2007 Annual Report of Inter-Association (IAGA/IASPEI/IAVCEI) Working Group of Electromagnetic Studies on Earthquakes and Volcanoes (EMSEV)

By Jacques Zlotnicki, Malcolm Johnston, Seiya Uyeda, Toshiyasu Nagao, Yoichi Sasai, and Jann-Yeng Liu

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1) Introduction

EMSEV - An inter-association Working Group actively promoting EM studies on earthquakes, tsunamis and volcanoes at international conferences and also at workshops, in-field campaigns, education in developing countries, etc.
Recently, EMSEV led four sessions at IUGG-2007 meeting at Perugia (Italy). The association has also maintained a high-level research activity on Taal volcano (Philippines).

2) Membership

During the 10th business at IUGG-2007meeting, EMSEV members decided:

- To elect, on IUGG request, a new EMSEV bureau in response to the wish of Chairperson Seiya Uyeda to step down. Jacques Zlotnicki (France) was nominated as new Chairperson, and Malcolm Johnston (USA) as Vice Chairperson. It was also decided that Jann-Yeng Liu, Malcolm Johnston, and Yoichi Sasai would act as IAGA, IASPEI and IAVCEI liaison-members, respectively. T. Harinarayana was designated as new representative of WG1.2.
- To elect new EMSEV members: Professor A.K. Gwal (India), Dr T. Harinarayana (India), Dr Friedemann Freund (USA), Dr D.S. Widarto (Indonesia), Professor K. Eftaxias (Greece), Dr N. Sarlis (Greece) and Dr V. Traumatoli (Italy).

Forty-two regular EMSEV members and well over 200 corresponding members are now enlisted in EMSEV mailing "http://www.emsev-iugg.org/emsev/".

3) Organizational Activity in 2007

Meetings:

- **Demeter Workshop**, Toulouse, France, June 29, 2007.
  Observations and results on the first two years of mission, (M. Parrot)

- **EGU**, Vienna, Austria, 15-20 April 2007.
  Session NH4.02. Electric, magnetic and electromagnetic phenomena related to earthquakes, convened by P. Biagi, O. Molchanov, M. Hayakawa, F. Vallianatos.
  Session NH4.03. Deformation processes and accompanying mechanical and electromagnetic phenomena, for rocks and other materials, from the laboratory to the geophysical scale, convened by K. Eftaxias, T. Chelidze, V. Morgounov, Nomicos, M. Mandea.
- **IUGG General Assembly Perugia, Italy; July 2-13, 2007**

EMSEV organized four integrated sessions at IUGG on "Progress in electromagnetic studies on earthquakes and volcanoes":

Crustal instabilities and earthquake precursors (JSS009) (Main convener P. Biagi)
Electromagnetic fields associated with earthquakes and active faulting (JSS008) (Main convener M. Johnston)
Seismo-electromagnetic studies using space technology (JSS010) (Main convener R.P. Singh)
Volcanic structure and activities (JSS007, JVS002)(Main convener: S. Spichak)
More than 143 abstracts were accepted and presented in these four sessions.

- **Italy/Japan bilateral Seminar on EM in Seismic and Volcanic Areas**, Chiba, Japan, July 25-27, 2007, organized by K. Hattori.
- **Third international school-seminar on electromagnetic sounding of the earth** (EMS-07), Zvenigorod, Russia. 3-8 September, 2007 organised by V. Spichak.
- **50 years of the International Geophysical Year and the International Electronic Year**, Suzdal, Russia, 16-19 September 2007, organized by A. Gvishiani (Geophysical Centre, Acad. Sci.).
  Session on Russian-French research on Geophysics, Volcanology and Seismic Danger; EM applications
- **The 8th China International Geo-Electromagnetic Workshop**, 11-14 October 2007, Yangtze University, Jingzhou, Hubei, China.
- **International Workshop on Seismo-Electromagnetic Phenomena: Recent Progress** (Japan/Indonesia Project), Bandung, Indonesia, 6-7 November 2007, organized by D. Widarto and K. Hattori.
  EMSEV gave some support to this workshop and the XI EMSEV local meeting was held there. Several Indonesian organizations (LIPI, LAPAN, BMG) have asked EMSEV to contribute to the development of several EM techniques for Natural Hazard assessment.
- **AGU Fall meeting in San Francisco**, 10-14 December, 2007.
  Session S21. Theory and Applications of Electromagnetic and Thermal Anomalies During Earthquakes, convened by D. Ouzounov, K. Hattori, M. Parrot, S. Pulinets, P. Taylor.

Inter-Association Initiative activities:

- Volcano Taal investigation (Philippines):

Under PHIVOLCS (Philippine Institute of Volcanology and Seismology)-EMSEV agreement, a Japan-French team has contributed to understand the slow unrest of Taal volcano. The activities include implementation of EM monitoring systems, and education of PHIVOLCS teams on electromagnetic methods etc. One paper has been published (Harada et al., 2006) and another one is in press (Zlotnicki et al., 2008).

Financial support from the Associations is used to facilitate PHIVOLCS teams to field campaigns. The foreign teams provide equipment and other materials.

Campaign 1 [January 29 to February 13, 2007]

This campaign replaced the one previously scheduled for November 2006 that was postponed due to a typhoon. Work was focused on:

- A resurvey of magnetic benchmarks and installation of new ones near recent magnetic field changes first observed during 2005-2006,
- A resurvey of several SP-GTE-CO_2 profiles made in 2005. The sampling distance was reduced to 12.5 m compared to 25 m in 2005, in order to completely describe the anomalies and to identify their evolution with time,
- The preliminary mapping of CO_2 fluxes and ground temperature gradient in the main geothermal areas,
- Maintenance of the first SP-GTE station, located across the northern 1992-94 active fissures,
- New resistivity soundings on the volcano. First, a south-north cross section on the northern flank is scheduled. Other soundings will be done during the next campaign.

Campaign 2 [April 17 to April 28, 2007]

The objectives were:

- To install a second SP-GTE continuous station (called MCL) in the geothermal field located to the NE of the Main Crater,
- To built a telemetry system for the two SP-GTE stations with real time data transmission to Buco observatory,
- To do added maintenance of the first SP-GTE station (called DAK), located across the northern 1992-94 active fissures,
- To resurvey magnetic benchmarks (see Y. Sasai report),
- To resurvey the SP (self-potential) - GTE (ground temperature) - CO_2 (soil degassing) profile along the northern trail, from the crater rim to down slope. The sampling distance was reduced to about 12.5 m in order to detail the anomalies,
- To extend resistivity soundings inside the Main Crater along the eastern border of MCL.

Campaign 3 [November 27-December 8, 2007]

The sporadic seismic crises and the time and spatial changes of the surface activity led PHIVOLCS and EMSEV to increase their studies. These included:

- Resurvey of several SP-GTE-CO_2 and magnetic surveys were completed,
- Telemetry system up to the local BUCO observatory was improved and a daily routine was set,
- Two continuous proton magnetometers with local data recordings were implemented at the SP-GTE stations,
- A three component magnetometer was installed in the crater and connected to the MCL SP-GTE station,
- Preliminary GPS benchmarks were set inside and outside the crater, and a first real time differential campaign was done,

- International Workshop on Seismo-Electromagnetic Phenomena, Recent Progress: IWSEP 2007, Bandung, Indonesia, November 2007.

Indonesia consists of more than 17,000 islands and severe natural disasters in this country are frequent. These include destructive earthquakes, tsunami, and volcanic eruptions. As an example, casualties of the 2004 Sumatra-Andaman Earthquake reached several hundred thousand. Mitigation of these disasters is obviously of essential importance. Identification of electromagnetic phenomena associated with crustal activity and the detection of these phenomena should be included in the methods for monitoring seismic and volcanic activities. To develop the methodology and to improve scientific knowledge for the seismo-electromagnetics, measurements with sensitive sensors, sophisticated signal processing, and theoretical consideration should be performed.

Even if this activity is well supported by LIPI, LAPAN, and BMG, further implementations of EM methods and the use of installed stations/equipment are crucial for improving the effectiveness of

current global investigations. Therefore, the international cooperation must be encouraged and EMSEV could largely contribute to this demand when it will be formalized. Three lines of organization can be set up:

(1) Acquiring high quality observations on the ground and from satellites for identification of phenomena related to crustal activity

(2) Broad-scale geophysical data integration

(3) Human resource development

4) Financial Report 2007

2007 Budget:

Incoming:

$2,500 from IUGG

$1,500 from IAGA

No support from other associations was given to EMSEV.

Total = $ 4000

Outgoing:

$ 1200 was attributed to PHIVOLCS field campaign on Taal volcano (November 2007).

$ 500 was given to support the Indonesian meeting 'International Workshop on Seismo-Electromagnetic Phenomena: Recent Progress' held in Indonesia (Bandung) on November 6-7, 2007.

$ 2300 will be allocated in the course of next months taking into account the 2008 budget that EMSEV will receive. Several programs and Symposia/Workshop should be supported:

Joined EMSEV-2008 and Demeter meeting in Romania in September 2008, Taal and possibly Indonesia activities, EMSEV session at IAVCEI-2008 meeting in Iceland …

EMSEV would like to promote more deeply case studies through international cooperation in countries including China, Greece, USA, Japan, Kyrgyz, Mexico, etc.

5) Activities for 2008-2009

a) Organised Meetings

In 2008, EMSEV will be deeply engaged in several International Workshops and meetings. One is IAVCEI-2008 meeting which will be held in Reykjavik (Iceland) in August 2008, second is the second scientific meeting on DEMETER observations, and third the EMSEV meeting which will be held in Sinaia (Romania). In order to reduce the cost of the meetings, EMSEV-2008 and DEMETER meeting will be organized jointly in Romania. A small meeting at PHIVOLCS in Manila should also be held in November to state on the current knowledge of Taal activity and to organize further researches and monitoring procedures.

- IAVCEI-2008 Assembly, Iceland

Information: http://www.iavcei2008.hi.is/

EMSEV session; Title: New insights from Electromagnetic (EM) Investigations of Active Volcanoes and Hydrothermal/Geothermal Fields.

Conveners: J. Zlotnicki, M. Johnston and R. Karlsdottir

New electromagnetic (EM) observations (i.e. magnetic and/or electric) have recently been obtained on and near active volcanoes, hydrothermal and geothermal systems. EM signals have also been recorded prior to, and during,

actual eruptions and hydrothermal activity. Analyses of these data have led to both improved understanding of unrest during volcanic, hydrothermal and geothermal activity, and identification of several of the physical processes involved. Furthermore, combining EM studies with other multi-parameter geophysical monitoring has allowed more unambiguous interpretation of these processes.

The session will focus on the following areas of research:

- The geophysical and geochemical behaviour of volcanoes during eruptions and relationships to observed EM phenomena such as self-potential, magnetic fields, electric fields, lightning, conductivity structure, etc.
- The characteristics of EM signals recorded during different volcanic, hydrothermal and geothermal activity particularly recent EM studies in Iceland,
- The complete description of EM signals before eruptions including physical mechanisms that result in EM signal generation,
- Correspondence between EM signals and other geophysical observations (seismic, geodetic, geochemical, etc),
- Combined ground and space observations,
- Modelling of EM tomography and EM processes,
- Review papers integrating multi-parameters analyses are particularly welcome.

- EMSEV 2008 meeting

Venue: Sinaia, Romania; Dates: September 7-12, 2008
Chair of the LOC: Dimitru Stanica (EMSEV member); dstanica@geodin.ro
Meeting Website: http://www.geodin.ro/~prezentare/EMSEV/emsev.html
Scientific Objectives: To report and analyze the recent results and progresses in the research of EM phenomena associated with Earthquakes, tsunami, landslides, volcanoes and geothermal fields.
General content:

1. Seismicity and seismotectonics of Vrancea zone. Inter correlation with other seismogenic zones.
2. Electric, magnetic, and electromagnetic methods related to earthquakes, tsunamis, volcanic eruptions, landslides and geothermal activities.
3. Integration of multi technique monitoring. Cross-correlation between ground and satellite observations.
4. Generation and propagation mechanism of EM signals, and related laboratory experiments.
5. Study of ionospheric perturbations, GPS based measurements.
6. Atmospheric turbulence related to earthquakes and volcanoes, thermal anomalies and latent heat flux.
7. Imaging active faults, volcanoes, landslides and geothermal fields by EM methods. Integration of other methods: geophysical, geochemical, geological …

- Second Scientific meeting on Micro-satellite DEMETER Mission

Venue: Sinaia, Romania as for EMSEV meeting
Dates: Early September 7-12, 2008
Chair of the LOC: Michel Parrot, mparrot@cnrs-orleans.fr; Dimitru Stanica
Meeting Website: http://www.geodin.ro/~prezentare/EMSEV/emsev.html
Scientific Objectives: To report and discuss the results and to plan future cooperative investigation on DEMETER data on earthquakes, tsunamis, and volcanic activity.

b) Scheduled International cooperation:

- Understanding and monitoring Taal volcano.

The Philippines Institute of Volcanology and Seismology is worried about the weak and intermittent seismic and surface activities at Taal volcano. The Institute relies on EMSEV capabilities to contribute to understanding of the volcano structure, the behavior of the hydrothermal system, and to monitor the weak but continuous unrest. Therefore, EMSEV should continue to cooperate with PHIVOLCS. Most probably, two campaigns will be undertaken during 2008, one in March or April and the other in November or December. Note that EMSEV support is allocated only for Philippines field work costs, while foreign teams contribute their own travel support, equipment costs and time to set up these experiments.

- Possible new EMSEV contribution to developing country: Indonesia.

At IWSEP-2007 meeting in Bandung (see above), the general discussion led by LIPI, LAPAN, and BMG pointed out that EM studies should be enlarged in Indonesia, first in the earthquakes mitigation and second in volcanic eruption forecast. A recommendation letter was drawn up and sent to Indonesia Authorities for highlighting the necessity to increase international cooperation in these domains.

The Indonesians colleagues have asked EMSEV to strengthen their EM studies. EMSEV will carefully consider any more formal request. We will propose to contribute to one or several areas of study in which EMSEV teams could participate for several years.

6) <u>Concluding Remarks</u>:

During the past years EMSEV has contributed greatly to improvement of the quality of observations and interpretations of pre-, co- and post-event EM phenomena related to earthquakes and volcanic eruptions. Multi-parametric EM observations, integrated in a multi-disciplinary approach (seismic, geodetic, geochemical, hydrology, thermal…), are now more commonly carried out. This leads to better determination of boundary conditions that control potential physical mechanisms generating EM signals and to a more accurate description of the physics of the processes. Temporal changes in EM signals and their spatial distribution are now tracked by combined ground based and satellite observations (such as ***DEMETER*** micro-satellite). And several other satellite imagery techniques (e.g. InSar, GPS, thermal, etc) may provide independent support for these observations.

On volcanoes, several examples unquestionably show that magnetic and electric signals may appear a long time before an eruptive event (Oshima, Miyake-jima, Merapi) and be associated with weak and sporadic activity (Etna, Taal). In such cases, stress changes, magma transport and fluids are key issues for generating EM signals.

On active faults, several observations show that pre- and co-seismic signals might appear in different frequency domains, from DC to VLF (Japan, Greece, Russia, Taiwan, India, China, and Mexico). Such signals are transient anomalies that may be recorded up to a few months before a large earthquake. Detailed analyses lead to suspicions that some of these transient signals are noise, while some others, detected by several independent stations, argue in favor of pre-seismic signals. At present, a part of the EM community considers that such signals take place through the so-called Lithosphere-Atmosphere-Ionosphere (LAI) coupling.

EM investigations related to earthquakes and volcanic eruptions require many specific and complementary long duration experiments. During the last decade, much progress has been made in the detection and examination of EM signals that further highlights the necessity to develop new investigations and international cooperation.