active volcanoes and thermal precursor identification.

Dissemination of results

♦ Articles

M. Harada, Julio P. Sabit, Y. Sasai, Paul K. B. Alanis, Jr. Juan M. Cordon, Ernesto G. Corpuz, J. Zlotnicki, T. Nagao and Jane T. Punongbayan, 2005. Magnetic and Electric Field Monitoring of Taal Volcano, Philippines. Part I: Magnetic Measurements, Japan Acad. Sci., 81, B, 261-266.

J. Zlotnicki, Y. Sasai, J.P. Toutain, E.U. Villacorte, A. Bernard, Julio P. Sabit, Juan M. Gordon Jr, Ernesto G. Corpuz, M. Harada, J.T. Punongbayan, H. Hase and T. Nagao, 2008. Combined Electromagnetic, geochemical and thermal surveys of Taal volcano (Philippines) during the period 2005-2006. Bull Volcanol., doi: 10.1007/s00445-008-0205-2.

Y. Sasai, M. Harada, J.P. Sabit, J. Zlotnicki, Y. Tanaka, J.M. Cordon Jr., S. Uyeda, T. Nagao, J.S. Sincioco, 2008, Geomagnetic and topographic survey of the Main Crater Lake in Taal Volcano (Philippines): preliminary report, J. Geography, 117, 894-900 (in Japanese with English abstract).

M. Harada, Y. Sasai, J. Zlotnicki, Y. Tanaka, H. Hase, J.P. Sabit, J.T. Punongbayan, J.M. Cordon Jr, E.U. Villacorte, E.G. Corpuz, and T. Nagao, 2008. Monitoring of volcanic activity of Taal volcano (Philippines) by electromagnetic methods, Bull. Inst. of Oceanic Res. and Dev., Tokai University, 29, 9-28, 2008 (in Japanese with English abstract).

J. Zlotnicki, Y. Sasai, J.P. Toutain, E. Villacorte, PHIVOLCS team, P. Yvetot, F. Fauquet, A. Bernard, 2009. Electromagnetic and Geochemical methods applied to investigations of Hydrothermal/magmatic unrests: Examples of Taal (Philippines) and Miyake-jima (Japan) volcanoes, Physics and Chesmistry of the Earth, 34, 394-408. doi:10.1016/j.pce.2008.09.012.

I. Fikos, G. Vargemezis, J. Zlotnicki, J.R. Puertollano, R.C. Pigtain, P.B. Alanis and Y. Sasai, 2011. Shallow structure of the hydrothermal system at Taal volcano (Philippines) inferred by detailed electrical resistivity tomography, in preparation to Bull. Volcanol.

M. Harada, J. Zlotnicki, Y. Sasai, 2011. Magnetic maaping and bathymetry of Taal Crater Lake (the Philippines). In preparation.

♦ Conferences

J. Zlotnicki, 2003. Invited conference. Electromagnetic investigations on Volcanoes : What to observe ? Workshop for initiating seismic and volcanic electromagnetic monitoring in Asian countries, organisé par IUGG et EMSEV, Manille (Philippines), 14-16 jan., 2003.

M. Harada, Y. Sasai, J. Zlotnicki, J.P. Sabit, J.T. Punongbayan, J.M. Cordon, E.U. Villacorte, P.K.B. Alanis, Ishmael C. Narag[4]; Raymond Patrick R. Maximo[4]; Teodorico, A. Sandoval, E.G. Corpuz, B.C. Bautista, R.U. Solidum, T. Nagao, S. Uyeda, 2005.

Magnetic and SP measurements in Taal Volcano, Philippines. Joint meeting for Earth and Planetary Science, May 22-26, 2005, Tokyo, Japan.

E.U. Villacorte, J. Zlotnicki, Y. Sasai, J.P. Toutain, A. Bernard, M. Harada, B.J.T. Punongbayan, I.C. Narag, R.P.R. Maximo, E.G. Corpuz and EM PHILVOLCS team, 2005. Taal volcano (Philippines): Gearing toward a new eruption? Combined land based self-potential, ground temperature and CO2 soil degassing surveys with the crater lake temperature monitored by satellite imagery. IAGA meeting, Toulouse July 18-29, France.

J. Zlotnicki, Y. Sasai, J.P. Toutain, E.U. Villacorte, A. Bernard, J.T. Punongbayan, H. Hase, M. Harada, Ernesto G. Corpuz, Julio P. Sabit, T. Nagao, 2006. Taal volcano (Philippines): Gearing toward a new eruption? Combined land based self-potential, magnetic, ground temperature and CO2 soil degassing surveys with the Crater Lake temperature monitored by satellite imagery. International Workshop on Demeter. Toulouse, June 14-16.

J. Zlotnicki, Y. Sasai, J.P. Toutain, E.U. Villacorte, A. Bernard, J.T. Punongbayan, H. Hase, M. Harada, Ernesto G. Corpuz, Julio P. Sabit, T. Nagao, 2006. Taal volcano (Philippines): Gearing toward a new eruption? Combined land based self-potential, magnetic, ground temperature and CO2 soil degassing surveys with the Crater Lake temperature monitored by satellite imagery, 2006. IWMEEMSV Workshop, India, Nov. 20-22.

J. Zlotnicki, Y. Sasai, J.P. Toutain, E.U. Villacorte, J.M Cordon Jr., A. Bernard, J. P. Sabit, M. Harada, H. Hase, J. Sincioco, J.T. Punongbayan, and T. Nagao, 2007. Electromagnetic and Geochemical monitoring of the slow unrest of Taal volcano (Philippines). IUGG, Perugia, Italy, July 2-13.

SenthilKumar, R.P. Singh J. Zlotnicki, Y. Sasai, and J. Sincioco, 2007. Monitoring slow unrest of Taal volcano (Philippines) Using Carbon Monoxide from MOPITT satellite. IUGG, Perugia, Italy, July 2-13.

J. Zlotnicki, J.P. Toutain, Y. Sasai, E.U. Villacorte, A. Bernard, J. Sincioco, J.M Cordon Jr., Senthilkumar, J. P. Sabit, M. Harada, H. Hase, J.T. Punongbayan, and T. Nagao. Electromagnetic and Geochemical monitoring of the slow unrest of Taal volcano (Philippines). IGOS, GeoHazards 2007. Frascati, Italy Nov. 6-9

Sasai, Y., J. P. Sabit, J. M. Cordon Jr., E. U. Villacorte, J. Zlotnicki, J-P. Toutain, M. Harada, H. Hase, J. Sincioco, T. Nagao: Electromagnetic and geochemical monitoring of Taal volcano, the Philippines: 2005-2007. The 5th International Congress of Cities on Volcanoes; COV-07), Shimabara, Nov. 2007.

J. Zlotnicki, J.P. Toutain, Y. Sasai, E.U. Villacorte, A. Bernard, J.M Cordon Jr., F. Sortino, J. P. Sabit, M. Harada, PHIVOLCS EM team, J. Sincioco, H. Hase, T. Nagao, 2008. Invited conference "Volcanic lakes". Integrated Electromagnetic and Geochemical methods applied to volcanic hydrothermal systems: Application to Taal volcano (Philippines). IAVCEI GA Assembly, Reykjavik, Iceland, Aug. 18-25, 2008.

J. Zlotnicki, Y. Sasai, J.P. Toutain, E. Villacorte, PHIVOLCS team, P. Yvetot, F. Fauquet, A. Bernard. Electromagnetic and Geochemical methods applied to investigations of Hydrothermal/magmatic unrests: Example of Miyake-jima (Japan) volcano, 2008. IAVCEI meeting, Reykjavik, Iceland, Aug. 18-25, 2008.

M. Harada, J.P. Sabit, Y. Sasai, J.M. Cordon Jr., J. Zlotnicki, Y. Tanaka, E.U. Villacorte, H. Hase, J.S. Sincioco and T. Nagao, 2008. Monitoring of volcanic activity in Taal volcano (Philippines) by electromagnetic methods: geomagnetic observations. EMSEV-DEMETER joint workshop, Sinaia, Romania, Sept. 7-12, 2008.

J. Zlotnicki, J.P. Toutain, Y. Sasai, E.U. Villacorte, M. Harada, A. Bernard, Paul Yvetot, F. Fauquet, J.M. Cordon Jr., F. Sortino, J. P. Sabit, J. Sincioco, PHIVOLCS EM team, H. Hase, T. Nagao, 2008. Integrated Electromagnetic and Geochemical methods applied to the volcanic hydrothermal system of Taal volcano (Philippines). EMSEV-DEMETER joint workshop, Sinaia, Romania, Sept. 7-12, 2008.

P.K.B. Alanis, J. Zlotnicki, J.P. Sabit, Y. Sasai, J.M. cordon Jr., M. Harada, J.P. Toutain, E.U. Villacorte, A. Bernard, H. Hase, J.T. Punongbayan, T. Nagao, R.U. Solidum Jr., 2009, Electromagnetic, geochemical and thermal studies on Taal Volcano (Philippines) from 2005 to present, AOGS conference, Singapore, August 11-15, 2009.

J. Zlotnicki, J.P. Toutain, Y. Sasai, E.U. Villacorte, M. Harada, A. Bernard, P. Yvetot, F. Fauquet, 4, F. Sortino, PHIVOLCS EM team, T. Nagao, and R. Solidium, 2009. Electromagnetic, Geochemical and thermal anomalies related to the hydrothermal activity of Taal volcano (Philippines). IAGA meeting, Sopron (Hungary), August 22-29, 2009.

M. Harada, Y. Sasai, J.P. Sabit, J.M. Cordon Jr., J. Zlotnicki, J.Sincioco, Y. Tanaka, T. Nagao, 2009. Magnetic and topographic studies on the main crater lake of Taal volcano (Philippines). IAGA meeting, Sopron (Hungary), August 22-29, 2009.

J. Zlotnicki, **Organisation du workshop EMSEV-PHIVOLCS International Meeting** on Monitoring active volcanoes by Electromagnetic and other geophysical methods, Mainla (Philippines), Feb. 25-27, 2010.

J. Zlotnicki, Y. Sasai, J.P. Toutain, E. Villacorte, M. Harada, PHIVOLCS team, P. Yvetot, F. Fauquet, A. Bernard, T Nagao, 2010. Electromagnetic, geochemical and thermal investigations of Taal volcano, 2010. EMSEV-PHIVOLCS Intern. Meeting on Monitoring active volcanoes by Electromagnetic and other geophysical methods, Mainla (Philippines), Feb. 25-27, 2010.

J. Zlotnicki, and EMSEV bureau, 2010. EMSEV project and its activities. EMSEV-PHIVOLCS Intern. Meeting on Monitoring active volcanoes by Electromagnetic and other geophysical methods, Mainla (Philippines), Feb. 25-27, 2010

P.K.B. Alanis, J.P. Sabit, Y. Sasai, J.M. Cordon, Jr., **J. Zlotnicki**, M. Harada, E.U. Villacorte, H. Hase, J.T. Punongbayan, T. Nagao, J.S. Sincioco and R.U. Solidum Jr, 2010. Magnetic observations on Taal Volcano (Philippines) in combination with other geophysical and geochemical methods from 2005 to present. Meeting on Monitoring active volcanoes by Electromagnetic and other geophysical methods, Mainla (Philippines), Feb. 25-27, 2010.

J.P. Toutain, F. Sortino, **J. Zlotnicki**, Phivolcs team, 2010. soil gas and heat flow assessment at Taal hydrothermal system. Meeting on Monitoring active volcanoes by Electromagnetic and other geophysical methods, Mainla (Philippines), Feb. 25-27, 2010.

J. Zlotnicki, 2010. Electromagnetic and Geochemical methods applied to the investigation of Taal hydrothermal system (Philippines). 6th International meeting Cities on Volcanoes, Tenerife, May 31- June 4, 2010.

J. Zlotnicki, 2010. Taal volcano (Philippines): gearing towards a new eruption? European Open Forum, EOSF-2010, Turino, July 3-7, 2010.

J. Zlotnicki, Y. Sasai, EM PHIVOLCS team, M.J.S. Johnston, J.P. Toutain, and G. Vargemezis, 2010. Five years of cooperation between EMSEV and PHIVOLCS for understanding and monitoring Taal volcano. EMSEV International 2010 workshop, Santa Ana, USA, 3-6 October, 2010.

Detail of November 2010 expenses

1500 € given to F Fauquet for the building of the thrid station

Frederic Fauquet field campaign

date	Income in €	outcome (Php)	Outcome (€)	details	
09. Nov	1000			chèque Jacques 1000 euros	1000 € from EMSEV
17. Nov			55	carte affaire excedent bagage	baggage overcharge
19. Nov	500			500 euros en liquide de Jacques	500 € in cash from EMSEV
18. Nov		150		30 sacs de transport	bags for caarying materials
18. Nov		160		2*2 piles AA	batteries
18. Nov		19.300		materiel de construction station	materials for the shelter
19. Nov		800		2 * 10m de cable alim + cosses batterie	electric cable
19. Nov		350		ouvrier faucheur herbes+arbres	man power
19. Nov		350		ouvrier faucheur herbes+arbres	man power
		700		2 ouvriers	man power
18. Nov		9000		porte	door for shelter
18. Nov		300		serrure	locker
18. Nov		3660		batterie 80AH	80Ah battery
19. Nov		65		?	
20. Nov		240		gazoil+huile	gasoline for rubber boat
20. Nov		400		4 tubes plastiques	plastic tubes
21. Nov		1000		2 chevaux de transport pour le bateau MAIN CRATE	renting horses
23. Nov		350		transport batterie cheval	renting horses
23. Nov		20.000		Transport materiel par chevaux	renting horses
23. Nov		1400		1 ouvrier tranchées pour 4 jours	man power/4 days
23. Nov		1400		1 ouvrier tranchées pour 4 jours	man power/4 days
23. Nov		350		1 ouvrier 1 jour	man power/1 day
23. Nov		270		cosses batterie	plugs for battery
24. Nov		18.000		ouvriers consctruction Shelter	man power, shelter
24. Nov		3000		location 6 jour Bateau	renting boat/6 days
Total	1500	81245		***taux; 1€=57.286 Php***	

Conclusion	1500	**1.418,22**		Je dois rendre à EMSEV 433,7 euros

Back to EMSEV on IUGG grant (€) **81,78**

18. Nov	351,92			Yo me donne du liquide 20 000 pesos	Additional budget given by Japan

Back to EMSEV **433,70 €**