



Commission on Earthquake Sources: Modeling and Monitoring for Prediction

Activity Report 2007-2010

*Compiled by
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Introduction

The basic attention of Commission is concentrated on researches of physics of destruction process at different scales, since experiments in laboratory on samples of rocks and finishing researches of a seismic regime. The activities of the Commission in the frame of the scope during 2007-2010 are presented bellow.

1. Scientific collaboration field

1.1. Cooperation agreement between the Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences (GFZ) and the Schmidt Institute of Physics of the Earth RAS (IPE RAS) for period of five years was signed in October 2008. The cooperation should be focused on a large range of Earth sciences problems including Earthquake Physics, Global Earth dynamics, Earth's structure, Seismotectonics, Lithosphere Stresses, Geoinformatics and Mathematical Geophysics. In particular according the scope of Commission the project "Physics of Rock Fracture Processes on Different Scales" will be carry out.

1.2. In the frame of Integrated Long Term Programme (ILTP) of cooperation in science & technology between India and Russia two new projects were started in 2008:

- "The transient geophysical processes in areas of strong natural and human-induced impacts: field observations and physical modeling" The objectives are: a) investigation of the time-space structure of seismicity and related geophysical fields after strong natural/technogenic influences, b) developing the technique, methods and algorithms for revealing time series regularities on the base of modern earthquake physics, scaling conception and laboratory verification of related subjects.
- "Preparation of catalogue of Indian earthquakes and test for its completeness". The objective of this project is development of catalogue of earthquakes of India on the basis of the available national, regional and local network data generated by various organizations/agencies and test for its completeness. The catalog so generated would serve as a basic input for research in the area of Earth Sciences.

1.3. The earthquake seismology group in Edinburgh University has led or been involved in several major projects in involving earthquake physics and statistics. These include EU-funded projects in triggering processes generally (as part of the TRIGS network) and specifically for earthquake forecasting (as part of the NERIES infrastructure project), and as part of the EPSRC-funded NANIA consortium on developing numerical methods for modelling and analysing complex systems in physics, earth science, biology and economics. In 2009 the earthquake seismology group in Edinburgh University has continued to work on earthquake source and population dynamics by combining methods of data analysis, analytical and numerical modelling, and laboratory experimentation.

1.4. Two new ESC Working Groups "2-10: Earthquake Physics: Field Observations, Experimental and Numerical Modeling and Comprehensive Analysis" (responsible Alexey Lyubushin (Russia) and Giovanni Martinelli (Italy)) and "3-10: Algorithms and models of earthquake prediction" (3-10)

(responsible George Purcaru (Germany)) were approved in Montpellier, September 2010 - XXXII General Assembly of ESC.

1.5. The New Zealand Earthquake Forecast Testing Center was established at GNS Science, with real-time tests on the New Zealand earthquake catalogue commencing at the beginning of 2008.

In 2009 tests were begun in the test regions in Italy and Japan. The objective of these centres is to undertake rigorous testing of earthquake forecasting methods in a range of tectonic environments by: constructing community standards and protocols for comparative testing of predictions; developing an infrastructure that allows groups of researchers to participate in prediction experiments; and providing access to authorized data sets and monitoring products for calibrating and testing prediction algorithms. Models are tested with a range of forecasting windows, e.g., 24 hours, 3 months, and 5 years, and tests are intended to run for at least five years.

1.6. In the frame of joint project "Physics of clustering in seismicity: laboratory modelling and field verification" between IPE (Moscow, Russia) and IPGP (Paris, France) regularities in the excitation and relaxation of rock failure were revealed under analyses of a series of laboratory experiments. Similar regularities are defined in natural conditions in the experiments on the rock's failure induced by water infusion into a borehole (Soultz-sous-Forets, France). A hypothesis of competitive excitation and relaxation is suggested for explaining the observed experimental data. Mathematical modeling has confirmed the validity of this hypothesis. The joint paper [V.Smirnov, A.Ponomarev, P.Benard, and A.Patonin. **Regularities in Transient Modes in the Seismic Process according to the Laboratory and Natural Modeling. ISSN 1069_3513, Izvestiya, Physics of the Solid Earth, 2010, Vol. 46, No. 2, pp. 104–135.**] is published.

1.7. The international group worked in the frame of the INTAS Project "Triggering and synchronization of seismic/acoustic events by weak external forcing as a sign of approaching the critical point". The following scientists participated intensively: R. Teisseyre, Z. Czechovsky (Poland), G. Sobolev, A. Ponomarev, A. Lyubushin (Russia), T.Chelidze, T.Matcharashvili (Georgia), V. DeRubeis, P. Tosi (Italy). The next main themes were studied:

- Using of modern seismological data to reveal the earthquake precursors.
- Space-Time combined correlation of earthquakes.
- Seismic process - random or ordered?
- Earthquakes Signatures in Water-Level Time Series.
- Man-made effects in seismic process.
- Nonlinear dynamics as a tool for revealing of synchronization and ordering in time geophysical series. Triggering and synchronization of stick-slip: experiments.

Two meetings of working group were held in Rome (2008 and 2009).

1.8. A Multi Parameter Geophysical Observatory (MPGO) is established by the Wadia Institute of Himalayan Geology, Dehradun at Ghuttu, Western Himalaya. The observatory is equipped with high-precision instruments, like magnetometer, magnetotelluric, super-conductivity gravimeter, broadband seismometer, GPS, radon, ULF emission, and also to monitor deep resistivity, density, elastic deformation, inert gas, electromagnetic emission and water level fluctuation. The MPGO is fully functional on continuous monitoring of geophysical parameters to detect earthquake precursory signals.

1.9. The Geological Survey of India (Govt of India) has established a permanent geophysical / seismological observatory in Gangtok, Eastern Himalaya for precursor study. In addition to these, some investigators in Universities proposed to carry precursor studies using ULF technique, radon emission etc on MoE (Ministry of Earth Sciences, Govt of India) sponsored projects. Establishment of two more MPGOs, one in northeast India and the other in Andaman Island, are approved under the MoE sponsorship.

2. Associated activities

2.1. Prof. I.Main (Scotland), Prof. G.Sobolev (Russia) and Prof. G.Papadopoulos (Greece) were invited by Italian Government to work in the International commission on earthquake forecasting

for civil protection following the destructive earthquake in L'Aquila, Italy, April 6, 2009, Mw=6.3. Before the commission two primary goals have been put: 1. Report on the current state of knowledge of short-term prediction and forecasting of tectonic earthquakes; 2. Indicate guidelines for utilization of possible forerunners of large earthquakes to drive civil protection actions, including the use of probabilistic seismic hazard analysis in the wake of a large earthquake. The results of the commission were published in a report "Operational Earthquake Forecasting: State of Knowledge and Guidelines for Utilization"

2.2. During the period January 2009-March 2010 topics related to the Commission "Earthquake Sources: Modeling and Monitoring for Prediction" were important object of discussion in Italy due to the strong seismic sequence occurred in March-April 2009 in Abruzzo region (Central Italy). In particular an intense scientific debate was developed about the possibility or no to issue a possible pre-seismic alarm. Most important scientific meeting on the described topic were the 10th International Conference on Gas Geochemistry (Cluji-Romania, September 2009), the CNR-Gruppo Nazionale Geofisica Terra Solida Meeting (Trieste, November 2009), The AGU Meeting of San Francisco (San Francisco, December 2010). A significant number of papers were presented at the described Meetings by Authors and their publication is planned during 2010. One time again the urgent topic about the possibility to forecast a possible seismic event attracted the attention of researchers and a more effective role of IASPEI on related researches has been recognized and solicited.

Many participants of the Commission actively participated in different international meetings and workshops including the next:

- **Evison symposium on seismogenesis and earthquake forecasting, Wellington, New Zealand, February 2008.**

The Evison Symposium on Seismogenesis and Earthquake Forecasting was held in Wellington, New Zealand, 18-22 February 2008. This symposium was held in memory of the pioneering contributions to earthquake forecasting by the late Professor Frank Evison, a former Chair of the IASPEI Sub-commission on earthquake forecasting. It attracted over 80 delegates from New Zealand, the USA, Canada, United Kingdom, France, Switzerland, Italy, Greece, Russia, Japan, China, India, and Australia, including altogether more than 50 from overseas. It comprised 28 invited talks, 12 contributed talks and 20 contributed posters. It was well supported by former students and colleagues of Frank Evison, and also by the growing international research community in the fields of seismogenesis and earthquake forecasting, including both physical and statistical modelling. "Seismogenesis and Earthquake Forecasting: the Frank Evison Volume" is now published in Pure and Applied Geophysics, 167, issues 6/7 and 8/9, 2010.

- **The International Symposium on Earthquake Seismology and Earthquake Predictability (ISESEP 09) was held in Beijing, China, from 5 to 9 July 2009.**

Chairman of IASPEI Commission on EQ Source: Modeling and monitoring for prediction Alexey Zavyalov actively participated in this meeting as a member of advisory board, convener of the session "Physics of the Seismic process" and keynote speaker of the lecture "Map of expected earthquakes for north-east China: ten years after". There was presented 6 oral presentations and few posters on the session. An Open Forum was organized, accommodating the debate on the future of the study on earthquake predictability and its application.

It is remarkable that the Symposium is carrying out after the 31-st General Assembly of IASPEI which was held in January 2009 in Cape Town, Southern Africa. This GA adopted special resolution concerning EQs prediction research: "IASPEI RECOGNIZING the opportunities provided by recent developments in earthquake science and technology RECOMMENDS that research on forecasting and predictability of earthquakes, and the validation and comparative testing of prediction methods be supported". Thus international scientific community put a point in twenty years discussion: can earthquakes be predicted or it is not possible at all.

- **The 8-th International Workshop "Physics and Forecasting of Rock Destruction" was held in Saint Petersburg, Russia, 24-29 May 2010.**



The workshop was organized by the Schmitt Institute of Physics of the Earth and the Ioffe Physical Technical Institute, both Institutes of the Russian Academy of Sciences (RAS) and co-sponsored by IUGG, the IASPEI Commission on Earthquake Sources: Modeling and Monitoring for Prediction, the Departments of Earth Sciences and Physics of RAS, the Russian Foundation for Basic Research, and Pradicom Ltd. More than 100 scientists representing eight countries (Belarus, Germany, Greece, India, Kazakhstan, Kyrgyzstan, Russia, and Tadjikistan) participated in the workshop. Three scientific sessions presented the latest development in the field. Session 1 discussed problems related to the theory of destruction of rocks, mathematical and physical modeling of processes in the sources, spatial-temporal regularities, fractal and multi-fractal structure of seismicity, and triggering and synchronization of processes of

rock instability. Problems of catastrophe theory, phase transitions and self-organized criticality in complex systems were considered in session 2, whereas session 3 was dedicated to earthquake precursors, regularities of seismic noise, and new approaches to the earthquake forecast.

The Workshop participants adopted a resolution noting (i) the progress in the understanding of complexity of the physical nature of fracture sources of different scale levels (seismicity, rock bursts, etc.); (ii) the progress in the interpretation of observations of various geophysical fields; (iii) the recent achievements in studies of trigger effects and effects of synchronization of geophysical fields; and (iv) the recent development of research methods in the field of seismology and mining.

- 31st ESC General Assembly, Hersonissos, Crete, Greece, September 2008.
- 32nd ESC General Assembly, Montpellier, France, September 2010.
- 7th ASC General Assembly, Tsukuba, Japan, November 2008.
- 8th ASC General Assembly, Hanoi, Vietnam, November 2010.
- **35th IASPEI General Assembly, Cape Town, Southern Africa, January 2009.**
Business meeting of Commission on Earthquake Sources: Modeling and Monitoring for Prediction was held on Wednesday, January 14, 2009 in the room 1.41-1.43 in Cape Town International Convention Center (CTICC). Commission discussed suggestions to the scientific programme for the IUGG 2011 General Assembly in Melbourne, Australia (*2 proposals were adopted and included in the scientific program IUGG 2011*) and Commission Activity Report 2007-2008 to IASPEI.

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